Digital Government Fostering Social Cohesion for Reducing Inequalities

Proceedings of the 26th Annual International Conference on Digital Government Research (DG.O 2025)

Porto Alegre, Brazil
09-12 June 2025

Editors: Flavia Bernardini, Marie Anne Macadar, David Dueñas-Cid, and Jooho Lee

Series Organizer

Co-organizers

Publisher



Digital Government Fostering Social Cohesion for Reducing Inequalities

Proceedings of the 26th Annual International Conference on Digital Government Research (DG.O 2025)

Pontifical Catholic University of Rio Grande do Sul
Porto Alegre, Brazil
09 – 12, June 2025

Editors:

Flavia Bernardini, Fluminense Federal University, Brazil
Marie Anne Macadar, Federal University of Rio de Janeiro, Brazil
David Dueñas-Cid, Kozminski University, Poland
Jooho Lee, University of Nebraska at Omaha, USA

Colophon

Digital Government Fostering Social Cohesion for Reducing Inequalities: Proceedings of the 26th Annual International Conference on Digital Government Research (DG.O 2025)

TU Delft OPEN Publishing

Editors:
Flavia Bernardini[1], Marie Anne Macadar[2], David Dueñas-Cid[3], and Jooho Lee[4]

[1] Department of Computer Science, Institute of Computing, Fluminense Federal University, Brazil | fcbernardini@ic.uff.br | 0000-0001-8801-827X
[2] COPPEAD Graduate School of Business, Federal University of Rio de Janeiro, Brazil | 0000-0003-2744-5352
[3] Department of Management in Networked and Digital Societies, Kozminski University, Poland | 0000-0002-0451-4514
[4] College of Public Affairs and Community Service, University of Nebraska at Omaha, USA | 0000-0001-8425-3491

Keywords:
Digital Government Transformation, Digital Governance & GovTech, Artificial Intelligence & Data Policy, Smart Cities & Infrastructure, Digital Democracy & Social Inclusion

Published by:
TU Delft OPEN Publishing | Delft University of Technology, The Netherlands

DOI: https://doi.org/10.59490/mt.264

ISBN: 978-94-6518-384-8

Copyright statement:

This work is licensed under a Creative Commons Attribution 4.0 International (CC BY 4.0) license unless otherwise stated ©2026 published by TU Delft OPEN Publishing on behalf of the authors.

Electronic version of this book is available at: https://books.open.tudelft.nl

Copyright clearance made by the TU Delft Library copyright team.

Conflict of Interest: No conflict of interest to disclose.

Data Access Statement, Funding, and Use of AI: Each paper in these proceedings includes its own data access policy, funding statement, and statement regarding the use of artificial intelligence (AI).

Peer Review: All the papers of this book have been double-anonymously peer reviewed. The Editors, the Authors, the Conference Organizers, and the Publisher would like to thank the reviewers for their time and effort. The entire list of reviewers is presented in the Program Committee section of this book.

Disclaimer: All relevant data are within each paper and its supporting information files. Every attempt has been made to ensure the correct source of images and other potentially copyrighted material was ascertained, and that all materials included in this book have been attributed and used according to their license. If you believe that a portion of the material infringes someone else's copyright, please contact fcbernardini@ic.uff.br or marie.macadar@coppead.ufrj.br. The Organizing Committee of the 26th Annual International Conference on Digital Government Research (DG.O 2025) is not responsible or accountable for any statements or opinions expressed in the papers printed in the conference proceedings. The papers have been prepared for final reproduction and printing as received by the authors, without any modification, correction, etc. Therefore, the authors are fully responsible for all information contained in their papers. Although all care is taken to ensure the integrity and quality of this publication and the information herein, no responsibility is assumed by the authors for any damage to the property or person as a result of the operation or use of this publication and/or the information contained herein.

Ethics Statement: The authors of the papers in this conference proceeding are responsible for ensuring ethical compliance and obtaining necessary approvals for any research involving human subjects, human data, tissue, or animals. Authors are responsible for complying with the terms of use for any intellectual property, licenses, rights, or copyrighted materials.

Table of Contents

Sponsors, Co-organizers and Institutional Support vi
Valerie Gregg International Student Fund vii
Digital Government Society President Welcome Letter viii
Conference Chairs Welcome Letter ix
Program Chairs Welcome Letter x
Conference Organization Committee xi
Track Chairs xii
Program Committee xiii

Track 1: Application of Artificial Intelligence, Data Science, and Computational Methods for Data-driven governance 1

Track 2: Artificial Intelligence Transforming the Public Sector 165

Track 3: Data-Driven Services in Government for Evidence-Based Policy and Public Value 266

Track 4: Digital Democracy & AI 320

Track 5: Digital Government and Sustainable Development Goals 355

Track 6: Digital Government Cybersecurity Management: Paradoxical Tensions and Responsible Innovation 371

Track 7: Digital Government for Stronger Society 400

Track 8: Digital Platform Government and Core Public Values 458

Track 9: Digital Transformation in Subnational Governments 479

Track 10: Generative Artificial Intelligence in Government 609

Track 11: GovTech and Digital Autonomy 683

Track 12: Increasing citizen engagement and active citizenship through digital government 743

Track 13: Legal Informatics – Foundations and Applications 812

Track 14: Organizational Factors, Adoption Issues, and Value Creation of Digital Government 843

Track 15: Re-imagining flexible work in the public service: the shift to remote and hybrid offices 967

Track 16: Smart Cities for Social Cohesion 1008

Track 17: Social Media and Government - Democratic challenges, regulation, uses of platforms, and actors' behavior 1085

Track 18: Sustainable and Ethical Public Service Co-Creation 1164

Track 19: Sustainable Public and Open Data Ecosystems for inclusive and innovative Digital Government 1210

Track 20: Digital Government: Bachelor's and Master's Student Track 1268

Track 21: Dialogues about Latin America (Portuguese, Spanish and English track) 1322

Track 22: Digital Government Ecosystem Cases: Collaboration for enhancing transformative innovations and overcoming challenges 1441

Track 23: Panels 1543

Track 24: Posters 1561

Track 25: Workshops 1690

Sponsors, Co-organizers, and Institutional Support

Gold Sponsor:

PROCERGS
CENTRO DE TECNOLOGIA DA INFORMAÇÃO E COMUNICAÇÃO DO ESTADO DO RIO GRANDE DO SUL S.A.

Bronze Sponsor:

nic.br

Sponsor:

NON SOLUS
ELSEVIER

Co-organizers:

digital government society

PUCRS

UFRJ
UNIVERSIDADE FEDERAL DO RIO DE JANEIRO

uff Universidade Federal Fluminense

Institutional Support:

MINISTÉRIO DA GESTÃO E DA INOVAÇÃO EM SERVIÇOS PÚBLICOS

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

CAPES

SECRETARIA DE PLANEJAMENTO GOVERNANÇA E GESTÃO
GOVERNO DO ESTADO RIO GRANDE DO SUL
O futuro nos une.

Valerie Greg International Student Fund



The Board of the Digital Government Society inaugurated the Valerie Gregg International Student Fund (the Fund) to honor Valerie Gregg's commitment to building a sustainable digital government research community. As an NSF program manager for digital government, Valerie worked tirelessly to build bridges across disciplines, professions, and cultures. The Fund, seeded with a bequest from her estate, is dedicated to Valerie's special interest in supporting doctoral students as they embark on their research careers. To continue her legacy and honor her dedication, the DGS is seeking personal and institutional contributions to the Fund on an ongoing basis for the purpose of funding the participation of doctoral students in the Doctoral Colloquium at the International Conference on Digital Government Research.

To contribute to the Fund, please contact Mila Gasco-Hernandez mgasco@albany.edu, Treasurer of the Digital Government Society.

Digital Government Society President Welcome Letter

Dear Digital Government Society Members, distinguished guests, and participants,

It is my great honor to welcome you to our annual International Digital Government Research Conference. For 26 years now, DG.O has been a meaningful platform where our members meet and advance digital government research in a collaborative way. Together, we share groundbreaking ideas, dive into insightful debates, and build long lasting networks and communities. We are thrilled to announce that this year, following the pattern of Poland and Taiwan conferences in the last two years, DG.O has attracted a historical number of submissions and participations. We received around 210 registrations from 32 countries in different parts of the world. You all are part of the history of this exciting community that has been and will continue to shape the development of research on the future of governance and society.

Last year, when I said that we were facing an unprecedented complexity in our world. I did not anticipate how rapidly the complexity could grow, evolve and shift. We always say that technology is a double-edged sword, but never before, it showed us just how alarmingly, technology can move the dial and play such critical role in both providing solutions and exacerbating the nature of many problems facing the public sector and our society. To name a few, climate modeling and monitoring, renewable energy tech, global health data sharing, pandemic monitoring and prediction, digital identity, vaccine/treatment development and distribution brings new hopes and solutions. Yet, cyber warfare and cybersecurity, misinformation and disinformation, Al surveillance and loss of privacy, automation and job displacement, and digital exclusion introduces yet a whole set of wicked problems and instability to our collective future.

To address these opportunities and pressing issues, researchers and practitioners must work together to create global standards, governance structures, and collaboration frameworks that can maximize technology's benefits while minimizing its risks.

The Digital Government Research Conference (DG.O) in Porto Alegre, Brazil is significant not only because it brings together leading scholars and professionals but also because it provides a platform for discussions that can shape the future of public governance worldwide. For Brazil and Latin America, it represents an opportunity to lead the digital governance conversation and create solutions that can improve transparency, service delivery, inclusion and equality in the society. The discussion taken place in this conference can have lasting and global implications for digital government research and practices.

Here, I wish to express my deepest gratitude to the host and conference organizing teams. So much planning and execution efforts have been done to make this conference a productive venue. The conference chairs, program chairs, poster chairs, doctoral colloquium chairs, and program committee has, once again, excelled in bringing in a variety of thought stimulating topics and speakers. I would especially like to highlight the contribution of Edimara Luciano, who has been extremely persistent, and hardworking in leading the organizing team. Our gratitude goes to the Program Chairs Flavia Bernardini, Marie Anne Macadar, David Dueñas-Cid, and Jooho Lee for all your dedication and work, and for creating the inspiring conference program.

Sincerely thanks to all the track chairs who reached out to the potential contributors and managed the review in a short period of time, and reviewers for responding in such prompt fashion. **Also, thanks go to all the staff and the student volunteers for managing all the sessions. Finally, I would like to thank all our sponsors for their support of the different awards and activities of the conference.**

Jing Zhang, Clark University, USA
President of the Digital Government Society

Conference Chairs Welcome Letter

It is our great pleasure to present the proceedings of the 26th Annual International Conference on Digital Government Research (DG.O 2025), held in Porto Alegre, the capital of Rio Grande do Sul, Brazil, from June 9 to 12, 2025. This edition was a landmark for the community: not only the 26th in a long and successful series, but also the very first time the conference took place in South America. The occasion brought together colleagues from 32 countries across different world regions, making DG.O 2025 a truly global gathering and one of the largest in the history of the conference.

The conference was hosted on the beautiful campus of the Pontifical Catholic University of Rio Grande do Sul (PUCRS), which provided excellent facilities and a vibrant setting for academic exchange. Beyond the university, the event was immersed in the welcoming culture of southern Brazil and the broader Brazilian context — a country marked by rich traditions, diversity, and hospitality. This atmosphere contributed to an inspiring environment for dialogue, reflection, and collaboration, fully in line with the ethos of the DG.O community.

Organized under the auspices of the Digital Government Society (DGS), DG.O 2025 welcomed around two hundred participants. This proceedings shows the complete versions of the 119 papers presented over the course of four days, across 24 thematic tracks, chaired by 63 colleagues. Many served in multiple roles, reflecting the dedication and collaborative spirit that characterize our community. Together, these efforts ensured both the scientific quality and the intellectual diversity of the program.

The theme of DG.O 2025, Digital Government Fostering Social Cohesion for Reducing Inequalities, was particularly meaningful in the Brazilian context and resonated strongly with broader global debates. Digital government goes far beyond technology: it holds the potential to address persistent social and economic disparities. Social cohesion is both a challenge and an aspiration in societies marked by inequality, and the Brazilian and Latin American contexts underscore the importance of inclusive initiatives that promote belonging, engagement, trust, and resilience.

The diversity of the program reflected this theme in multiple ways. Tracks and sessions explored, among others, artificial intelligence and ethics in government, data-driven governance and open data, digital transformation strategies, cybersecurity and responsible innovation, digital democracy and GovTech platforms, smart cities, and citizen engagement. These contributions showcased a wide range of methodologies — from computational modeling to in-depth case studies, qualitative approaches, participatory design, and mixed methods — underscoring the intellectual richness of the field.

The value of DG.O 2025 was not only academic but also cultural and geographic. Just as digital government research addresses questions of inclusion, participation, and shared value, the conference itself embodied these principles by bringing together scholars and practitioners from diverse regions, traditions, and perspectives. Hosting DG.O in Brazil, a country with extraordinary social, cultural, and ethnic diversity, reinforced the importance of connecting academic studies with real-world challenges in societies where inequalities are acute but opportunities for innovation and collaboration are equally significant.

Organizing DG.O 2025 was a collective effort made possible by the energy, generosity, and commitment of many individuals and institutions. We are deeply grateful to the authors, reviewers, track chairs, and program committee members, whose contributions ensured the quality of these proceedings. We thank the keynote speakers, panelists, PhD students attending the Ph.D. Colloquium, poster, and workshops participants, and paper sessions attendees, whose engagement enriched the debates and fostered new opportunities for collaboration.

We expect that the papers collected in these proceedings will not only document the contributions of DG.O 2025 but also inspire further inquiry and collaboration. May they provide fruitful reading and generate insights that advance research and create impact in practice, contributing to our shared endeavor of fostering digital government that promotes social cohesion and reduces inequalities worldwide.

Edimara M. Luciano, Pontifical Catholic University of Rio Grande do Sul, Brazil
Jing Zhang, Clark University, USA
Yu-Che Chen, University of Nebraska at Omaha, USA
Tomasz Janowski, Gdańsk University of Technology, Poland
DG.O 2025 Conference Chairs

Program Chairs Welcome Letter

Dear Colleagues,

Welcome to the 26th Annual International Conference on Digital Government Research!

This year, our conference theme is "Digital Government Fostering Social Cohesion for Reducing Inequalities". We have received a diverse and high-quality range of submissions, totaling 268 papers. From these submissions, we have accepted 119 papers, 5 panels, 6 workshops, and 28 posters for presentation at the conference.

None of this would have been possible without the dedication of our program committee members. A total of 240 committee members contributed with more than 550 comprehensive reviews to assess the quality of the submissions. The papers were selected through a rigorous and competitive process guided by 74 track chairs of 24 tracks, all of whom worked diligently to ensure a successful conference. We extend our sincere thanks to everyone who has been part of this effort: the organizing committee, program committee members, Ph.D. volunteers, and Digital Government Society members who contributed to managing the conference, including Mila Gasco and Paula Hauser, as well as Loni Hagen for the website support. We also sincerely thank Frederique Belliard, Monique IJzinga, and Rixt Tuinstra from the TU Delft library, who were responsible for publishing the proceedings, Érica Menezes for supporting the work of the Program Chairs, and José Viterbo Filho for all the support in pioneering this new proceedings process.

We are confident that you will find the DG.O 2025 conference to be a source of stimulating content, ideas, discussions, and research avenues that will contribute to your professional development. We are delighted to have played a role in the success of this year's conference and hope it serves as a stepping stone for future endeavors.

Flavia Bernardini, Fluminense Federal University, Brazil
Marie Anne Macadar, Federal University of Rio de Janeiro, Brazil
David Dueñas-Cid, Kozminski University, Poland
Jooho Lee, Ph.D., University of Nebraska at Omaha, USA
DG.O 2025 Program Co-Chairs

Conference Organization Committee

Conference Chairs

Edimara Luciano, Pontifical Catholic University of Rio Grande do Sul, Brazil
Jing Zhang, Clark University, USA
Yu-Che Chen, University of Nebraska at Omaha, USA
Tomasz Janowski, Gdańsk University of Technology, Poland

Program Chairs

Flavia Bernardini, Fluminense Federal University, Brazil
Marie Anne Macadar, Federal University of Rio de Janeiro, Brazil
David Dueñas-Cid, Kozminski University, Poland
Jooho Lee, University of Nebraska at Omaha, USA

Poster and Demo Chairs

Aurora Sánchez Ortiz – Universidad Católica del Norte, Chile
David Valle-Cruz – Universidad Autónoma del Estado de México
Fernando Bichara Pinto – Federal University of Rio de Janeiro, Brazil

Doctoral Colloquium Chairs

J.Ramon Gil-Garcia, University at Albany, SUNY, USA
Ida Lindgren, Linköping University, Sweden
Gabriela Viale Pereira, Danube University Krems, Austria

Finance Chair

Mila Gasco, University at Albany, SUNY, USA

Local chair

Milene S. Silveira, Pontifical Catholic University of Rio Grande do Sul, Brazil

Local Communication Chair

José Viterbo Filho, Fluminense Federal University, Brazil

Local Supporting Team

Claiton Marques Correa, Farroupilha Federal Institute, Brazil
Carolina T. Lopes, Pontifical Catholic University of Rio Grande do Sul, Brazil
Claucia P. Faganello, Pontifical Catholic University of Rio Grande do Sul, Brazil
Erica Menezes, Federal University of Rio de Janeiro, Brazil
Fernando Bichara Pinto, Federal University of Rio de Janeiro, Brazil
Igor S. Garcia, Fluminense Federal University, Brazil
Raissa S. Barcellos, State University of Rio de Janeiro, Brazil
Rosiane A. Palacios, Pontifical Catholic University of Rio Grande do Sul, Brazil

Track Chairs

Adegboyega Ojo, Carleton University, Canada
Alois Paulin, Univ. of Public Administration and Finance Ludwigsburg, Germany
Anastasija Nikiforova, University of Tartu, Estonia
Anneke Zuiderwijk, Delft University of Technology, The Netherlands
Anthony Simonofski, Université de Namur ASBL, Belgium
Beatriz Barreto B. Lanza, IDB, Brazil
Carmine Bianchi, Università degli Studi di Palermo, Italy
Charalampos Alexopoulos, University of the Aegean, Greece
Chris Hinnant, Florida State University, USA
Chung-Pin Lee, National Taipei University, Taiwan
Claudia Cappelli, University of Rio de Janeiro State, UERJ, Brazil
David Dueñas-Cid, Kozminski University, Poland
David Valle-Cruz, Universidad Autónoma del Estado de México, Mexico
Diogo Sasdelli, University for Continuing Education Krems, Austria
Donavon A. Johnson, Florida International University, USA
Edimara M. Luciano, Pontifical Catholic University of Rio Grande do Sul, Brazil
Elsa Estevez, Universidad Nacional del Sur, Argentina
Fadi Salem, MBR School of Government, United Arab Emirates
Fernando Kleiman, TUDelft, The Netherlands
Gabriela V. Pereira, University for Continuing Education Krems, Austria
Gianluca Misuraca, Universidad Politécnica de Madrid, Spain
Guilherme C. Wiedenhöft, Federal University of Rio Grande, Brazil
Hendrik Scholta, German University of Administrative Sciences, Germany
Hsien-Lee Tseng, National University of Taiwan, Taiwan
Iryna Susha, Utrecht University, The Netherlands
J. Ignacio Criado, Universidad Autónoma de Madrid, Spain
J. Ramon Gil-Garcia, CTG SUNY Albany, USA
Jawad Haqbeen, Kyoto University, Japan
Jing Zhang, Clark University, Main, USA
João Maurício Adeodato, Federal University of Pernambuco, Brazil
Jolien Ubacht, Delft University of Technology, The Netherlands
Jooho Lee, University of Nebraska at Omaha, USA
Kellyton Brito, Universidade Federal Rural de Pernambuco, Brazil
Kerk Kee, Texas Tech University, USA
Kevin C. Desouza, Queensland University of Technology, Australia
Leonidas Anthopoulos, University of Thessaly, Greece
Loni Hagen, University of South Florida, USA
Luis F. Luna-Reyes, University at Albany, USA
Luiz Pinheiro, Positivo University, Brazil
Magdalena Ciesielska, Gdańsk University of Technology, Poland
Manuel Pedro Rodríguez Bolívar, University of Granada, Spain
Manuella Maia Ribeiro, Brazilian Network Information Center, NIC.br
Maria Alexandra Cunha, Fundação Getúlio Vargas, Brazil
Maria Gintova, McMaster University, Canada
Marijn Janssen, Delft University of Technology, The Netherlands
Michael Ahn, UMass Boston, USA
Nadzeya Sabatini, Gdansk University of Technology, Poland
Nina Rizun, Gdansk University of Technology, Poland
Nitesh Bharosa, Delft University of Technology, The Netherlands
Noella Edelmann, University of Continuing Education Krems, Austria
Peter Parycek, Fraunhofer Fokus, Germany
Richard Knepper, Cornell University, USA
Robert Müller-Török, Univ. of Public Adm. and Finance Ludwigsburg, Germany
Rodrigo Sandoval-Almazan, Universidad Autónoma del Estado de México, México
Rony Medaglia, Copenhagen Business School, Denmark
Sehl Mellouli, Université Laval, Canada
Shefali Virkar, WU Vienna University of Economics and Business, Austria

Sofia Sahab, Kyoto University, Japan
Soon Ae Chun, City University of New York, USA
Sukumar Ganapati, Florida International University, USA
Takayuki Ito, Kyoto University, Japan
Theresa A. Pardo, University at Albany, USA
Thiago José Tavares Ávila, Fundação Getulio Vargas, Brazil
Tomasz Janowski, Gdańsk University of Technology, Poland; University for Continuing Education Krems, Austria
Vanessa Nunes, Inteli Leadership and Technology Institute, Brazil
Wookjoon Sung, Seoul National University of Science and Technology, South Korea
Yogesh K. Dwivedi, Swansea University, United Kingdom
Yu-Che Chen, University of Nebraska, USA
Zach Bastick, Harvard University, USA

Program Committee

Abhishek Srivastava, Indian Institute of Management Visakhapatnam, India
Abílio Barros, Universidade Federal Rural de Pernambuco (UFRPE), Brazil
Adegboyega Ojo, Carleton University, Canada
Adrián Osiel Millán Vargas, Universidad Autónoma del Estado de México, Mexico
Aleksandra Revina, TU Berlin, Germany
Alesia Rudnik, Karlstad University, Sweden
Alois Paulin, Vienna University of Technology, Austria
Álvaro Sobrinho, Federal University of the Agreste of Pernambuco, Brazil
Amal Marzouki, Université du Québec à Rimouski (UQAR), Canada
Anastasija Nikiforova, University of Tartu, Estonia
André Araújo, Federal University of Alagoas, Brazil
Andrea Loreggia, University of Brescia, Italy
Andrée-Anne Deschênes, Université du Québec à Rimouski, Canada
Andreiwid Correa, Federal Institute of Sao Paulo, Brazil
Anna Picco-Schwendener, Università della Svizzera italiana (USI), Sweden
Anna-Sophie Novak, University for Continuing Education Krems, Austria
Annus Azhar, Arizona State University, USA
Antoine Clarinval, Université de Namur, Belgium
Antonia Sattlegger, Technical University Delft, The Netherlands
António F. Tavares, University of Minho, Portugal
Arpan Kar, Indian Institute of Technology Delhi, India
Aurora Sanchez, Universidad Católica del Norte, Chile
Basit Shafiq, Lahore University of Management Sciences, Pakistan
Battulga Buyannemekh, University at Albany, SUNY, USA
Beomgeun Cho, University at Albany, SUNY, USA
Bert Lukkien, Delft University of Technology, The Netherlands
Bianca Steffes, Saarland University, Germany
Binh An Patrick Nguyen, German University of Administrative Sciences Speyer, Germany
Boriana Rukanova, Delft University of Technology, The Netherlands
Boutheyna Nouri, École Nationale Supérieure d'Informatique, Algeria
Bruno Andrade de Figueiredo, Fundação Getulio Vargas (FGV-EAESP), Brazil
Bruno Figueiredo, Roraima State University (UERR), Brazil
Byoung Joon Kim, Kookmin University, South Korea
Carolina Tavares Lopes, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil
Catherine Annis, Syracuse University, Maxwell School of Citizenship and Public Affairs, USA
Catia Regina Muniz, Fundação Getulio Vargas (FGV-EAESP), Brazil
Cesar Casiano Flores, University of Twente, The Netherlands
Chian-Wen Wang, Tamkang University, Taiwan
Chiara Mercuri, Università della Svizzera italiana (USI), Sweden
Christos Karelis, University of the Aegean, Greece
Chun-Yuan Wang, Central Police University, Taiwan
Chung-Pin Lee, National Taipei University, Taiwan
Cinara Carneiro Rocha, Universidade do Minho, Portugal
Cintia Melchiori, Fundação Getulio Vargas (FGV-EAESP), Brazil
Cláucia Piccoli Faganello, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil
Colin van Noordt, Tallinn University of Technology, Estonia
Cristiano Maciel, Universidade Federal de Mato Grosso, Brazil
Dae-Eun Kim, Seoul National University, South Korea
Daniel Schiff, Purdue University, USA
Daniel Valotto, Universidade Federal do Paraná (UFPR), Brazil
Danilo Araújo, Federal Rural University of Pernambuco, Brazil
David Valle-Cruz, Universidad Autónoma del Estado de México (UAEMex), Mexico
Debora Barbosa Leite Silva, Federal University of Alagoas (UFAL), Brazil
Décio Bittencourt Dolci, Federal University of Rio Grande, Brazil
Delfina Soares, University of Minho, Portugal
Demetrios Sarantis, National Technical University of Athens, Greece
Devyani Pande, National Law School of India University, India

Diana Cruz Rodrigues, Universidade Federal da Amazônia (UNAMA), Brazil
Dimitrios Tselios, University of Thessaly, Greece
Dimitris Symeonidis, University of Tartu, Estonia
Dmytro Khutkyy, University of Tartu, Estonia
Dolores Edwiges Luna, Universidad de las Americas, Puebla, Mexico
Doris Allhutter, Austrian Academy of Sciences, Austria
Douglas Silva, Universidade Federal de Goiás (UFG), Brazil
Edgar Alejandro Ruvalcaba Gómez, Universidad de Guadalajara, Mexico
Edimara Luciano, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil
Edna Dias Canedo, Universidade de Brasília (UNB), Brazil
Eduardo Diniz, Fundação Getulio Vargas (FGV-EAESP), Brazil
Efthimios Tambouris, University of Macedonia, Greece
Elaine Tavares, Federal University of Rio de Janeiro, Brazil
Elli Kontogianni, University of Thessaly, Greece
Emanuel Queiroga, Federal University of Pelotas, Brazil
Érica Maria Menezes, Federal University of Rio de Janeiro, Brazil
Erica Souza Siqueira, Fundação Getulio Vargas (FGV-EAESP), Brazil
Erico Przeybilovicz, University at Albany, SUNY, USA
Eriks Sneiders, Stockholm University, Sweden
Eunice Nunes, Universidade Federal do Mato Grosso (UFMT), Brazil
Eunmi Lee, Kookmin University, South Korea
Euripidis Loukis, University of the Aegean, Greece
Evgeny Styrin, National Research University Higher School of Economics, Russia
Fabiano Angélico, Università della Svizzera italiana (USI), Sweden
Fernando Pinto, Federal University of Rio de Janeiro, Brazil
Flavia Santoro, Universidade Estadual do Rio de Janeiro (UERJ), Brazil
Flavia Bernardini, Fluminense Federal University (UFF), Brazil
Francesco Mureddu, Lisbon Council, Portugal
Francois Duhamel, Universidad de las Américas Puebla (UDLAP), Mexico
Frank Bannister, Trinity College Dublin, Ireland
Gabriel Figueirêdo, Centro Universitário de João Pessoa (UNIPÊ), Brazil
Gabriel Silva Cogo, Fundação Getulio Vargas (FGV-EAESP), Brazil
Gabriela Viale Pereira, University for Continuing Education Krems, Austria
Georgios Papageorgiou, University of the Aegean, Greece
Gianluigi Viscusi, Imperial College, Linköping University, Sweden
Grażyna Musiatowicz-Podbiał, Gdańsk University of Technology, Poland
Gregor Eibl, University for Continuing Education Krems, Austria
Gregory Michener, Fundação Getulio Vargas (FGV-EBAPE), Brazil
Gregory Porumbescu, Rutgers University, USA
Guilherme Wiedenhöft, Federal University of Rio Grande, Brazil
Guilherme Lerch Lunardi, Federal University of Rio Grande, Brazil
Guo, Tsinghua University, China
Hanbyul Choi, Kunsan National University, South Korea
Helen Liu, National Taiwan University, Taiwan
Hendrik Scholta, German University of Administrative Sciences Speyer, Germany
Henry Hosseini, University of Münster, Germany
Hsien-Lee Tseng, National University of Taiwan, Taiwan
Hsini Huang, National University of Taiwan, Taiwan
Hun Yeong Kwon, Korea University, South Korea
Hyun Joon Kim, Korea University, South Korea
Ida Lindgren, Linköping University, Sweden
Igor Sampaio, Fluminense Federal University (UFF), Brazil
Ioannis Nikolaou, University of Thessaly, Greece
Isis Gutiérrez-Martínez, Universidad de las Américas-Puebla, Mexico
Iulia Cioroianu, University of Bath, UK
Iván Cantador, Universidad Autónoma de Madrid, Spain
J. Ignacio Criado, Universidad Autónoma de Madrid, Spain
Jae Shin Park, Kookmin University, South Korea
Jakub Chabik, Gdańsk University of Technology, Poland
Javiera Macaya, Brazilian Network Information Center (NIC.br), Brazil
Jawad Ahmad Haqbeen, Kyoto University, Japan

Jing Zhang, Clark University, USA
Jing Shi, Huazhong University of Science and Technology, China
Jingrui Ju, Harbin Institute of Technology, China
João Luís Oliveira Martins, University of Minho, Portugal
João Alvaro Carvalho, University of Minho, Portugal
João Guilherme de Melo Peixoto, Catholic University of Pernambuco, Brazil
Joep Crompvoets, KU Leuven, Belgium
John Carlo Bertot, University of Maryland, USA
Jolien Ubacht, Delft University of Technology, The Netherlands
Jose Viterbo, Fluminense Federal University (UFF), Brazil
José Luis Ros Medina, Universidad Internacional de La Rioja (UNIR), Spain
José Romualdo Costa Filho, Institute of Technology and Leadership (INTELI), Brazil
Julián Villodre, Leiden University, The Netherlands
Jwan Khisro, College of Information, University of Maryland, USA
Karla Negrete-Huelga, Universidad Autónoma de Querétaro, Mexico
Kate Revoredo, Humboldt University of Berlin, Germany
Kaylyn Schiff, Purdue University, USA
Kellyton Brito, Universidade Federal Rural de Pernambuco, Brazil
Kilian Sprenkamp, University Zurich, Germany
Kristof Meding, University of Tübingen, Germany
Kuang-Ting Tai, Nova Southeastern University, USD
Lahis Kurtz, Federal University of Santa Maria (UFSM), Brazil
Laura Alcaide-Muñoz, University of Granada, Spain
Leif Sundberg, Mid Sweden University, Sweden
Lenardo Silva, Universidade Federal Rural do Semi-Árido (UFERSA), Brazil
Leonidas Anthopoulos, University of Thessaly, Greece
Lieselot Danneels, Ghent University, Vlerick Business School, Belgium
Louise van der Peet, Delft University of Technology, The Netherlands
Luca Tangi, Joint Research Centre - European Commission, Italy
Luciana Portilho, Center for Studies on the Development of the Information Society (Cetic.br), Brazil
Luciana Santa Rita, Federal Universidade de Alagoas, Brazil
Luis F. Luna-Reyes, University at Albany, SUNY, USA
Luiz Vargas, Federal University of Rio de Janeiro, Brazil
Luiza Jardim, Fundação Getulio Vargas (FGV-EAESP), Brazil
Luiza Schuch de Azambuja, Tallinn University of Technology, Estonia
Lung-Teng Hu, National Taipei University, Taiwan
Maddalena Sorrentino, University of Milan, Italy
Magdalena Ciesielska, Gdańsk University of Technology, Poland
Manuel Pedro Rodríguez Bolívar, University of Granada, Spain
Manuela Cruz, Fundação Getulio Vargas (FGV-EAESP), Brazil
Manuella Maia Ribeiro, Brazilian Network Information Center (NIC.br), Brazil
Marcia Hino, Federal University of Paraná, Brazil
Maria Gintova, McMaster University, Canada
Maria Ioanna Maratsi, University of the Aegean, Greece
Marianna Sampaio, Fundação Getulio Vargas (FGV-EAESP), Brazil
Marie Anne Macadar, Federal University of Rio de Janeiro, Brazil
Marijn Janssen, Delft University of Technology, The Netherlands
Marissa Hoekstra, TNO, The Netherlands
Martha Alicia Avila-Maravilla, University at Albany, USA
Martin Lněnička, Univerzita Pardubice, Czechia
Mary Feeney, Arizona State University, USA
Matheus Cruz, Fluminense Federal University (UFF), Brazil
Mei Jen Hung, National Taiwan University, Taiwan
Michael Räckers, University of Münster, Germany
Milber Bourguignon, Federal University of Rio de Janeiro, Brazil
Ming-Hung Wang, University Chiayi (R.O.C.), Taiwan
Mohsan Ali, University of the Aegean, Samos, Greece
Mortaza S. Bargh, Rotterdam University of Applied Sciences, The Netherlands
Naci Karkin, United Nations University, Portugal
Nailing Kuo, National Taiwan University, Taiwan
Nancy Jiaxin Wu, The Hong Kong University of Science & Technology (Guangzhou), China

Nic DePaula, SUNY Polytechnic Institute, USA
Nicolas Bono Rossello, Nature Digital Institute, University of Namur, Belgium
Nina Rizun, Gdańsk University of Technology, Poland
Nitesh Bharosa, Delft University of Technology, The Netherlands
Noella Edelmann, University for Continuing Education Krems, Austria
Oscar Corcho, Universidad Politécnica de Madrid, Spain
Pablo Sampaio, Universidade Federal Rural de Pernambuco, Brazil
Panos Karadimos, University of Thessaly, Greece
Paolo Gerbaudo, Complutense University Madrid, Spain
Peter Cruickshank, Edinburgh Napier University, UK
Poty Lucena, Universidade Federal do Oeste da Bahia, Brazil
Rafael Oliveira, Università degli Studi di Napoli Federico II, Italy
Rahul De', Indian Institute of Management Bangalore, India
Raissa Barcellos, Universidade do Estado do Rio de Janeiro, Brazil
Reginaldo Arakaki, Institute of Technology and Leadership (INTELI), Brazil
Renato Penha, Institute of Technology and Leadership (INTELI), Brazil
Ricardo Matheus, Delft University of Technology, The Netherlands
Rita Grandinetti, Universidad Nacional de Rosario (UNR), Argentina
Rodrigo Oliveira, Federal University of Rio de Janeiro, Brazil
Rodrigo Sandoval-Almazán, Universidad Autónoma del Estado de Mexico, Mexico
Rony Medaglia, Copenhagen Business School, Denmark
Rosiane Alves Palacios, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil
Sabrina Callegaro, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Brazil
Salma Elkhaoudi, Stanford University, Mohammed bin Rashid School of Government (MBRSG), USA
Sehl Mellouli, Université Laval, Canada
Sélinde van Engelenburg, Delft University of Technology, The Netherlands
Sem Nouws, Delft University of Technology, The Netherlands
Seok-Jin Eom, Seoul National University, South Korea
Sergio Picazo-Vela, Universidad de las Americas Puebla, Mexico
Shefali Virkar, WU Vienna University of Economics and Business, Austria
Shih-Lung Chao, Taipei City Government, Taiwan
Shreyas Kumar, Texas A&M University, USA
Sidney C. Nogueira, Universidade Federal Rural de Pernambuco (UFRPE), Brazil
Soon Chun, City University of New York, USA
Sounman Hong, Yonsei University, South Korea
Suhyeon Park, Korea University, South Korea
Suzana Gilioli, Universidade Federal do Tocantins (UFT), Brazil
Taiane Ritta Coelho, Universidade Federal do Paraná, Brazil
Thomas Lampoltshammer, University for Continuing Education Krems, Austria
Tomer Libal, University of Luxembourg, Luxembourg
Tzuhao Chen, University at Albany, SUNY, USA
Umair Ahmed, University of Camerino, Italy
Uwe Serdült, Ritsumeikan University, Japan
Valdemar Vicente Graciano Neto, Universidade Federal de Goiás (UFG), Brazil
Vasco Furtado, Universidade de Fortaleza, Brazil
Victor Hayashi, Institute of Technology and Leadership (INTELI), Brazil
Vittorio Scarano, University of Salerno, Italy
Wookjoon Sung, Seoul National University of Science and Technology, South Korea
Xian Gao, California State University, Los Angeles, USA
Yannis Charalabidis, University of the Aegean, Greece
Yao Qu, Nanyang Technological University, Singapore
Yen-Chen Huang, National Chi Nan University, Taiwan
Yi-Fan Wang, University of Nebraska at Omaha, USA
Yiwei Gong, Wuhan University, China
Yu-Che Chen, University of Nebraska at Omaha, USA
Yue Gao, Clark University, USA
Yuliia Bartashevska, Alfred Nobel University, Ukraine
Yuri Misnikov, University of Leeds, UK
Zepeng Gong, University of Electronic Science and Technology of China, China
Zoi Lachana, University of the Aegean, Greece

Track 1: Application of Artificial Intelligence, Data Science, and Computational Methods for Data-driven governance

Track Description

The aim of the track is to focus on papers discussing the harnessing of computational methods to transform digital government. Its focus includes: a) Technical and behavioral studies using computational approaches to analyze, model, and simulate social phenomena; b) Data-driven decision-making and citizen service enhancement; c) Empirical studies leveraging computational methods and big data to co-create public services; d) Innovative models and tools for improved government service delivery; e) Design science research developing and evaluating technical artifacts; f) Best practices in applying AI and machine learning to government operations. The track chairs also invited authors to submit papers aligned with the conference theme of "digital government fostering social cohesion for reducing inequalities" by applying AI, data science, computational methods, and big data.

Track Chairs

L. Hagen, University of South Florida, United States of America
K. Brito, Universidade Federal Rural de Pernambuco, Brazil
C. Alexopoulos, University of the Aegean, Greece
D. Valle-Cruz, Universidad Autónoma del Estado de México, Mexico
S. Virkar, WU Vienna University of Economics and Business, Austria

Contents

Advanced Leveraging of Government Data on Firms' Vulnerability to Crisis Using Artificial Intelligence 3
M. Ali, E. Louki, Y. Charalabidis, and C. Alexopoulos

Applying Active Learning in Named Entity Recognition Corpora Expansion in Legal Domain 16
R. P. Gouveia, A. C. P. L. F. de Carvalho, E. Souza, H. O. Albuquerque, D. Vitório, and N. F. F. da Silva

Assessing rule-based document segmentation and word normalization for legal ruling classification 32
G. A. de Godoi, A. Rivolli, D. L. Freire, F. S. F. Pereira, N. R. Ventura, A. M. G. de Almeida, L. P. F. Garcia, M. de S. Dias, and A C. P. de L. F. de Carvalho

Automating Test Design Using LLM - Results from an Empirical Study on the Public Sector 42
A. R. Cavalcanti, L. Accioly, G. Valença, S. C. Nogueira, A. C. Morais, A. Oliveira, and S. Gomes

Comparing Machine Learning and an Expert System for Legal Document Classification 57
J. J. de Q. Santos Filho, F. A. Dantas, M. da S. Lima, S. B. dos Santos, G. Genesis, M. G. L. da Silva, Á. F. Pinheiro, and E. G. da Silva

Data-Driven Analysis for Improving Educational Policies: A Case in Brazil's Textbook Program 67
A. Araújo, R. Araújo, L. Cabral, L. Silva, H. Tomaz, E. Martins, D. Dermeval, Á. Sobrinho, A. P. da Silva, L. Marques, F. Recch, S. M.-N. Galvez, S. Isotani, and I. I. Bittencourt

Development and Deployment of Sentiment Analysis AI on Citizens' Feedback in Goiás 82
R. M. Rosa, J. D. de Souza, and C. do N. Freitas

Enhancing Open Data Findability: Fine-Tuning LLMs(T5) for Metadata Generation 94
U. Ahmed and A. Polini

Ensuring Data Quality in National Educational Databases: Insights from Brazil's Centralized Database of High School Students' Data 108
A. N. Barros, E. M. Queiroga, M. R. Marcolino, D. B. L. Silva, D. Dermeval, A. Lima, L. B. Marques, C. Cechinel, and T. Vieira

Forecasting Student Enrollments in Brazilian Schools for Equitable and Efficient Education Resource Allocation 122
L. Chaves e Silva, L. de S. Cabral, J. J. dos Santos Júnior, L. L. P. dos Santos, T. T. M. de Oliveira, B. J. D. da Costa, J. F. Lobo, D. M. Pinho Júnior, N. J. T. da Cruz, R. de A. Silva, and B. A. Pimentel

Interactive Data Visualization for Decision-making in Government-funded Advanced Research Computing Service 137
X. Cheng, Y.-C. Chen, R. Knepper, and A. Burk

Leveraging String Similarity Algorithms for Educational Data Validation: A Scalable Approach for Digital Governance 152
D. B. L. Silva, E. M. Queiroga, A. N. Barros, M. R. Marcolino, D. Dermeval, A. Lima, L. B. Marques, C. Cechinel, and T. Vieira

Advanced Leveraging of Government Data on Firms' Vulnerability to Crisis Using Artificial Intelligence

Mohsan Ali [a*], *Euripidis Loukis* [b], *Yannis Charalabidis* [c], *Charalampos Alexopoulos* [d]

[a] Department of Information and Communication Systems Engineering, University of Aegean, Samos, Greece, mohsan@aegean.gr, ORCID number 0000-0002-3956-3543

[b] Department of Information and Communication Systems Engineering, University of Aegean, Samos, Greece, eloukis@aegean.gr, ORCID number 0000-0002-5932-4128

[c] Department of Information and Communication Systems Engineering, University of Aegean, Samos, Greece, yannisx@aegean.gr, ORCID number 0000-0003-3760-5495

[d] Department of Information and Communication Systems Engineering, University of Aegean, Samos, Greece, aloxp@aegean.gr, ORCID number 0000-0002-6610-0675

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Government agencies possess large quantities of valuable data, which have to be leveraged to the highest possible extent, using the most advanced processing methods, in order to extract as much as possible the valuable knowledge they contain, in order to support future decisions, policies and programs. In this paper we develop a methodology for sophisticated advanced leveraging of data that government agencies possess concerning firms' behaviour during recessionary economic crises as well as firms' vulnerability to them, which is based on a combination of artificial intelligence (AI) techniques, both unsupervised and supervised ones. Economic crises are one of the most important significant challenges that market-based economies face, which has detrimental effects on businesses of most sectors. Governments employ diverse interventions, including extensive programs in order to mitigate the adverse effects of economic crises, which may include employment reduction, famine, public disturbance, and political instability. These government interventions, particularly the extensive economic stimulus programs during crises, can be rendered more efficacious by concentrating on the firms that are more vulnerable to economic crisis. In this direction the proposed methodology includes initially the use of unsupervised learning AI techniques (clustering) in order to identify based on the abovementioned government data the main typologies of firms with respect to the impacts of economic crisis they experience. Then it includes supervised learning AI techniques (classification) in order to predict based on these data the susceptibility/vulnerability of individual firms to future economic crises. Additionally, the authors present an initial implementation and substantiation (application) of the proposed methodology utilizing a dataset from the Greek Statistical Authority made available upon request, pertaining to 363 companies, data acquired during the Greek economic crises that occurred from 2009 to 2014. Satisfactory results were obtained from this first application.

Keywords. Artificial Intelligence, Government data, Machine Learning, Clustering, Economic Crises
Research paper, DOI: https://doi.org/10.59490/dgo.2025.940

1. Introduction

Government agencies possess large quantities of valuable data, which have to be leveraged to the highest possible extent, using the most advanced processing methods, in order to extract as much as possible the valuable knowledge they contain, in order to supporting future decisions, policies and programs. In this paper we make a

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

contribution towards this direction: we develop a methodology for sophisticated advanced leveraging of data government agencies possess concerning firms' behaviour during recessionary economic crises, as well as firms' vulnerability to them, using a combination of artificial intelligence techniques, both unsupervised and supervised ones. However, the proposed methodology has a wider applicability to a wide range of social and economic problems, for supporting the corresponding government decisions, policies and programs.

Economic crises are one of the most important significant challenges faced by market-based economies; they are caused by various events leading to instability of economic activities, which may cause recessions and result in economic crises of varying durations, geographical scopes, and intensities, (Allen, 2016; Keeley & Love, 2010; Knoop, 2010; Kottika et al., 2020; OECD, 2009a; Saifi & Horowitz, 2023). Economic crises that happened over the span of the previous century are succinctly outlined in (Knoop, 2010), along with their causes and detrimental effects on social and economic scales. In the beginning of the twenty-first century, there was an initial outbreak of the severe Global Financial Crisis in 2007 (Loukis et al., 2021; OECD, 2009a). Subsequently, the COVID-19 pandemic emerged, sparking an additional economic crisis (Baldwin & di Mauro, 2020). Most recently, the Ukraine conflict has led to substantial price increases for commodities including oil, gas, wheat, and others, which has led to another economic crisis. We generally observe that economic crises have become more frequent in this century and tend to propagate to wider geographic areas due to the internationalization of the economy, so periods of "normal" economic activity tend to become shorter, while periods of recessionary economic crisis tend to increase.

The society and the economy are profoundly impacted negatively by these economic crises (Dagoumas & Kitsios, 2014; Das, 2022; Keeley & Love, 2010; OECD, 2009a; Oliveras et al., 2021; Stylidis & Terzidou, 2014). As a consequence of economic crises, which are characterized by a decline in aggregate economic activity and incomes, the majority of firms encounter significant hindrances to their economic standing. These include a reduction in sales, which subsequently affects revenue and liquidity; an escalation in debts; a decrease in investments and personnel employment; and in certain cases, an inability to sustain operations and insolvency. Nevertheless, there is considerable variation in the adverse effects of economic crises among firms (Allen, 2016; Arvanitis & Loukis, 2023; Knoop, 2010; OECD, 2009a); certain firms demonstrate greater capacity to manage such crises and, consequently, are more susceptible/vulnerable to them; conversely, others lack the capability to do so effectively and are thus more susceptible/vulnerable.

These economic crises pose challenges to the governments, such as public disturbance, political instability, poverty and famine, and the governments struggle to minimize all these challenges and their destructive effects on the economy and the society. In order to achieve this objective, governments implement extensive interventions, including massive economic stimulus programs that provide firms with financial aid, tax rebates, subsidies, investment financial support, minor interest rate (or even interest less) loans, and so forth (Coenen et al., 2012; Kalinowski, 2015; Khatiwada, 2009; Taylor, 2018). For optimal efficiency and effectiveness of these interventions, particularly the extensive economic stimulus programs, it is important that they are accurately aimed and prioritized towards the most susceptible/vulnerable firms to the economic crisis.

In order to effectively allocate government support during an economic crisis, it is beneficial on one hand to understand the existing typologies of firms with respect to the impacts of economic crisis they experience, and on the other hand to be able to anticipate the multi-dimensional vulnerability to crisis of individual firms. The latter involves predicting their susceptibility/vulnerability to a recessionary economic crisis across various key aspects of their financial situation. By doing so, the government can concentrate its interventions, particularly the large-scale economic stimulus programs, on the firms that are most in need of this support: those that are most vulnerable to economic crises. The capacity to predict the susceptibility/ vulnerability of various firms to economic crises across multiple dimensions is additionally exceedingly beneficial for investment firms and institutions as well. This enables them to invest in and extend loans and other benefits to firms that will be more susceptible/vulnerable to subsequent crises, so that they endure and rebound once the crisis subsides. Further, this type of prediction will be beneficial for banks and investment firms (aiding them to avoid granting loans and investing in firms that might be quite vulnerable to future economic crises); and also to firms of all industries that rely heavily on extensive supply chains: it will aid them in selecting supply chain partners (including subcontractors, suppliers, wholesale and retail merchants, and others) that will exhibit a lower susceptibility/vulnerability to forthcoming economic downturns (supply chain partners that are more susceptible/vulnerable to such crises will consequently increase the vulnerability of a firm).

In this direction we propose a methodology for leveraging to the highest possible extent data that government agencies possess concerning firms' behaviour during recessionary economic crises, as well as firms' vulnerability to them; which is based on Artificial Intelligence (AI), and includes two main components: a) initially use of unsupervised artificial intelligence techniques (clustering) in order to identify, using the abovementioned government data, the main typologies of firms with respect to the impacts that economic crisis have on them; and b) a second component that includes use of supervised learning techniques (classification) in order to predict, based on the above data, the susceptibility/vulnerability of individual firms to future economic crises. This second component enables the prediction of the multi-dimensional "impact pattern" of a firm, which includes predicted

impacts of economic crisis on several important aspects of the firm. For this purpose, using the above data a series of prediction models of various aspects of the vulnerability of an individual firm to economic crisis are constructed; as independent variables are used the characteristics of the firm, such as personnel, ICT infrastructure, innovation activities, exports, strategic standings, and economic performances as compared to competitors. To validate the proposed methodology a first application of it has been made, using open government data provided by the "Greek Statistical Authority" upon request, comprising of 363 firms' information that was collected during the Greek economic decline and crises from 2009 to 2014. The results of this validation/application were deemed satisfactory.

The rest of this research paper is structured as follows: the second section provides an overview of the background containing notions of economic crisis, open government data and AI utilization in government. Section 3 describes the proposed methodology, and then section 4 contains the validation application of the proposed methodology and the results; finally, the 5th section summarizes the conclusions.

2. Background

2.1 Economic crises

Many countries experience diverse economic crises over time, and considering the global economic landscape, all nations are vulnerable to encountering an economic crisis at some juncture in their history; in the present century we had several significant economic crises, as due to the internationalization of the economy crises appearing in one country can rapidly propagate to other countries (Allen, 2016; Baldwin & di Mauro, 2020; Keeley & Love, 2010; Knoop, 2010; Kottika et al., 2020; Loukis et al., 2021; OECD, 2009a; Saifi & Horowitz, 2023). Economic crises lead to recessions, which are significant downturns in economic activity, and can be triggered by various factors, such as: a) unstable and inconsistent long-term macroeconomic policies; b) emergence of unsustainable budgetary imbalance; c) significant inflationary pressures resulting in substantial price hikes for essential commodities such as oil and gas; d) misalignment of currency rates; e) retraction of foreign capital; f) crisis in the banking and financial institutions (Acemoglu et al., 2003). Firms are negatively affected by economic crises, as the latter result in economic recessions, leading to a decrease in the demand for most goods and services, as well as in their prices, decrease in liquidity provision by banks, etc.; so, firms react to the decrease of the demand for their products and services, and therefore of their sales revenue and liquidity, by reducing production and procurement, as well as personnel employment, with the latter leading to higher rates of unemployment, poverty, and social exclusion; furthermore, due to the reduced availability of financial resources, for the reasons mentioned above, resulting to an increase of their debts, and also higher difficulty to borrow from banks, firms decrease their capital expenditures for investments, including those in machinery, ICT, research and development, new products, etc. Possible negative consequences of this in the medium- to long-term include falling behind the technological trend, missing out on key growth opportunities, and slowing the rate of competitiveness progress. (Allen, 2016; Baldwin & di Mauro, 2020; Keeley & Love, 2010; Knoop, 2010; Kottika et al., 2020; Loukis et al., 2021; OECD, 2009a; Saifi & Horowitz, 2023).

Nevertheless, the adverse effects of economic crises vary considerably among firms (Allen, 2016; Arvanitis & Loukis, 2023; Knoop, 2010; OECD, 2009a). Certain firms have personnel with advanced educational backgrounds, with extensive expertise and experience, as well as more efficient production equipment and processes, and better digital infrastructures, so they can offer more attractive products/services of higher value-for money during the crisis, and in general adapt better to the tough crisis conditions, so they finally exhibit lower vulnerability to the crisis than other firms that are more vulnerable.

The frequent occurrence of economic crises, particularly in recent times, poses a significant and pressing challenge for governments. On one hand, they must strive to prevent these crises from happening, and on the other hand, they must take measures to mitigate their severity and the adverse outcomes they bring, such as widespread business closures, a sharp rise in unemployment, poverty, and social exclusion. These consequences can potentially lead to social unrest and political extremism. In regard to the latter, governments devise and execute enormous and expensive interventions, such as the expansive economic stimulus programs, which consume enormous quantities of financial resources (and can lead to substantial increases in public debt); they comprise (among others) a variety of financial support actions for firms, including rebates on taxes, monetary assistance, subsidies (aid), investment financial support, low-interest (or even no-interest) financing, and financial support for investments (Coenen et al., 2012; Kalinowski, 2015; Khatiwada, 2009; Taylor, 2018).

Significant governmental interventions, particularly expansive boost to the economy (stimulus) programs, are more economically viable when they are focused on the most susceptible/vulnerable businesses to the economic crisis rather than being "horizontal" (i.e., providing assistance to all firms), which can waste enormous financial resources. As stated in the Introduction, it would be extremely helpful if it was possible: a) to understand the main typologies of firms with respect to the impacts of economic crises on them; b) to predict the susceptibility/vulnerability of individual firms to future economic crises in light of their financial circumstances.

Especially with respect to the latter, it would be exceedingly practical to forecast the comprehensive "pattern" of a specific firm's susceptibility/vulnerability to economic crises. For these purposes pre-existing government data from economic crisis periods, processed through sophisticated AI, might be quite useful. In this direction our paper makes a contribution.

In the past, there has been some research that employs AI-based techniques in order to provide an early prediction and warning for economic crises. For instance (Wang & Zong, 2023), use AI/ML and currency data in order to assist private sector firms in China in early detection of crises. In (Samitas et al., 2020) is developed a method of using AI/ML and net-work analysis for creating an early-warning system for predicting financial crises, focusing on contagion risks. The benefits of using ML tools to assess the risk of fiscal crises are investigated in (Hellwig, 2021) , and a comparison is made with the standard econometric approaches that are usually employed for this purpose, concluding that the former outperform the latter. However, there is a lack of research concerning the use of AI for understanding and predicting the impacts of financial crises on firms, which constitute the primary actors of modern economies. The current investigation serves towards bridging this research gap.

2.2 Open Government Data

As mentioned in the Introduction government agencies possess large amounts of valuable data, usually developed through their operations of direct data collection from citizens and firms; for some of these data they decide to open them to the society, so that various actors (e.g. universities and research centres, firms, citizens communities, etc.) can process them, and extract additional useful insights from them as well as develop useful services; this has made a substantial contribution to the growth of the "data economy (Ali et al., 2022; Charalabidis et al., 2018; Gao et al., 2023; Van Loenen et al., 2021; Wirtz et al., 2022; Zuiderwijk et al., 2019). According to (Gao et al., 2023) “Open Government Data (OGD) refers to publishing public sector information in open and reusable formats, without restriction or monetary charge for use by society”. Most of these data are provided freely in government websites, but some sensitive data can be provided only upon request and subject to specific conditions. An increasing number of nations are formulating OGD policies and implementing targeted OGD initiatives with the following goals in mind: a) to promote economic activity that capitalizes on OGD (e.g., pioneering value-added e-services derived from the combination of diverse forms of OGD and potentially private data, and overall OG); and b) to advance social objectives (in-creased the government accountability and transparency, as well as citizen engagement and trust) (Official Journal of the European Union, 2019; Open, Useful and Re-Usable Data (OURdata) Index, 2020).

Despite the fact that these OGD initiatives have made available substantial quantities of public sector data, neither their use nor the social-political and economic value produced from them have met the initial expectations (Gao et al., 2023; Van Loenen et al., 2021; Zuiderwijk et al., 2019). This is quite negative given the large investments that have been made by governments for these OGD initiatives, as well as the loss of great opportunities that the utilization OGD could provide. As possible solutions of this problem have been proposed: a) on one hand the alignment of OGD supply with demand (i.e., the provision of the kinds of OGD that the public (citizens, firms, journalists, etc.) is really interested in), and the development of appropriate collaborations and ecosystems for the exploitation of OGD and the creation of significant societal and economical goals through these stakeholders (Van Loenen et al., 2021; Zuiderwijk et al., 2019); b) the more ‘intensive’ exploitation of the large quantities of public sector data that have been opened through the use of highly sophisticated processing techniques, such as AI techniques, in order to maximize the knowledge extraction and in general the value generation from them (Charalabidis et al., 2018; Gao et al., 2023). However limited is the research that has been conducted concerning the use of AI for increasing the generation of value from OGD. A good example of this research direction is the study described in (Tsagkis et al., 2023), which uses ML trained with OGD for the forecast of urban growth in order to improve city planning; in particular, an artificial neural network is constructed, which is used for five major Greek cities in order to make an urban growth prediction for each city for the following 12-years. Also, (Gao & Janssen, 2020) examines three instances of AI implementation for OGD, and concludes that it can lead to the generation of substantial innovation and efficiency related benefits. So, much more research is required concerning the more sophisticated and intensive utilization of the OGD using AI techniques for enhancing knowledge extraction and, in general, value generation from OGD; the current work provides a valuable addition to this particular area.

2.3 AI in Government

Over the course of the previous decade, AI has experienced significant growth in its implementation and exploitation beyond academic research centres; initially, private sector organizations and, more recently, government agencies have begun to utilize AI in their operations and decisions (European Commission. Joint Research Centre., 2022; Gomes de Sousa et al., 2019; Madan & Ashok, 2023; Medaglia et al., 2023; van Noordt & Misuraca, 2022; Zuiderwijk et al., 2021). The current automation in the government's processes and operations based on the utilization of traditional information systems methods can be extended and enhanced towards cognitive processes, through the exploitation of vast amounts of data available fed into AI algorithms, such as machine learning and deep learning ones.

Several highly beneficial applications of AI in government operations and decision making have been developed (European Commission. Joint Research Centre., 2022). For instance, the government in the fight against the tax evasion developed an automated ways to recognize citizens and businesses with a high risk of tax dodging. This application helps the governments to develop tax audits more precisely. Healthcare also utilizes AI to tackle several issues in the disease diagnosis-identification, prevention, as well as treatment of the patients. Healthcare also uses AI for clinical-related decision support systems and decision-making processes. In the social policy and crime prevention field, some of the AI uses, such as fraud identification, youth monitoring for prevention of any future risk and preventing any unwanted situation, identification of spatial crimes and patterns, face recognition from videos and images, and improving interaction with citizens through chatbots, are a few of the uses of AI, among others. In this direction the European Union initiative called "AI Watch" aims at recognizing the possible applications and goals of the AI utilization in the government's process, and disseminating them, aiming to increase the use of AI in governments (European Commission. Joint Research Centre., 2022). AI Watch highlights some specific uses of AI in the public sector; the first one is that the government uses it for the improvement in the public services provision by providing tailored and citizen-oriented services, information, and data; the second is that, governments use AI for improving the internal processes and administrative efficiencies by managing the available public resources as well as improving the quality of the process/service and reducing the overall cost of them. Moreover, there is high research interest in the AI's possible role in the government, which distinguished two possible roles:
a) Administration tasks automation through the utilization of AI, which can help in reducing the costs and increasing the efficiencies of these tasks.
b) Administration process enhancement through the use of AI augmentation, particularly duties related to top-level decision-making and policy devising, by providing AI with high-quality data to improve decision effectiveness and overall quality and performance.
There have been several studies discuss AI utilization and exploitation in the governments and their assessment methods (Gomes de Sousa et al., 2019; Madan & Ashok, 2023; Medaglia et al., 2023; van Noordt & Misuraca, 2022).

Nonetheless, it is widely acknowledged that the utilization of AI in government has only scratched the surface of its immense potential in automating, supporting, and enhancing various government functions. Furthermore, the majority of AI applications in government pertain to activities of low or medium administrative importance and financial significance (Gomes de Sousa et al., 2019), (Medaglia et al., 2023), and (van Noordt & Misuraca, 2022). As a result, substantial additional research is necessary to further exploit this enormous potential by developing new approaches and methodologies for utilizing AI in government, particularly in its most critical and expensive operations, with the aim of enhancing their efficacy and efficiency. This paper contributes in this direction towards increasing our knowledge about advanced utilization of AI in government in order to manage better one of the most important challenges it faces: the economic crises that frequently appear in this century in our economies and societies. In this direction we propose a methodology which combines the use of supervised machine learning (estimation of a prediction model of the value of a 'dependent variable' – outcome for a specific 'unit' (e.g. individual, firm, etc.) from the values of a number of 'independent variables' for the same unit, based on existing historic data for a number of units concerning both the value of the dependent variable and the values of the independent variables); with the use of unsupervised machine learning (use of existing historic data for a number of units concerning a number of variables, for the identification of possible clusters of 'similar' units, having similar values in these variables) (Russel and Norvig, 2020).

3. Proposed Methodology

The proposed methodology leverages existing data in government agencies about the behaviour of individual firms during economic crises and their vulnerability to them; these data include various aspects of impact of the economic crisis on these individual firms as main variables (e.g. impacts of various important economic aspects of the firms). Its structure is shown in Fig.1.

Initially it is important to use these data in order to understand the main typologies of firms with respect to the impact of economic crisis on them; if we find quite different typologies then we can design for each of them a different appropriate support policy and corresponding programs (mainly for the impact typologies that really require such support). For this purpose, we can use unsupervised learning techniques, such as clustering ones (e.g. k-means clustering) (Russel and Norvig, 2020), based on the above variables; the number of clusters can be identified through dendrogram or/and elbow techniques, and then in order to understand each cluster (typology) its centroid is calculated (=average values of all variables across all firms of the cluster).

Then we can proceed to the use of supervised learning techniques, such as classification ones (Russel and Norvig, 2020), based on the same data, in order to construct prediction models of the "vulnerability pattern" of an individual firm in the event of a future economic crisis. This pattern is represented as a vector, which has components the impacts of the crisis on various economic aspects of the firm (e.g. impacts on the decrease of domestic demand from other private sector firms and individual consumers, impact on the decrease of domestic demand from public sector, impact of the decrease of foreign demand, etc.):

$$IMP = [IMP_1, IMP_{2, \ldots\ldots,} IMP_N]$$

These N components can be measures in Likert scale with three or five levels of impact measurement (e.g. "not at all," "small impact", "moderate impact", "large impact" and "very large impact"); for each component a different prediction model is constructed using the available historic data.

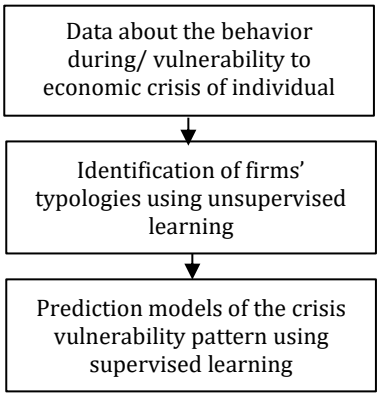


Fig.1. Structure of the proposed methodology

In particular, for each of the components of the "vulnerability pattern" IMPi we develop a predictive model that has this element as dependent variable. In order to define the independent variables of this model we have been based on theoretical foundations from economic and management science.

According to economic science, the main factors influencing a firm's output and overall performance are its labor force, which is made up of people with a variety of specializations and educational backgrounds, and its capital, which includes all types of equipment used for production and administrative tasks; the renowned production function of Cobb-Douglas is often used to quantify this connection (Douglas, 1976; Mahaboob et al., 2019; Pilat, 2004). Additionally, a variety of frameworks have been developed in the discipline of management science to outline the key elements of a firm that impact its performance. With five fundamental components—strategy, processes, people, technology, and organizational structure—the 'Leavitt's Diamond' framework is the most prominent among them (Leavitt, 1962; Scott Morton, 1991, p. 19). We can see that the 'people' and 'technology' components correspond broadly to the 'capital' and 'labour' ones of the Cobb-Douglas production function, so the other three 'strategy', 'processes' and 'structure' elements are additional (in comparison with the Cobb-Douglas production function). Therefore, the 'Leavitt's Diamond' framework is more comprehensive, so we have used it as basis and theoretical foundation for determining the independent variables of our prediction models, since it includes both the main production factors determined by the economic science and also the above three additional highly important management-oriented elements. It is reasonable to anticipate that these five pivotal components within the 'Leavitt's Diamond' framework will serve as primary determinants of a firm's performance in both typical economic conditions and during economic crises.

Therefore, each of these N prediction models (of IMPi, i=1…N) comprises five categories of independent variables:
a) Strategy: the first category of the independent variables comes from the strategy component of the 'Leavitt's Diamond' framework, and includes elements related to firm's adoption of key competitive strategies listed in strategic management literature studies, such as cost leadership, innovation, differentiation, and focus.
b) Process: the second category of independent variables covers process-related features of a firm's operations, such as complexity and flexibilities in operations.
c) People: it includes independent variables concerning the workforce of the firm in terms of education levels, particulars skills, certifications, and related attributes etc.
d) Technology: it refers to the utilization of various technologies for firm's manufacturing and administrative functions.
e) Structure: it refers to the fundamental elements of the company's organizational structure, such as the use of "organic" work organization techniques like cooperation, etc.
Additionally, a sixth category of independent variables is necessary concerning basic information about the firm, including its size, industry, and performance in comparison to rivals. Figure 2 shows the structure of these prediction models (dependent and independent variables).

For constructing each of these prediction models we can use several alternative widely used AI/ML algorithms, such as the decision tree (DT), random forest (RF), logistic regression (LR) and support vector machines (SVM) ones (Russel and Norvig, 2020), and determine the top performing one; they will be trained using available OGD (that might be freely available, or due to the sensitivity of these data available on request and under specific conditions) about individual firm's behaviour during and vulnerability to economic crisis, as well as main characteristics of them (including the ones of the main categories a) to e) mentioned above), from Statistical

Authorities or other government agencies collecting such data.

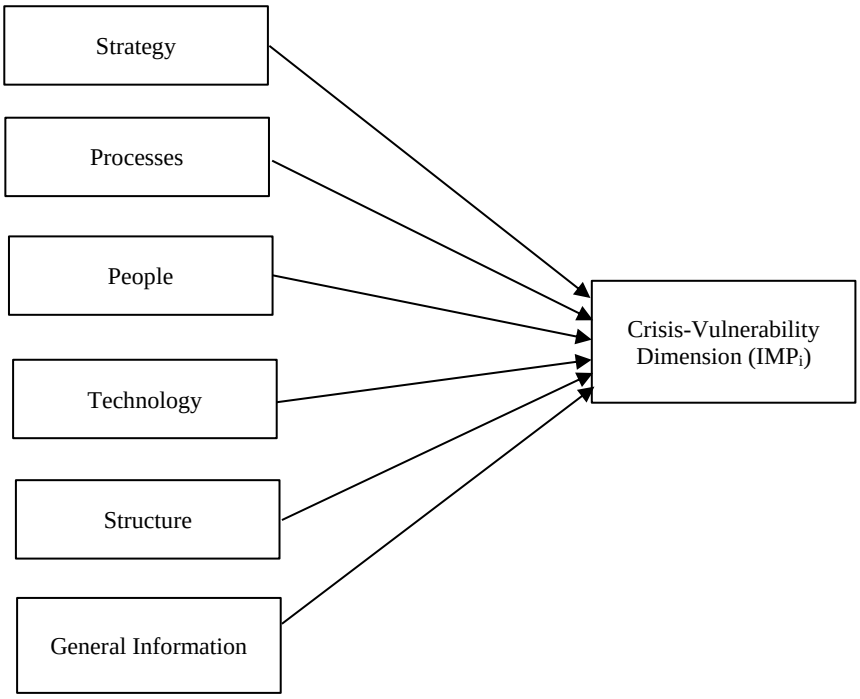


Fig. 2 - The structure for the prediction models of each of the elements of a firm's vulnerability pattern to economic crisis

Nonetheless, such datasets often exhibit several issues:
i) they tend to be noisy due to missing values;
ii) their size may not be sufficiently large to train robust and accurate machine learning models;
iii) and also, these datasets are frequently imbalanced, with some classes having a limited number of observations compared to others (this imbalance can lead to prediction models with reduced performance and potential bias).
In order to address problems ii) and ii), we include a preprocessing phase using the Synthetic Minority Over-sampling Technique (SMOTE) (Dudjak & Martinović, 2020). By filling in missing values, balancing the distribution of classes, and oversampling the dataset's existing samples, SMOTE allays these worries. This can improve the prediction model's performance and accounts for any possible bias.

Furthermore, our method starts with an exploratory data analysis (EDA) that incorporates data visualization to get a fundamental understanding of the dataset. This EDA step facilitates the necessary adjustments and informs the subsequent operations. Following the EDA, a Principal Component Analysis (PCA) is used to choose or exclude features according to their relative value (Mishra et al., 2017). This feature selection process reduces training time and enhances model performance.

4. Application

The proposed method was applied and validated using a OGD dataset obtained from the Greek Statistical Authority; it was provided to the authors upon request and with written authorization, in order to be used for research purposes, under a non-disclosure agreement. The dataset had 363 instances, each of which represented a distinct firm. It included a comprehensive list of traits and assessments for each firm, organized as follows:
- Vulnerability variables: Each firm's vulnerability to the economic crisis for the period 2009 to 2014, assessed through five variables: decrease of domestic demand from other private sector firms and individual consumers (IMP_DPRD), decrease of domestic demand from public sector (IMP_DPUD), decrease of foreign demand (IMP_DFOD), decrease of products/services prices (IMP_DPRI) and decrease of liquidity provision by banks (IMP_DLIQ). They were initially measured in a five levels Lickert scale ("not at all", "small", "moderate", "large" and "very large")
- Firm Characteristics: This part had forty variables that addressed various firm's characteristics: strategy, personnel, technology (especially digital technology), structure (including the use of "organic" forms of work organization, such collaboration), and general company information were some of these elements; this general information comprised the firm's size, as indicated by the number of employees, its industry (services or manufacturing), and a comparison of its financial performance over the last three years with that of its competitors.

All the processing of the above data described below was performed using Python language, specifically Python

3.11.7. For the machine learning tasks, we have used the open-source package within the Python environment — scikit-learn. This package contains the machine learning models and other data processing and splitting functions which are readily available to perform the supervised and unsupervised machine learning tasks, as we performed in our experimentation. Furthermore, scikit-learn supports parametric tuning; however, we used default parameters in all these experiments

The dataset's initial cause of noise was missing values; however, this was re-solved by replacing the missing values with the best values based on the variable type; for instance, the value with the highest relative frequency value was used to fill in the missing values for ordinal variables. The necessary visualizations and transformations were then used in an exploratory data analysis (EDA) to enhance data understanding. The size of the dataset—which, as previously said, included data for 363 firms—made it difficult to build a supervised ML prediction model of high prediction performance; so, as mentioned in the previous section 3, we used the oversampling and class-balancing method SMOTE to overcome this constraint.

After the above preprocessing we proceeded to the application of unsupervised learning to the above data; we conducted clustering, using the abovementioned five vulnerability variables (IMP_DPRD, IMP_DPUD, IMP_DFOD, IMP_DPRI, IMP_DLIQ), in order to examine if we can distinguish some distinct clusters – typologies of firms with respect to the above five kinds of impact of the economic crisis on them. Using both the dendrogram and the elbow techniques we identified the number of clusters; both techniques indicated the existence of three clusters. Then using this identified number of three clusters we performed k-means clustering. The results concerning the centroids of the three clusters are shown in Fig. 3 (we can see for each of the above five vulnerability variables (features) its average value over all firms of each class). We can distinguish one cluster (cluster 3 – it includes 78 firms) that experienced on average a negligible to small negative impact of the decrease of domestic public sector demand and foreign demand due to the crisis, and also a small to moderate negative impact of the decrease of domestic private sector and individual consumers' demand, as well as the decrease of products/services prices caused by the crisis; furthermore they experienced a small negative impact of the decrease of liquidity provision by banks during the crisis. We can characterize this cluster as 'low crisis-vulnerability firms' (the average value over all five vulnerability variables equals to 1,87). Also, we can distinguish another cluster (cluster 1 – it includes 118 firms) that experienced on average a moderate to large negative impact of the decrease of domestic private sector demand and the products/services prices caused by the crisis, a small to moderate negative impact of the decrease of the foreign demand, and a small negative impact of the decrease of domestic public sector demand; furthermore, they experienced a large negative impact of the decrease of liquidity provision by banks during the crisis. We can characterize this cluster as 'moderate crisis-vulnerability firms' (the average value over all five vulnerability variables equals to 2,9). Finally, we can distinguish another cluster experiencing even higher negative impacts (cluster 2 – it includes 167 firms): a high negative impact of the decrease of the domestic private sector and individual consumers' demand, as well as the domestic public sector demand, caused by the crisis; also a moderate to large negative impact of the decrease of products/services prices and the decrease of liquidity provision by banks during the crisis; and finally a small to moderate impact of the decrease of foreign demand. We can characterize this cluster as 'moderate to large crisis-vulnerability firms' (the average value over all five vulnerability variables equals to 3,45). The above clustering results indicate the existence of a large heterogeneity among the firms regarding the effects of the crisis, which necessitates the design and implementation of different policies and programs for each cluster-typology of crisis negative impacts, especially for clusters 1 and 2 (placing emphasis on supporting them to cope with the decrease of liquidity provision by banks during the crisis).

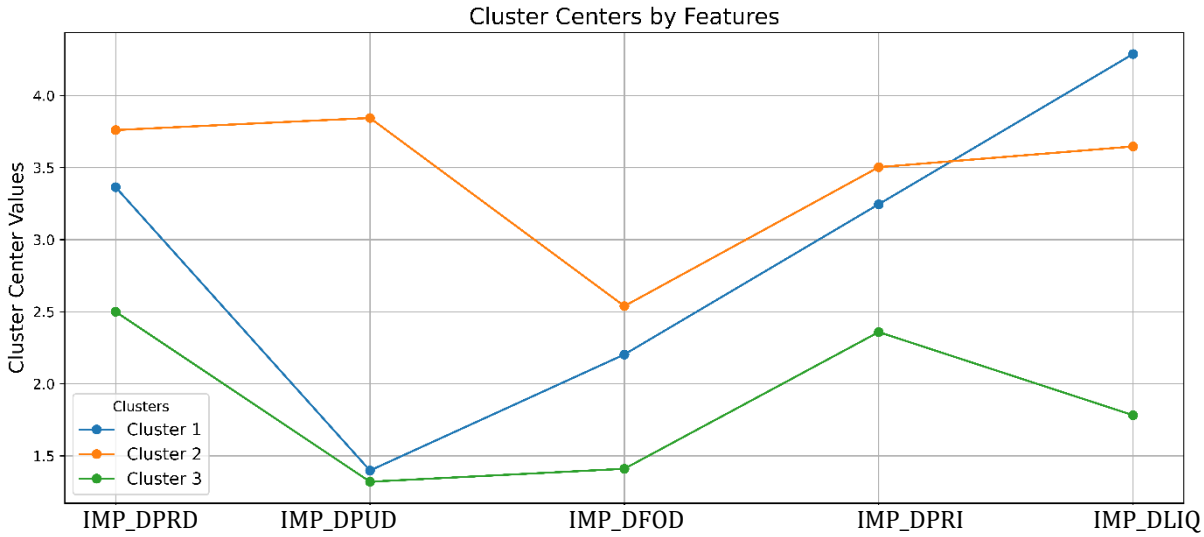


Fig.3. The centroids of the three clusters

Then we proceeded to the application of supervised machine learning to the above data: we used AI/ML algorithms in order to predict the 'vulnerability pattern' of an individual firm: we constructed for each of the five vulnerability variables one prediction models, having as independent variables the forty firm's characteristics mentioned in the beginning of this section (concerning firm's strategy, personnel, use of digital technologies, structure and general firm information). Due to the small size of our dataset (data for 363 firms) we focused on a less-detailed prediction of these five vulnerability variables, and for this purpose they were converted into binary form, with the first three values (not at all, small, moderate) being marked as "non-vulnerable" and the other two (large, very large) as "vulnerable". The dataset was divided into two subsets: a training dataset containing 70% of the samples and a testing dataset containing the remaining 30% of the samples; then another division of the dataset was made: a training dataset with 80% of the samples, and a test dataset with the remaining 20%. For both cases we used the training sets in order to construct AI/ML models, making use of four widely used algorithms: Decision Tree (DT), Random Forest (RF), Logistic Regression (LR) and Support Vector Machines (SVM). In each case the corresponding test set was used in order to evaluate the prediction performance of each of these AI/ML models. The results, including prediction accuracy, precision, recall, and F-score, are presented in Table 1, with bold highlights indicating the best-performing algorithm for each of the five crisis vulnerability variables. We have repeated the same for the prediction of firm's cluster membership (i.e. whether it will belong to cluster 1, 2 or 3 = whether in a future crisis it is going to exhibit low, moderate or moderate to large crisis-vulnerability) using the same firm's characteristics as independent variables.

Tab. 1 – Evaluation of Prediction Performance of the AI/ML models for each of the five crisis vulnerability variables

Variable.e.	Algorithm	Split Ratio							
		Performance with 70-30 (weighted average precision, recall, and F-score)				Performance with 80-20 (weighted average precision, recall, and F-score)			
		accuracy	precision	recall	F-score	accuracy	precision	recall	F-score
IMP_DPRD	DT	0.8165	0.83	0.82	0.82	0.7982	0.82	0.80	0.80
	RF	**0.9266**	**0.93**	**0.93**	**0.93**	**0.9083**	**0.91**	**0.91**	**0.91**
	LR	0.7431	0.74	0.74	0.74	0.7431	0.74	0.74	0.74
	SVC	0.8899	0.89	0.89	0.89	0.8899	0.89	0.89	0.89
IMP_DPUD	DT	0.7591	0.76	0.76	0.76	0.7810	0.78	0.78	0.78
	RF	**0.8686**	**0.89**	**0.87**	**0.86**	**0.8905**	**0.90**	**0.89**	**0.89**
	LR	0.6861	0.69	0.69	0.66	0.6861	0.69	0.69	0.66
	SVC	0.7810	0.80	0.78	0.77	0.7810	0.80	0.78	0.77
IMP_DFOD	DT	0.8050	0.80	0.81	0.80	0.7610	0.76	0.76	0.76
	RF	**0.8616**	**0.88**	**0.86**	**0.86**	**0.8742**	**0.89**	**0.87**	**0.87**
	LR	0.6792	0.68	0.68	0.68	0.6792	0.68	0.68	0.68
	SVC	0.7358	0.73	0.74	0.73	0.7358	0.73	0.74	0.73
IMP_DPRI	DT	0.8235	0.85	0.82	0.83	0.8039	0.83	0.80	0.81
	RF	**0.9216**	**0.93**	**0.92**	**0.92**	**0.9608**	**0.96**	**0.96**	**0.96**
	LR	0.7941	0.80	0.79	0.79	0.7941	0.80	0.79	0.79
	SVC	0.9020	0.91	0.90	0.90	0.9020	0.91	0.90	0.90
IMP_DLIQ	DT	0.7698	0.78	0.77	0.77	0.7770	0.78	0.78	0.78
	RF	**0.9065**	**0.91**	**0.91**	**0.90**	**0.9137**	**0.92**	**0.92**	**0.92**
	LR	0.7338	0.73	0.73	0.73	0.7338	0.73	0.73	0.73
	SVC	0.7626	0.78	0.76	0.75	0.7626	0.78	0.76	0.75
Cluster	DT	0.6500	0.66	0.65	0.65	0.6400	0.65	0.64	0.63
	RF	**0.7600**	**0.76**	**0.76**	**0.75**	**0.7400**	**0.74**	**0.74**	**0.73**
	LR	0.5500	0.54	0.55	0.55	0.5500	0.54	0.55	0.54
	SVC	0.6900	0.70	0.69	0.69	0.6900	0.70	0.69	0.69

We can see that for all the crisis vulnerability variables the highest prediction performance is achieved through the Random Forest (RF) algorithm; these prediction performances are high (especially if we take into account the small

size of the available dataset), ranging (for the 70-30 training-test set case) from an accuracy of 0.9266 for IMP_DPRD and 0.9216 for IMP_DLIQ, to 0.8616 for IMP_DFOD. For the cluster membership again the RF algorithm achieves the highest prediction performance, which is however lower, with an accuracy equal to 0.76 (which was expected as now the prediction provided by this model is more detailed than in the previous ones: it has to predict one out of three possible values, while the previous models had to predict one out of two possible values); nevertheless it is satisfactory, taking into account the small size of the available dataset.

5. Conclusion

In the preceding sections of this paper, we have developed a methodology for sophisticated advanced leveraging of data that government agencies possess concerning firms' behaviour during and vulnerability to recessionary economic crises, using a combination of AI techniques, both unsupervised and supervised ones, the latter in conjunction with the Synthetic Minority Oversampling Technique (SMOTE) to optimize their performance. The primary goal of the proposed methodology is to provide valuable support and enhance the crucial and resource-intensive types of interventions undertaken by governments during economic crises, in order to mitigate their adverse consequences on firms (including large-scale economic stimulus programs). It quite important to bolster the effectiveness of such interventions and focus them on the most susceptible businesses affected severely by the economic crisis, thereby reducing the detrimental impact of economic crises.

From the two main roles that AI can play in government discussed in Section 2.3, namely automation and augmentation, our methodology aligns with the latter. Its primary objective is to augment and enhance the decision-making processes of competent government agencies when it comes to identifying firms to be supported through extensive and costly programs and interventions implemented during economic crises. This is particularly crucial in the context of large-scale economic stimulus programs. By offering an additional input, specifically the typologies of firms with respect to their behaviour in/vulnerability to economic crises, and the prediction of the vulnerability pattern of individual firms to economic crises, our methodology proves highly valuable for facilitating the critical decisions involved in designing and implementing policies and programs for mitigating the consequences of economic crises for firms, as well as in selecting firms to support, especially when numerous firms submit applications for such assistance.

The proposed methodology is useful not only to government agencies, but also to banks and investment firms as well, as it strengthens and improves their decision-making procedures when it comes to identifying firms eligible for loans or investments; our methodology enables them to identify firms that will be particularly vulnerable to future economic crises (which have become frequent in this century), which makes granting loans to or investing in them highly risky (this predicted vulnerability to future crises can be one of the criteria they use for selecting firms eligible for loans or investments). Our methodology also extends its utility to firms across various sectors that heavily rely on extensive supply chains: it improves and supplements the process of choosing supply chain partners, by enabling them to take into account their predicted vulnerability to future crises and avoid supply chain partners (e.g. suppliers, wholesalers, etc.) exhibiting high risk of vulnerability to future economic crises.

Furthermore, OGD provided on request from the Greek Statistical Authority, which includes data from 363 firms for the turbulent 2009–2014 period of the severe Greek economic crisis, has been used for a first application and validation of the suggested methodology, which gave satisfactory results.

The research presented in this paper carries substantial implications for both research and practice. In the realm of research, it offers significant contributions to two crucial research streams. Firstly, it enriches the ever-expanding research on the utilization of AI in government by introducing a novel approach that leverages AI/ML to bolster a vital government activity of high economic, social, and financial significance: government intervention for mitigating the impacts of crises on firms. Secondly, it extends the OGD research by presenting a methodology that enhances the economic and social value derived from OGD through advanced processing of them through AI-based processing techniques (unsupervised and supervised ML). In the context of practical applications, this research equips government agencies, and also banks, investment firms, and businesses across various sectors heavily reliant on extensive supply chains, with a valuable tool for augmenting and enhancing highly important decision-making.

Nonetheless, further research is warranted in several critical directions. Firstly, there is a need for expanded application of the proposed methodology, encompassing larger datasets from diverse national and sectoral contexts that have encountered varying types and intensities of economic crises. This will enhance the methodology's robustness and applicability. Secondly, exploration of alternative pre-processing algorithms, such as over-sampling and class-balancing algorithms, missing data treatment techniques, as well as more advanced AI/ML algorithms, including deep learning ones, is essential to broaden the methodology's capabilities. Lastly, investigating the integration of OGD with data from other sources, such as data from other government agencies and private firms, including private business information databases, is vital to enrich the information available about firms. This expanded data could potentially enhance the prediction performance of a firm's vulnerability

pattern to economic crises, as well as provide deeper insights concerning heterogeneities among firms with respect to their behaviour in/vulnerability to economic crises.

Acknowledgement

- **Funding or Grant** (if applicable)**:** The research presented in this paper has been conducted as part of a project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955569. The opinions expressed in this document reflect only the author's view and in no way reflect the European Commission's opinions. The European Commission is not responsible for any use that may be made of the information it contains.
- **Data/Software Access Statement** (if applicable): The data we have used for the application described in section 4 have been provided by the Greek Statistical Authority upon request and under a non-disclosure agreement.
- **Contributor Statement**: The first author has been involved mainly in sections 1,2 and 3, the second has been involved mainly in sections 3 and 4, while the thid author has been involved mainly in the section 1, ans in general in developing the main research objectives and directions of the paper, as well as in the conclusions presented in section 5.
- **Use of AI***: No AI tool has been used the preparation of this work.
- **Conflict Of Interest (COI)**: There is no conflict of interest

References

Acemoglu, D., Johnson, S., Robinson, J., & Thaicharoen, Y. (2003). Institutional causes, macroeconomic symptoms: Volatility, crises and growth. *Journal of Monetary Economics*, *50*(1), 49–123. https://doi.org/10.1016/S0304-3932(02)00208-8

Ali, M., Alexopoulos, C., & Charalabidis, Y. (2022). A Comprehensive Review of Open Data Platforms, Prevalent Technologies, and Functionalities. *Proceedings of the 15th International Conference on Theory and Practice of Electronic Governance*, 203–214. https://doi.org/10.1145/3560107.3560142

Allen, R. E. (2016). *Financial Crises and Recession in the Global Economy, Fourth Edition*.

Arvanitis, Sp., & Loukis, E. (2023). Factors Explaining ICT Investment Behavior of Firms During the 2008 Economic Crisis. *Information Systems Management*, 1–22. https://doi.org/10.1080/10580530.2023.2213839

Baldwin, R., & di Mauro, B. W. (2020). *Mitigating the COVID Economic Crisis: Act Fast and Do Whatever It Takes* (1ª edition).

Charalabidis, Y., Alexopoulos, C., Lampoltshammer, T., Zuiderwijk, A., Janssen, M., & Ferro, E. (2018). The world of open data: Concepts, methods, tools and experiences. *Public Administration and Information Technology*, *28*, 1–194. https://doi.org/10.1007/978-3-319-90850-2_1

Coenen, G., Straub, R., & Trabandt, M. (2012). Gauging the effects of fiscal stimulus packages in the Euro area. *European Central Bank*.

Dagoumas, A., & Kitsios, F. (2014). Assessing the impact of the economic crisis on energy poverty in Greece. *Sustainable Cities and Society*, *13*, 267–278. https://doi.org/10.1016/j.scs.2014.02.004

Das, M. (2022). Economic crisis in Sri Lanka causing cancer drug shortage. *The Lancet Oncology*, *23*(6), 710. https://doi.org/10.1016/S1470-2045(22)00254-6

Douglas, P. H. (1976). The Cobb-Douglas Production Function Once Again: Its History, Its Testing, and Some New Empirical Values. *Journal of Political Economy*, *84*, 903–915.

Dudjak, M., & Martinović, G. (2020). In-Depth Performance Analysis of SMOTE-Based Oversampling Algorithms in Binary Classification. *International Journal of Electrical and Computer Engineering Systems*, *11*(1), 13–23. https://doi.org/10.32985/ijeces.11.1.2

European Commission. Joint Research Centre. (2022). *AI Watch, road to the adoption of Artificial Intelligence by the public sector :a handbook for policymakers, public administrations and relevant stakeholders.* Publications Office. https://data.europa.eu/doi/10.2760/693531

Gao, Y., & Janssen, M. (2020). Generating value from government data using AI: an exploratory study. In G. V. Pereira, M.

Janssen, H. Lee, I. Lindgren, M. P. R. Bolívar, H. J. Scholl, & A. Zuiderwijk (Eds.), *Electronic Government: Proceedings of the 19th IFIP WG 8.5 International Conference, EGOV 2020* (Vol. 12219, pp. 319–331). Springer International Publishing. https://doi.org/10.1007/978-3-030-57599-1

Gao, Y., Janssen, M., & Zhang, C. (2023). Understanding the evolution of open government data research: Towards open data sustainability and smartness. *International Review of Administrative Sciences*, *89*(1), 59–75. https://doi.org/10.1177/00208523211009955

Gomes de Sousa, W., Pereira de Melo, E. R., De Souza Bermejo, P. H., Sousa Farias, R. A., & Oliveira Gomes, A. (2019). How and where is artificial intelligence in the public sector going? A literature review and research agenda. In *Government Information Quarterly* (Vol. 36, Issue 4, p. 101392 [1-14]). https://doi.org/10.1016/j.giq.2019.07.004

Hellwig, K.-P. (2021). *Predicting fiscal crises: A machine learning approach*. International Monetary Fund. https://doi.org/10.5089/9781513573588.001

Kalinowski, T. (2015). Crisis management and the diversity of capitalism: Fiscal stimulus packages and the East Asian (neo-)developmental state. *Economy and Society*, *44*(2), 244–270. https://doi.org/10.1080/03085147.2015.1013354

Keeley, B., & Love, P. (2010). *From Crisis to Recovery: The Causes, Course and Consequences of the Great Recession*. OECD Insights OECD Publishing. https://doi.org/10.1787/9789264077072-en

Khatiwada, S. (2009). Stimulus Packages to Counter Global Economic Crisis: A Review. *International Institute for Labour Studies Geneva, DISCUSSION PAPER SERIES, NO. 196*. http://gesd.free.fr/dp19609.pdf

Knoop, T. A. (2010). *Recessions and Depressions: Understanding Business Cycles* (2nd ed). Praeger.

Kottika, E., Özsomer, A., Rydén, P., Theodorakis, I. G., Kaminakis, K., Kottikas, K. G., & Stathakopoulos, V. (2020). We survived this! What managers could learn from SMEs who successfully navigated the Greek economic crisis. *Industrial Marketing Management*, *88*, 352–365. https://doi.org/10.1016/j.indmarman.2020.05.021

Leavitt, H. J. (1962). *Applied Organizational Change in Industry: Structural, Technological and Humanistic Approaches*. Carnegie Institute of Technology, Graduate School of Industrial Administration.

Loukis, E., Arvanitis, S., & Myrtidis, D. (2021). ICT-related Behavior of Greek Banks in the Economic Crisis. *Information Systems Management*, *38*(1), 79–91. https://doi.org/10.1080/10580530.2020.1775916

Madan, R., & Ashok, M. (2023). AI adoption and diffusion in public administration: A systematic literature review and future research agenda. In *Government Information Quarterly* (Vol. 40, Issue 1, p. Article no. 101774 [1-18]). https://doi.org/10.1016/j.giq.2022.101774

Mahaboob, B., Ajmath, K. A., Venkateswarlu, B., Narayana, C., & Praveen, J. P. (2019). *On Cobb-Douglas production function model*. 020040. https://doi.org/10.1063/1.5135215

Medaglia, R., Gil-Garcia, J. R., & Pardo, T. A. (2023). Artificial intelligence in government: Taking stock and moving forward. In *Social Science Computer Review* (Vol. 41, Issue 1, pp. 123–140). https://doi.org/10.1177/08944393211034087

Mishra, S., Sarkar, U., Taraphder, S., Datta, S., Swain, D., Saikhom, R., Panda, S., & Laishram, M. (2017). Principal Component Analysis. *International Journal of Livestock Research*, 1. https://doi.org/10.5455/ijlr.20170415115235

OECD. (2009a). *Responding to the Economic Crisis Fostering Industrial Restructuring and Re-newal.*

Official Journal of the European Union. (2019). *DIRECTIVE (EU) 2019/1024 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 on open data and the re-use of public sector information*. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L1024

Oliveras, L., Peralta, A., Palència, L., Gotsens, M., López, M. J., Artazcoz, L., Borrell, C., & Marí-Dell'Olmo, M. (2021). Energy poverty and health: Trends in the European Union before and during the economic crisis, 2007–2016. *Health & Place*, *67*, 102294. https://doi.org/10.1016/j.healthplace.2020.102294

Open, Useful and Re-usable data (OURdata) Index: 2019 (OECD Public Governance Policy Papers 01; OECD Public Governance Policy Papers, Vol. 01). (2020). https://doi.org/10.1787/45f6de2d-en

Pilat, D. (2004). The ICT Productivity Paradox: Insights from Micro Data. *OECD Economic Studies*, *1*.

Saifi, S., & Horowitz, J. (2023, February 2). *Blackouts and soaring prices: Pakistan's economy is on the brink*.

https://edition.cnn.com/2023/02/02/economy/pakistan-economy-crisis/index.html

Samitas, A., Kampouris, E., & Kenourgios, D. (2020). Machine learning as an early warning system to predict financial crisis. *International Review of Financial Analysis*, *71*, 101507. https://doi.org/10.1016/j.irfa.2020.101507

Scott Morton, M. S. (Ed.). (1991). *The Corporation of the 1990s: Information technology and organizational transformation*. Oxford University Press.

Stylidis, D., & Terzidou, M. (2014). Tourism and the economic crisis in Kavala, Greece. *Annals of Tourism Research*, *44*, 210–226. https://doi.org/10.1016/j.annals.2013.10.004

Taylor, J. B. (2018). *Fiscal Stimulus Programs During the Great Recession*. Hoover Institution. https://www.hoover.org/research/fiscal-stimulus-programs-during-great-recession-0

Tsagkis, P., Bakogiannis, E., & Nikitas, A. (2023). Analysing urban growth using machine learning and open data: An artificial neural network modelled case study of five Greek cities. *Sustainable Cities and Society*, *89*, 104337. https://doi.org/10.1016/j.scs.2022.104337

Van Loenen, B., Zuiderwijk, A., Vancau-Wenberghe, G., Lopez-Pellicer, F. J., Mulder, I., Alexopoulos, C., Magnussen, R., Saddiqa, M., Dulong De Rosnay, M., Crompvoets, J., Polini, A., Re, B., & Flores, C. C. (2021). Towards value-creating and sustainable open data ecosystems: A comparative case study and a research agenda. *eJournal of eDemocracy and Open Government*, *13*(2), 1–27. https://doi.org/10.29379/jedem.v13i2.644

van Noordt, C., & Misuraca, G. (2022). Artificial intelligence for the public sector: Results of landscaping the use of AI in government across the European Union. In *Government Information Quarterly* (Vol. 39, Issue 3, p. [1-13]). https://doi.org/10.1016/j.giq.2022.101714

Wang, P., & Zong, L. (2023). Does machine learning help private sectors to alarm crises? Evidence from China's currency market. *Physica A: Statistical Mechanics and Its Applications*, *611*, 128470. https://doi.org/10.1016/j.physa.2023.128470

Wirtz, B. W., Weyerer, J. C., Becker, M., & Müller, W. M. (2022). Open government data: A systematic literature review of empirical research. *Electronic Markets*, *32*(4), 2381–2404. https://doi.org/10.1007/s12525-022-00582-8

Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. In *Government Information Quarterly* (Vol. 38, Issue 3, p. [1-19] 101577). https://doi.org/10.1016/j.giq.2021.101577

Zuiderwijk, A., Shinde, R., & Janssen, M. (2019). Investigating the attainment of open government data objectives: Is there a mismatch between objectives and results? In *International Review of Administrative Sciences* (Vol. 85, Issue 4, pp. 645–672). https://doi.org/10.1177/0020852317739115

Applying Active Learning in Named Entity Recognition Corpora Expansion in Legal Domain

Rafael P. Gouveia[a*], André C.P.L.F. de Carvalho[b], Ellen Souza[c], Hidelberg O. Albuquerque[d], Douglas Vitório[e], Nádia F. F. da Silva[f]

[a] Institute of Mathematics and Computer Sciences, University of São Paulo, São Paulo, Brazil, rafael.p.gouveia2@usp.br, https://orcid.org/0000-0002-4684-8037

[b]Institute of Mathematics and Computer Sciences, University of São Paulo, São Paulo, Brazil, andre@icmc.usp.br, https://orcid.org/0000-0002-4765-6459

[c]MiningBR Research Group, Federal Rural University of Pernambuco, Recife, Brazil, ellen.ramos@ufrpe.br, https://orcid.org/0000-0002-7706-4809

[d]MiningBR Research Group, Federal Rural University of Pernambuco, Recife, Brazil, hidelberg.albuquerque@ufrpe.br, https://orcid.org/0000-0003-2277-8860

[e]Centro de Informática, Federal University of Pernambuco, Recife, Brazil, damsv@cin.ufpe.br, https://orcid.org/0000-0003-2285-574X

[f]Institute of Informatics, Federal University of Goiás, Goiás, Brazil, nadia.felix@ufg.br, https://orcid.org/0000-0002-3875-2211

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. This work investigates the application of Active Learning methodologies for data annotation in Named Entity Recognition (NER) tasks mainly when used in documents from the legal domain in Portuguese. Its aim is to determine an algorithm able to improve the efficiency of the annotation process and reduce the human cost involved, without compromising the quality of the classifiers trained in these corpora. Three sample selection methods were explored: (i) Multi-Criteria Active Learning, using informativeness, representativeness, and diversity as selection criteria, (ii) Dynamic Selection Guided by Entity Volume, and (iii) Random Sentence Selection (used as a baseline for evaluating the other two). The study was conducted using the BERT model for classification, employing different amounts of labeled data for each approach (annotation budgets). The results show that, although Multi-Criteria Active Learning performed better in some scenarios, Dynamic Selection Guided by Entity Volume consistently showed good performance, especially for low annotation budgets, in addition to being computationally more efficient. Thus, the analysis of the results suggests that the volume of named entities is a good predictor for selecting informative samples. This study contributes to the Active Learning field by applying these techniques to modern language models and providing efficient solutions for reducing costs in data annotation for Named Entity Recognition.

Keywords. Active Learning, Named Entity Recognition (NER), Selection Criteria, Information Retrieval, Natural Language Processing, Machine Learning.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.945

1. Introduction

The exponential growth of data generated daily poses a significant challenge for the efficient retrieval of information. The ever-growing magnitude of information collections has made subsequent querying increasingly

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

unfeasible for humans. This difficulty is particularly pronounced when the target of the query involves finding information not based on a formal label (such as a book title) but rather on some description of the desired information. One domain where this challenge is exacerbated is the legislative domain. The Brazilian Chamber of Deputies alone has analyzed over 144,000 projects, each generating documents detailing the process. Moreover, during the drafting of each project, it is necessary to consult related documents such as laws and bills, which are numerous and dispersed among a vast number of unstructured documents (Brandt, 2020).

To address this problem, investments have been made in developing tools that assist in the process of information retrieval from document collections using Natural Language Processing (NLP) techniques—a subfield of artificial intelligence aimed at solving problems related to the automatic understanding and generation of data in human natural languages (Albuquerque et al., 2022). One of the challenges in NLP is automating the process of Named Entity Recognition (NER), which involves detecting textual elements representing names of objects, concepts, etc., and potentially classifying them by entity type. The ability to perform this task automatically and reliably is highly desirable, as much of the subject matter in sentences can be identified solely by the named entities mentioned in the text. For this reason, NER is a widely used technique in various activities, including information retrieval. (Jehangir et al., 2023) However, there are no morphological elements that allow the creation of deterministic algorithms to reliably detect these entities (like the A* algorithm for determining optimal routes). This necessitates the application of sophisticated techniques to achieve the goal.

For this reason, the current state-of-the-art involves the use of Machine Learning techniques. Mitchell, 1998 defines Machine Learning by describing the concept of a "computer learning" as follows: "A computer program is said to learn from experience E with respect to some task T and performance measure P, if its performance on T, as measured by P, improves with E." Machine Learning algorithms are thus designed to improve over time without requiring humans to continuously provide explicit instructions for improvement, such as conditionals (which would require humans to have such information and enough time to account for all possible cases, which is often unreasonable). Machine Learning algorithms require experience (training) to improve their performance to an acceptable level, often surpassing deterministic algorithms or even human experts. The most commonly used machine learning paradigm for NER algorithms is supervised learning, where the algorithms are provided with a list of possible "inputs" along with the expected output for each input. After adapting the resolution algorithm (often achieved by updating the mathematical model used to represent the task at hand), the program should demonstrate improved performance (typically defined as "making fewer errors" when exposed to corresponding inputs). However, obtaining these input-output pairs (referred to as "labeled examples" or "annotated examples") is often a costly process, requiring various domain experts to ensure that the annotation is completed within an acceptable time frame and error rate. This process can be financially expensive or even unfeasible due to time and labor constraints. Such costs frequently become prohibitive, especially when considering that the state-of-the-art for various tasks, such as image processing and NLP, involves programs based on more sophisticated models. These models, while achieving higher performance, often require enormous labeled datasets. For example, during the training of the BERT (bi-directional encoding representations from transformers) model, which was once state-of-the-art for NER tasks, Devlin et al., 2018 used the CONLL-2003 dataset, which contains about 300,000 tokens.

Among the initiatives to address problems related to large-scale legislative domain data using NLP is the Ulysses project—a set of initiatives aimed at leveraging artificial intelligence to support legislative activities and improve the relationship between the Brazilian Chamber of Deputies and citizens. Various systems have been explored within the project, including systems that utilize NER models in their architecture to enhance information retrieval systems for use by the Legislative Consultancy of the Chamber of Deputies, as explored by Albuquerque et al., 2024. Therefore, achieving optimal performance for these systems requires highly performant NER models, which, as mentioned earlier, necessitate the availability of a large annotated domain-specific dataset. Although there are large relevant datasets, such as the recently introduced Ulysses Tesemõ by Siqueira et al., 2024 (an extensive corpus in the legal and governmental domain with over 3 million documents sourced from various origins), annotating corpora of this magnitude is unfeasible. Even if only a sample of it is annotated, the decision on which samples to annotate is often arbitrary and potentially inefficient for building a corpus that enhances the performance of classifiers trained with these samples (Albuquerque et al., 2022).

Solving this problem is the goal of the field of Active Learning (AL). The methodology employed by active learning involves generating a selection criterion based on a pre-trained model capable of automatically selecting the best inputs—that is, those whose respective outputs, if labeled and provided to a model, would

result in the greatest improvement in its performance, often using, in the NER domain, its uncertainty regarding the labels of the entities it classified. Ideally, this would produce the best possible model by providing the smallest number of labeled examples. This would reduce annotation effort (and, as a side effect, also reduce algorithm training times), making the use of Machine Learning algorithms via supervised learning more accessible (de Sá Vitório, 2020). This work aims to determine an effective active learning algorithm to be employed in the expansion of corpora in the legislative domain in Portuguese intended for training modern named entity recognition models, efficiently reducing the amount of data to be manually labeled for the creation of such models that have a vast array of applications in the streamlining of legislative-related government tasks. To achieve this goal, algorithms will be proposed and implemented that consider different sample selection criteria described in prior literature. These algorithms will be applied in the context of corpus expansion for NER in the legislative domain, with the aim of determining:

- The best algorithm for executing active learning aimed at corpus expansion for training named entity recognition models in the legislative domain;
- The effectiveness of using the proposed attributes for sample selection compared to the annotation of random samples (effectively the non-use of active learning);
- The best hyperparameters for the selected algorithm, given the proposed task.

2. Background and Related Work

In this chapter, a literature review is presented, highlighting previous approaches to reducing the annotation effort required for generating a dataset capable of creating an efficient NER classifier using active learning-based techniques. These serve as the foundation for the methodologies proposed and evaluated.

2.1. Less is More: Active Learning with Support Vector Machines

One of the pioneers in using active learning for text classification had it's main innovation being the use of a simpler metric for selecting annotation candidates: while previous studies employed complex statistical methods to determine the impact of including an example in the training corpus (often requiring retraining the model multiple times considering all annotation possibilities for each candidate), the author proposed that the informativeness of an example should be considered as simply inversely proportional to its margin relative to the hyperplane separating the classes in the current model, given that the model used was an SVM (Support Vector Machine) (Schohn & Cohn, 2000).

The proposed algorithm was tested on document classification tasks using the "20 Newsgroup" corpus, which contains various posts from different online discussion groups. The goal was to perform binary classification on data subsets drawn from any two of the twenty discussion groups. Additionally, the algorithm was tested on topic classification of documents using a dataset of news articles from the Reuters-21578 Distribution 1.0 corpus.

The results were promising, as the learning curves were consistently better for active learning than for the case in which training examples were randomly selected. In some cases, the model's performance with a small number of selected examples even surpassed the performance achieved when using the entire dataset. This suggests that, for certain models, a smaller set of meaningful examples may offer better generalization capability than simply using large random samples.

2.2. Multi-Criteria-based Active Learning for Named Entity Recognition

In the first work in the area of active learning for named entity recognition (NER), the authors aimed to propose an active learning approach based on three criteria and to apply it effectively to facilitate the training of NER models, with the goal of minimizing human annotation effort by selecting the most valuable examples for labeling (Shen et al., 2004).

To maximize the contribution of selected examples, the authors proposed, in addition to informativeness, to also consider representativeness and diversity. To incorporate these three selection criteria at the entity level, two algorithms were proposed. The first aims to ensure representativeness and diversity of the samples with

respect to the entire corpus through clustering techniques, based on a similarity metric between tokens. The second proposes a scoring system that weighs informativeness and representativeness using global metrics and then iteratively checks whether the diversity of the selected sample matches the established standard.

The algorithms were tested and compared against random selection and selection based solely on the most informative entities. These tests involved training several SVM models for NER using two corpora for comparison: GENIA (biomedical, containing protein-related names) and MUC-6 (news domain, containing names of people, places, and organizations). After initial training using only part of each corpus to create initial models to determine informativeness, the algorithms and number of selected entities were varied, and additional training and performance testing were conducted using the new examples.

The results were promising, showing that it is possible, using active learning, to select samples comprising only 20% of the corpus size and still achieve performance comparable to a classifier trained on the full dataset (F1-Score of 63.3, which is low by current standards). Moreover, it was concluded that the algorithm which checks for local diversity consistently outperformed the others, and that the active learning process more effectively reduced the required sample size for MUC-6. This suggests that the technique's performance may depend on the complexity of the target task.

However, this work did not explore the effect of varying the hyperparameters of the proposed algorithms. It is also noteworthy that the methods select at the entity level; therefore, in a real-world scenario, entities would be sent for annotation in isolation. Nonetheless, it is important to highlight that the lack of context can hinder the performance of human annotators.

2.3. Accelerating the Annotation of Sparse Named Entities by Dynamic Sentence Selection

In 2008, a paper presented an active learning-based technique that shares the same use case—reducing the number of manually labeled examples required through intelligent sample selection. To this end, it also utilizes feedback from a previously trained classifier for the target task (Tsuruoka et al., 2008).

However, the suggested method diverges from classical active learning by not using uncertainty-based selection criteria. Instead, it selects examples based on the number of named entities that the model predicts exist in the example. This technique is based on the premise that named entities are sparse in the domain where it is applied. Therefore, for better performance, examples containing the largest number of entities should be prioritized.

Thus, the method consists of iteratively selecting sentences with the highest number of predicted named entities and sending all these selected sentences for token-level annotation by a human annotator. The process is repeated until the estimated fraction of annotated named entities reaches a desired value.

Experiments were conducted using a CRF (Conditional Random Fields)-based probabilistic graphical model classifier and the NLPBA (biomedical, a variant of GENIA containing protein names) and CoNLL-2003 (general domain) corpora. It was found that a reduction of approximately 52.4% in annotated sentences was possible to annotate 99% of the named entities. However, the impact of the remaining 1% of unannotated entities, or the effect of these samples on classifier performance, was not explored.

2.4. Active Learning with Pre-trained Language Models for Named Entity Recognition in Requirements Engineering

In 2024, it was published an article about an experiment evaluating active learning techniques for NER using a BERT classifier (a modern model based on transformers, the technology behind state-of-the-art models for various NLP tasks). These techniques were based on informativeness criteria, all derived from the probability distribution provided by the model when predicting the label of a candidate token for manual annotation (Riesener et al., 2024).

The criteria used for sample selection were "least confidence" (token with the lowest probability for the class it was assigned), "margin sampling" (token with the largest difference between the two most probable classes), and "entropy-based sampling." Since the selection for annotation occurred at the sentence level, while the

scores were at the token level, a ”weakest link” policy was used, where a sentence’s informativeness was defined by the informativeness of its most informative token.

Experiments were conducted on NER tasks using datasets with aerospace domain documents from various sources, where the performance of the different techniques across various sentence budgets was compared to that of random sampling.

The results indicated that ”margin sampling” was the most effective technique and confirmed that results similar to those obtained with the full corpus could be achieved using only a fraction of the data (36% in the experiments), even for tasks involving deep learning models.

3. Research Methods

This study aims to evaluate the use of specific criteria (informativeness, representativeness, diversity, and entity volume) for sentence selection to support manual annotation through two active learning algorithms, with the goal of improving named entity recognition (NER) models. The basic workflow of the study is illustrated in Figure 1.

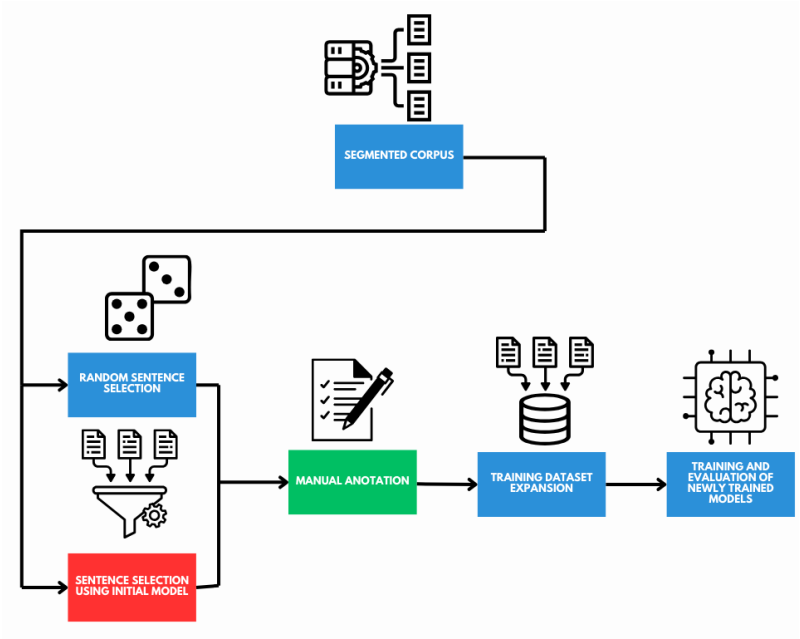


Fig. 1 – Research Flow Schematic

However, the selected dataset, UlyssesNER-Br, is pre-labeled. Thus, the study evaluates model improvement as it is progressively exposed to different samples of this corpus during training, using varying methodologies and sample sizes to define the training sets. The initial model, used to guide the selection criteria, is pretrained on a fixed sample, achieving low performance compared to the results obtained when trained on the entire corpus.

To achieve this, two algorithms (Multi-Criteria Active Learning and Dynamic Selection Guided by Entity Volume) will be implemented, as detailed in the following subsections. Using the initial model, all proposed algorithms will be executed multiple times, varying hyperparameters and sample sizes to generate diverse training datasets. After retraining the model by concatenating each selected sample with the initial one, the performances will be compared among the different approaches, against a baseline trained on randomly selected samples, and the potential performance gains will be assessed.

3.1. Corpus

The corpus used in these experiments, both for training the initial model used in the selection criteria and for providing sentences to be selected via active learning, is UlyssesNER-Br.

UlyssesNER-Br is a dataset developed for named entity recognition (NER) within the legal domain in Portuguese, as part of the Ulysses project, and is publicly available in an online repository. Entities in this dataset are annotated according to 18 entity types, organized into 7 categories, all of which are relevant for information retrieval efforts in legislative texts, as outlined in Table 1 (Albuquerque et al., 2022).

Tab. 1 – UlyssesNER-Br named entity types

Category	Type	Description	Example from corpus
DATA	DATA	Date	01 de janeiro de 2020
EVENTO	EVENTO	Event	Eleições de 2018
FUNDAMENTO	FUNDlei	Law	Lei no 8.666, de 21 de junho de 1993
	FUNDapelido	Law nickname	Estatuto da Pessoa com Deficiência
	FUNDprojetodelei	Bill	PEC 187/2016
	FUNDsolicitacaotrabalho	Legislative consultation	Solicitação de Trabalho nº 3543/2019
LOCAL	LOCALconcreto	Concrete place name	Niterói-RJ
	LOCALvirtual	Virtual place name	Jornal de Notícias
ORGANIZAÇÃO	ORGpartido	Political party	PSB
	ORGgovernamental	Governmental organization	Câmara dos Deputados
	ORGnãogovernamental	Nongovernmental organization	Conselho Reg. de Medicina (CRM)
PESSOA	PESSOAindividual	Person name	Jorge Sampaio
	PESSOAgrupoind	Group of people	Família Setúbal
	PESSOAcargo	Occupation	Deputado
	PESSOAgrupocargo	Group of people named by their occupation	Parlamentares
PRODUTO DE LEI	PRODUTOsistema	System	Sistema Único de Saúde (SUS)
	PRODUTOprograma	Program	Programa Minha Casa, Minha Vida
	PRODUTOoutros	Other law products	Fundo partidário

Initially, the dataset consisted of legislative bills retrieved from the Brazilian Chamber of Deputies' website and internal legislative consultation requests (these being the objects referenced by the entities "FUNDlei" and "FUNDprojetodelei," respectively). The dataset was subdivided into two corpora: the PL-corpus and the ST-corpus. However, the ST-corpus was deemed confidential and was not made publicly available; thus, it was excluded from this study.

Later, the corpus was expanded the dataset to include the "C-corpus", which comprises informal comments made by citizens on legislative bills, extracted from a web platform provided by the Chamber of Deputies. This expansion aimed to test the hypothesis that exposing the model to formal sentences from the other two corpora could enhance the predictive capacity of a model trained on a same-domain but informal corpus. This hypothesis was confirmed by the experiments published in the same article (Costa et al., 2022).

Finally, the issue of data leakage present in the PL-corpus was addressed and a higher-quality version of the corpus was provided (Nunes et al., 2024). This updated version was used in this study, along with an updated version of the C-corpus, containing more annotated documents (da Costa, 2023).

3.2. Classifier

The named entity recognition model used in this work was the HuggingFace implementation of the BERT architecture, specifically for token classification, called "AutoModelForTokenClassification" (Hugging Face, 2019). More specifically, the model employed was BERTikal, a checkpoint (pre-trained BERT model) created by training the "BERTimbau base cased model" on a corpus of Brazilian legal documents (Polo et al., 2021). BERTimbau, in turn, is a checkpoint developed by training a BERT model on the BrWaC corpus, short

for "Brazilian Web as Corpus," a large Portuguese-language dataset obtained via web scraping (Souza et al., 2020).

This model was repeatedly fine-tuned (training a classification layer using the BERT model embeddings generated for each token sequence as input) with the UlyssesNER-Br corpus so that it could recognize the named entities of interest. It was then employed in the active learning processes evaluated in this work, including both the selection of sentences for annotation and the evaluation of the quality of classifiers trained using such samples.

3.3. Multi-criteria Active Learning

The first three criteria to be explored are informativeness, representativeness, and diversity (the latter two obtained using similarity measures between tokens). These criteria are incorporated into a single algorithm, with the weight assigned to each controlled by hyperparameters.

This algorithm was adapted from previous ones to select not only entities for annotation but also textual elements containing them, with a granularity arbitrarily defined by the user of the active learning method (in this study, sentences are used) (Shen et al., 2004). Unlike the original work, where the metrics of each token in the entity are aggregated, this study considers the highest score among all tokens in a sentence as representative of the sentence's overall value. This approach aims to facilitate scalability for various granularities and avoid introducing arbitrariness into the metrics, similar to more recent methodologies (Riesener et al., 2024).

Informativeness is a criterion commonly used in classical active learning methods (Schohn & Cohn, 2000). An example is considered highly informative for training if the respective model exhibits high uncertainty in its classification. This information can be extracted directly from models that provide the probability distribution of possible classes for a given token. As such, informativeness is calculated as follows in the Equation 1:

$$\text{Informativeness}(u) = \text{Uncertainty}(u) = 1 - \mu\left(u, \left(\arg\max_{E} \mu(u, E)\right)\right) \tag{1}$$

Where μ is the token and $\mu(u, E)$ is the probability that the token μ belongs to class E. Since the token is classified into the class with the highest probability, the formula calculates the probability of the token belonging to any class other than the chosen one.

A min-max normalization is also applied to the scores to produce values more representative of the token's informativeness relative to others, as shown in the Equation 2:

$$\text{Informativeness}_{\text{normalized}}(u) = \frac{\text{Informativeness}(u) - \min}{\max - \min} \tag{2}$$

Where min and max are the smallest and largest informativeness values obtained in the corpus, respectively.

For the model used (BERT), the predicted probability distribution for each token's classes can be easily extracted. Hugging Face's implementation (Hugging Face, 2019), used in this study, provides logits (values from the final classification layer, one for each possible class, with the largest value indicating the predicted class). By applying the Softmax function, a corresponding probability distribution can be obtained.

To avoid annotating outliers—entities that, despite high informativeness, are very rare and thus provide little value for frequent model usage—representativeness is considered. An example is representative if it is, on average, highly similar to other tokens.

The similarity is calculated using the token representation provided by BERT (the final layer before the classification head), which incorporates semantic information. For a pair of tokens, similarity is calculated using cosine similarity as in Equation 3:

$$\text{Cosine Similarity}(A, B) = \frac{A \cdot B}{\|A\|\|B\|} \tag{3}$$

Where A and B are the two vectors (in this case, token embeddings) that will have their similarity evaluated, the numerator represents the dot product between them and the denominator represents the product of their respective euclidean lengths. Cosine similarity produces a value between -1 and 1, indicating the similarity between two vectors (Manning et al., 2008). The representativeness score is then defined as the average similarity of a token to all others in the corpus as in Equation 4:

$$\text{Representativeness}(u) = \frac{\sum_{v \in \text{dataset}} \text{sim}(u, v)}{|\text{dataset}|} \tag{4}$$

A min-max normalization is also applied to representativeness scores, similarly to informativeness.

To avoid annotating redundant entities—those that, despite being highly informative, are very similar to others already selected and thus do not add new information to the model—diversity is incorporated. An example is considered highly diverse when it has low similarity to other selected examples.

Diversity is ensured by discarding selected tokens that have a similarity above a certain threshold with any other selected tokens.

The algorithm itself involves calculating informativeness and representativeness scores for all tokens in the corpus, combining them using a weighting parameter λ (the weight assigned to representativeness) as shown in Equation 5:

$$\text{score}(u) = (1 - \lambda)\,\text{Informativeness}_{\text{normalized}}(u) + \lambda\,\text{Representativeness}_{\text{normalized}}(u) \tag{5}$$

Sentences (or other textual elements containing the token, depending on the chosen granularity) are then iteratively selected for annotation in descending order of their scores. Sentences are not repeated, and tokens are discarded if their similarity to any already selected token exceeds a threshold γ. The algorithm is illustrated in Figure 2.

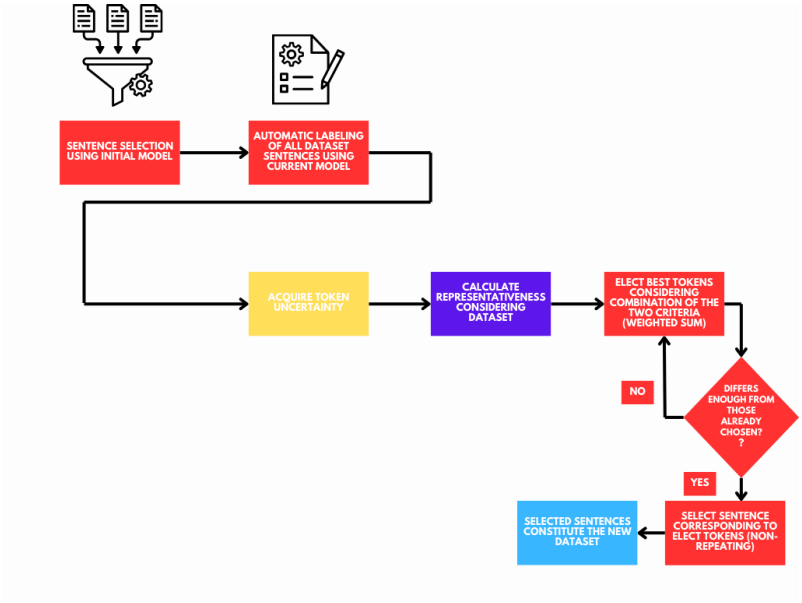


Fig. 2 – Multi-criteria Active Learning Pipeline Schematic

It's noteworthy that, by the definition given in Equation 4, the calculation of the informativeness value of a single token includes n cosine similarity calculations, in which n is the number of tokens in the dataset. This

makes the informativeness calculation complexity proportional to the size of the dataset as a whole, which is unique among all the criteria used in this study. Consequently, in order to calculate the representativeness of all n tokens in the dataset, in order to be able to start the process of selecting sentences, kn^2 cosine similarity operations are needed (where k is a constant to account for basic optimizations), leading to the representativeness calculation part of the algorithm being considered of quadratic time complexity with regards to the total number of tokens in the dataset of sentences to be forwarded to annotation. This could lead to poor scalability, because, as the pool of sentences one can choose for labeling grows (the use case of interest for active learning), the time taken to calculate representativity may become prohibitively large.

3.4. Dynamic Selection Guided by Entity Volume

The fourth criterion to be explored is solely the predicted quantity of named entities present in the analyzed sentence. This criterion is addressed using an algorithm adapted from Tsuruoka et al., 2008. This information can also be obtained directly from models that provide the probability distribution of possible classes for each processed token (such distribution is derived similarly to that used for informativeness calculation, as described earlier).

To calculate this, the expected value for each entity class is considered as fractional occurrences of the entity. The total number of entity occurrences across all tokens in the same sentence is then summed as in Equation 6:

$$\text{Entity Volume}(S) = \sum_{t \in S} (1 - \mu(t, O)) \tag{6}$$

Where S is the sentence, t is the token, and $\mu(t, E)$ is the probability of token t belonging to class E. The null class O corresponds to tokens that are not named entities.

Since all sentences are considered to have the same cost, the selection algorithm involves simply counting the number of entities using the method described above and selecting those sentences with the highest entity count.

The algorithm is illustrated in Figure 3.

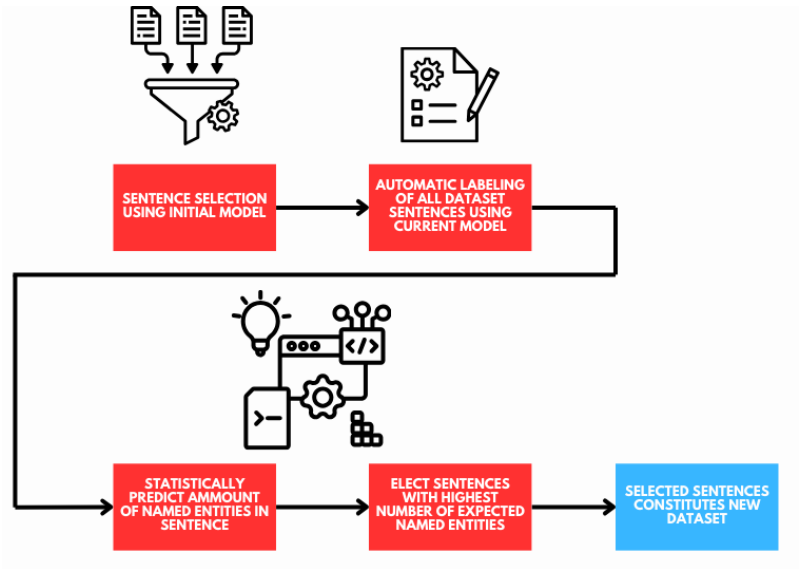


Fig. 3 – Dynamic Selection Guided by Entity Volume Pipeline Schematic

3.5. Experiment Structure

Initially, the classifier is trained to classify all 18 different types from UlyssesNER-Br except "FUNDsolicitacaotrabalho" (since no instance of it occurs in the specific corpora used). This initial process will be done using the C-corpus with an 80/20 train-validation split. Afterward, using the generated model, samples are

extracted from the PL-corpus for the three proposed methods: the two described in this chapter and random element selection. Specifically, for the Multi-Criteria Active Learning method, different variations are considered, adjusting the values of its hyperparameters λ and γ. The parameter λ (corresponding to the weight of the representativeness criterion) will be tested for values of 0 (no representativeness), 0.25, 0.5, and 0.75. λ (representing the diversity criterion) will be tested, due to computational and time constraints, only for the cases of 0 (no diversity) and one non-zero value determined through inspection during the experiment, based on the similarity values among tokens present in the dataset.

For each method or variation, four samples will be taken, consisting of 500, 1000, 1500, and 2000 elements for annotation. These elements correspond to the natural division of the dataset, typically segmented by sentences, which in this study are assumed to have equivalent annotation difficulty given the contextual requirements for entity annotation.

Afterward, several classifier training sessions will be conducted using all possible combinations between a generated sample and the C-corpus. Training follows a k-fold cross-validation approach, where the model is trained k times (in this case, 5 times), alternating the portion of the data used for testing, with the remaining portions used for training. This approach yields statistics on the classifier's average performance for the sample generated by each active learning algorithm, mitigating the effects of randomness during training (Scikit-learn, 2024).

The metrics used to compare the performance of the models trained during the experiments are the F1-score and the coefficient of variation. The F1-score is a widely used metric for evaluating classification models, especially in scenarios where class imbalance is present. It is defined as the harmonic mean of precision (the proportion of correctly predicted positive instances out of all predicted positives) and recall (also known as sensitivity, defined as the proportion of true positive instances identified out of all actual positives) (Scikit-learn, 2024).

The coefficient of variation, on the other hand, is the percentage that the variance represents relative to the mean value of the data. This metric is important because it allows us to favor the methods that consistently deliver good results, addressing the fact that focusing solely on average performance can obscure variability in outcomes.

Finally, to ensure greater robustness in the analysis of results, hypothesis tests are conducted using Welch's t-test. This test compares the location parameters (typically the means of normal distributions) of one or two samples. Unlike the more common Student's t-test, Welch's t-test does not assume that the samples have equal variances or sizes, making it more flexible and suitable for real-world data scenarios (Navarro, 2022).

4. Results and Discussion

4.1. Experimental Results

The experiments described earlier tested the three proposed algorithms (Multi-Criteria Active Learning with different weights for representativeness and with or without the diversity criterion, Entity Volume-Oriented Dynamic Selection, and random sentence selection). Samples were generated for training, and following the k-fold cross-validation methodology previously outlined, five fine-tuning processes of the BERT model were conducted, starting from the pre-trained BERTikal model introduced in the previous section. Figure 4, 5 and 6 shows the average F1-score metrics of each of the five models generated, corresponding to each training sample.

It should be noted that each trace represents a configuration of the active learning algorithm. Thus, they illustrate the model's performance evolution as larger training samples are allowed.

Visual analysis of the results reveals that, as expected, all algorithms provided an apparent improvement, albeit marginal, over random selection, except for the multi-criteria algorithm configuration that disregarded diversity and assigned the highest weight to representativeness. This result can be explained by the fact that this configuration favors the creation of a homogeneous sample, which therefore offers little new information to the model (justifying its inferior performance compared to random sampling, especially for larger data sample sizes).

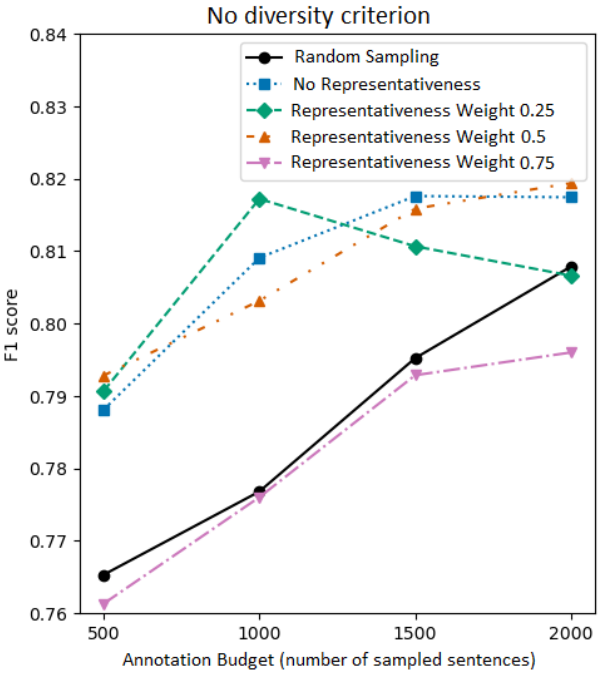


Fig. 4 – Graphs containing the performance of the multi-criteria method without diversity

Regarding the multi-criteria algorithm, although applying the diversity criterion seemingly corrected the issues mentioned above for cases with excessive weight given to representativeness—enabling the model to marginally outperform random sampling—it generally resulted in worse performance on average when diversity was considered. This difference was more pronounced for low-budget scenarios, diminishing as the budget increased. However, this reduction may be attributed to the exhaustion of options, leading the algorithms to select from the same examples (as the PL-Corpus contains only 2,527 data entries).

On the other hand, analyzing the entity volume-oriented algorithm reveals that it performed superiorly, achieving the best model with the smallest number of entries, with an average F1-score of approximately 0.795, about 0.03 higher than the average for random samples with the same budget. The other algorithms that performed better with low budgets only achieved an advantage of approximately 0.015 over random selection. Furthermore, despite the reduction in the advantage relative to random selection with increasing budgets, the difference consistently remained no less than 0.01.

Finally, the entity volume-oriented algorithm is considered superior not only due to its better performance with smaller budgets but also because of its greater simplicity and faster execution. It does not require computationally expensive steps, such as the representativeness calculations necessary for multi-criteria active learning, nor does it depend on optimizing hyperparameters specific to the corpus properties. Instead, it relies only on the assumption of named entities' sparsity being valid.

These results suggest that the predicted volume of named entities is a better predictor of good examples to include in the sample, although informativeness (alone) and representativeness (when properly weighted) can also serve as good predictors, despite the latter being computationally costly. Diversity, however, did not prove to be a good predictor. On the contrary, within the limited scope explored in this study, it was detrimental to the algorithm's performance.

However, it is important to note that this analysis is based on average performance across a series of experiments. Therefore, to confirm these results, hypothesis testing was conducted to exclude the influence of variance on the main outcomes of the analysis.

4.2. Hipotesis Testing

Four hypotheses were tested using Welch's t-test, as described in the Subsection 2.5 The hypotheses were formulated sequentially based on the results of previously tested hypotheses.

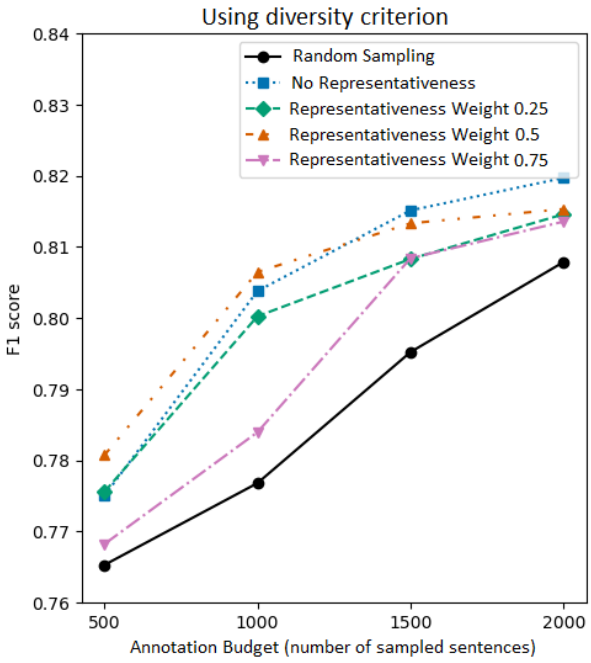


Fig. 5 – Graphs containing the performance of the multi-criteria method including diversity

The first hypothesis tested was whether any of the proposed methods resulted in an improvement compared to random sampling (used as the control in this experiment) in terms of F1-score for low budgets. Low budgets were prioritized in the evaluation since the primary goal of active learning is efficiency with small samples. Thus, the null hypothesis, which we wish to reject, consists of the proposed methods being worse or equivalent to random sampling, as explained below in Equation 7:

$$\begin{cases} H_0 : \mu_{\text{method}} <= \mu_{\text{random}} \\ H_a : \mu_{\text{method}} > \mu_{\text{random}} \end{cases} \tag{7}$$

After calculating the relevant values, Table 2 was generated:

Tab. 2 – Hypothesis Test 1 (Equation 7) - Whether, for a low budget, any method outperformed random sampling

Method	Average F1-Score	Standard Deviation	Var. Coef. %	t-statistic	P-value
Amostragem aleatória	0.765312	0.014761	1.928702	-	-
info.	0.788102	0.020510	2.602401	2.016675	**0.04102**
info. + repres. (0.25)	0.790656	0.017582	2.223775	2.468595	**0.01982**
info. + repres. (0.5)	0.792830	0.015609	1.968725	2.864208	**0.01054**
info. + repres. (0.75)	0.761319	0.010901	1.431814	-0.486585	0.67964
info. + diver.	0.775049	0.013038	1.682240	1.105487	0.15077
info. + repres. (0.25) + diver.	0.775598	0.027827	3.587758	0.730130	0.24622
info. + repres. (0.5) + diver.	0.780737	0.021791	2.791018	1.310466	0.11560
info. + repres. (0.75) + diver.	0.768246	0.010041	1.307029	0.367483	0.36202
volume	0.794829	0.007793	**0.980508**	3.954136	**0.00366**

For a significance level of $\alpha = 0.05$, only Multi-Criteria Active Learning with high representativeness weight or including the diversity factor failed to reject the null hypothesis. For all other methods, superiority over the random method was statistically confirmed.

Thus, as an initial conclusion, the Entity Volume-Oriented Dynamic Selection was chosen as the best method. This choice was not only due to its significant p-value but also because it demonstrated a considerably lower coefficient of variation than the other methods. Furthermore, its low computational complexity solidified its position as the preferred method, confirmed through subsequent tests.

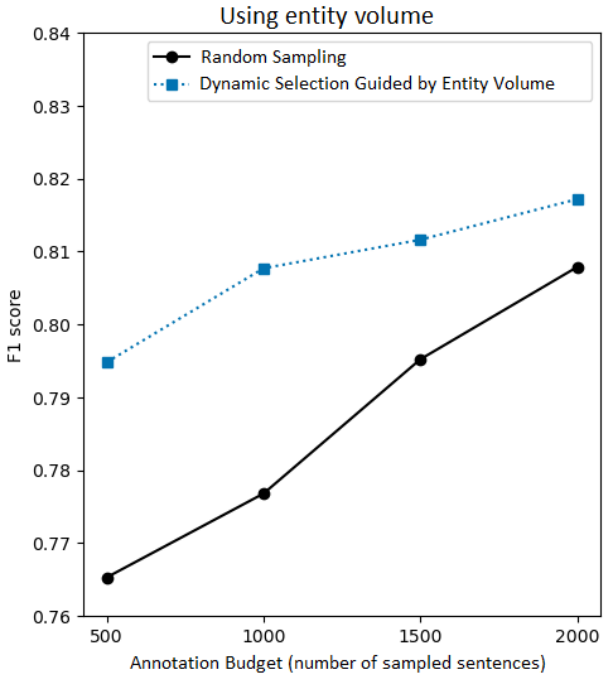


Fig. 6 – Graphs containing the performance of the entity volume method

Next, to confirm the choice of Dynamic Selection Guided by Entity Volume as the best method, the hypothesis that all methods superior to random sampling perform equivalently to this method was tested. If this hypothesis were rejected, it would then be necessary to test whether the other methods are superior to it. Thus, the null hypothesis is equality with respect to the performance of the volume-based method, as shown below in Equation 8:

$$\begin{cases} H_0 : \mu_{\text{volume}} = \mu_{\text{method}} \\ H_a : \mu_{\text{volume}} \neq \mu_{\text{method}} \end{cases} \tag{8}$$

After calculating the relevant values, Table 3 was generated.

Tab. 3 – Hypothesis Test 2 (Equation 8) - Whether, for a low budget, any method was distinct from entity volume sampling

Method	Average F1-Score	Standard Deviation	Var. Coef. %	t-statistic	P-value
Amostragem aleatória	0.765312	0.014761	1.928702	3.954136	**0.00733**
info.	0.788102	0.020510	2.602401	0.685582	0.52271
info. + repres. (0.25)	0.790656	0.017582	2.223775	0.485122	0.64625
info. + repres. (0.5)	0.792830	0.015609	1.968725	0.256235	0.80650
info. + repres. (0.75)	0.761319	0.010901	1.431814	5.591745	**0.00073**
info. + diver.	0.775049	0.013038	1.682240	2.911764	**0.02441**
info. + repres. (0.25) + diver.	0.775598	0.027827	3.587758	1.488121	0.20150
info. + repres. (0.5) + diver.	0.780737	0.021791	2.791018	1.361609	0.23138
info. + repres. (0.75) + diver.	0.768246	0.010041	1.307029	4.67642	**0.00186**
volume	0.794829	0.007793	0.980508	-	-

The analysis showed that distinction in performance could only be confirmed for some methods that were not superior to the control (random sampling). Thus, it was considered reasonable to assume that they are inferior to volume selection.

Consequently, it can be concluded that Dynamic Selection Guided by Entity Volume is not necessarily superior to Multi-Criteria Active Learning, as they demonstrated equivalent performance. However, since both are valid active learning methods for improving models with low budgets (as shown in Test 1), and the volume-

based method has lower computational complexity and a lower variation coefficient, it is considered the better method.

The first graph in Figure 4 exhibited an outlier, suggesting the superiority of Multi-Criteria Active Learning for the case without diversity and with a representativeness weight of 0.25. Therefore, the aim is to reject the hypothesis that this method is inferior or equivalent to others at that budget, as shown below in Equation 9:

$$\begin{cases} H_0 : \mu_{\text{info.+repres. }(0.25)} <= \mu_{\text{method}} \\ H_a : \mu_{\text{info.+repres. }(0.25)} > \mu_{\text{method}} \end{cases} \tag{9}$$

After calculating the relevant values, Table 4 was generated.

Tab. 4 – Hypothesis Test 3 (Equation 9) - Whether, for a budget of 1000 sentences, any method outperformed the multicriteria sampling info. + repres. (0.25)

Method	Average F1-Score	Standard Deviation	Var. Coef. %	t-statistic	P-value
Amostragem aleatória	0.776813	0.011072	1.425348	4.428778	**0.00161**
info.	0.809079	0.009620	1.188965	0.926857	0.19408
info. + repres. (0.25)	0.817225	0.017138	2.097133	-	-
info. + repres. (0.5)	0.803147	0.021569	2.685575	1.142693	0.14391
info. + repres. (0.75)	0.776030	0.021806	2.809931	3.321323	**0.00568**
info. + diver.	0.803814	0.011866	1.476264	1.438642	0.09636
info. + repres. (0.25) + diver.	0.800263	0.018085	2.259836	1.522326	0.08326
info. + repres. (0.5) + diver.	0.806487	0.006227	0.772124	1.316829	0.1223
info. + repres. (0.75) + diver.	0.783971	0.013619	1.737138	3.396902	**0.00506**
volume	0.807713	0.011623	1.439041	1.027128	0.16918

At the chosen significance level ($\alpha = 0.05$), it was not possible to reject the hypothesis that the method was inferior or equivalent to the other candidates for the best method.

Thus, it can be concluded that the observed outlier was merely a result of randomness in the experiment's execution and does not represent any significant phenomenon.

Finally, it was necessary to determine whether the result for low budgets (that the best method was Dynamic Selection Guided by Entity Volume) also held true for high budgets. Thus, we sought to reject the null hypothesis that the methods are inferior or equivalent to the volume method, as shown below in Equation 9:

$$\begin{cases} H_0 : \mu_{\text{method}} <= \mu_{\text{volume}} \\ H_a : \mu_{\text{method}} > \mu_{\text{volume}} \end{cases} \tag{10}$$

After calculating the relevant values, Table 5 was generated.

However, for the chosen significance level ($\alpha = 0.05$), the null hypotheses could not be rejected. Thus, for high budgets, other methods remained inferior or equivalent to the method initially deemed the best: Dynamic Selection Guided by Entity Volume.

5. Conclusion

Through the experiments conducted, it was possible to study the performance of algorithms based on relatively older literature in the field of active learning, which were adapted for use alongside modern large language model-based classifiers. Thus, it was concluded that these algorithms are capable of obtaining, as proposed, samples that are significantly more informative for classifiers than random samples, making them a valuable resource for reducing the cost of corpus annotation.

Tab. 5 – Hypothesis Test 4 (Equation 10) - Whether, for high budget, any method outperformed entity volume-based sampling

Method	Average F1-Score	Standard Deviation	Var. Coef. %	t-statistic	P-value
Amostragem aleatória	0.807885	0.016930	2.095648	-0.839945	0.78728
info.	0.817446	0.011734	1.435467	0.026275	0.48989
info. + repres. (0.25)	0.806624	0.020560	2.548955	-0.862897	0.79314
info. + repres. (0.5)	0.819404	0.017945	2.190047	0.194081	0.42547
info. + repres. (0.75)	0.796019	0.013833	1.737745	-2.079001	0.96319
info. + diver.	0.819714	0.016079	1.961481	0.232992	0.41084
info. + repres. (0.25) + diver.	0.814607	0.011369	1.395702	-0.270612	0.6026
info. + repres. (0.5) + diver.	0.815335	0.011909	1.460666	-0.191755	0.57328
info. + repres. (0.75) + diver.	0.813570	0.018985	2.333498	-0.308862	0.61733
volume	0.817192	0.018090	2.213674	-	-

Additionally, this research's main contribution was the determination that, among the two proposed algorithms, the best one for active learning in legal domain corpora in Brazilian Portuguese, given the configurations studied in this work, is the Dynamic Selection Guided by Entity Volume, as it has lower computational and theoretical complexity and significantly better performance for lower annotation budget values.

Finally, from these results, it is concluded that the predicted volume of named entities is a better predictor of good examples for sample selection, although informativeness and representativeness can also be good predictors, despite the latter being computationally costly.

6. Future Work

To further this research, future work could involve testing the proposed methods with models other than BERT to assess the extent to which the results depend on the underlying model. Additionally, it would be valuable to conduct direct comparisons between these methods and other state-of-the-art approaches. Finally, the methodology identified as the most effective could be applied to develop additional annotated corpora of legal domain documents.

Acknowledgement

- **Funding or Grant**: We express our gratitude to research funding agencies, CAPES, FAPESP, and CNPq for supporting this research. We also thank the Center for Applied Research in Artificial Intelligence Recreating Environments (CPA IARA) and the Brazilian National Institute of Artificial Intelligence (IAIA) for supporting this research.
- **Data/Software Access Statement**: The corpus used can be found on the oficial repository: https://github.com/ulysses-camara/ulysses-ner-br
- **Contributor Statement***: Conceptualization: Rafael P. Gouveia, André C.P.L.F. de Carvalho, Ellen Souza; Formal analysis: Rafael P. Gouveia; Funding acquisition: André C.P.L.F. de Carvalho, Ellen Souza; Methodology: Rafael P. Gouveia, Ellen Souza, Hidelberg O. Albuquerque, Douglas Vitório, Nádia F. F. da Silva; Software: Rafael P. Gouveia; Resources: Ellen Souza, Hidelberg O. Albuquerque, Douglas Vitório; Writing - Original Draft: Rafael P. Gouveia; Writing – Editing: Ellen Souza, Nádia F. F. da Silva;
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Albuquerque, H. O., Costa, R., Silvestre, G., Souza, E., da Silva, N. F. F., Vitório, D., Moriyama, G., Martins, L., Soezima, L., Nunes, A., Siqueira, F., Tarrega, J. P., Beinotti, J. V., Dias, M., Silva, M., Gardini, M., Silva, V., de Carvalho, A. C. P. L. F., & Oliveira., A. L. I. (2022). Ulyssesner-br: A corpus of brazilian legislative documents for named entity recognition. *PROPOR 2022*.

Albuquerque, H. O., Souza, E., Silva, T., Gouveia, R. P., Junior, F., Vitório, D., da Silva, N. F. F., de Carvalho, A. C., Oliveira, A. L., & de Andrade, F. E. (2024, March). Ulyssesnerq: Expanding queries from brazilian portuguese legislative documents through named entity recognition. https://aclanthology.org/2024.propor-1.35/

Brandt, M. B. (2020). *Modelagem da informação legislativa: Arquitetura da informação para o processo legislativo brasileiro* [Doctoral dissertation, UNIVERSIDADE ESTADUAL PAULISTA].

Costa, R., Albuquerque, H. O., Silvestre, G., Silva, N. F. F., Souza, E., Vitório, D., Nunes, A., Siqueira, F., Tarrega, J. P., Beinotti, J. V., de Souza Dias, M., Pereira, F. S. F., Silva1, M., Gardini, M., Silva, V., de Carvalho, A. C. P. L. F., & Oliveira, A. L. I. (2022). Expanding ulyssesner-br named entity recognition corpus with informal user-generated text. *EPIA 2022*.

da Costa, R. P. (2023, Abril). Reconhecimento de entidades nomeadas em textos informais no domínio legislativo. https://repositorio.bc.ufg.br/tede/items/c2783ab8-8aba-487d-bdc2-8fbf0a375a10

de Sá Vitório, D. Á. M. (2020). Avaliando estratégias de seleção de active learning para mineração de opinião com fluxos contínuos de dados. https://repositorio.ufpe.br/bitstream/123456789/38119/1/DISSERTA%c3%87%c3%83O%20Douglas%20%c3%81lisson%20Marques%20de%20S%c3%a1%20Vit%c3%b3rio.pdf

Devlin, J., Chang, M.-W., Lee, K., & Toutanova, K. (2018). Bert: Pre-training of deep bidirectional transformers for language understanding.

Hugging Face, I. (2019). https://huggingface.co

Jehangir, B., Radhakrishnan, S., & Agarwal, R. (2023). A survey on named entity recognition – datasets, tools, and methodologies. *Natural Language Processing Journal*, *3*, 100017. DOI: https://doi.org/10.1016/j.nlp.2023.100017.

Manning, C. D., Raghavan, P., & Schütze, H. (2008). *Introduction to information retrieval*. Cambridge University Press.

Mitchell, T. (1998). *Machine learning*. McGraw-Hill Science/Engineering/Math.

Navarro, D. (2022, Dezembro). The independent samples t-test (welch test). https://stats.libretexts.org/Workbench/Learning_Statistics_with_SPSS_-_A_Tutorial_for_Psychology_Students_and_Other_Beginners/10%3A_Comparing_Two_Means/10.04%3A_The_Independent_Samples_t-test_(Welch_Test)

Nunes, R. O., Spritzer, A. S., Freitas, C. M. D. S., & Balreira, D. G. (2024, Setembro). *Reconhecimento de entidades nomeadas e vazamento de dados em textos legislativos: Uma reavaliação da literatura* [Não publicado]. https://www.researchgate.net/publication/384467812_Reconhecimento_de_Entidades_Nomeadas_e_Vazamento_de_Dados_em_Textos_Legislativos_Uma_Reavaliacao_da_Literatura

Polo, F. M., Mendonça, G. C. F., Parreira, K. C. J., Gianvechio, L., Cordeiro, P., Ferreira, J. B., de Lima, L. M. P., do Amaral Maia, A. C., & Vicente, R. (2021, Outubro). Legalnlp – natural language processing methods for the brazilian legal language. https://arxiv.org/pdf/2110.15709

Riesener, M., Kuhn, M., Schümmelfeder, S., & Xiao, D. (2024, Outubro). Active learning with pre-trained language models for named entity recognition in requirements engineering. https://www.sciencedirect.com/science/article/pii/S2212827124007078

Schohn, G., & Cohn, D. A. (2000, June). Less is more: Active learning with support vector machines. https://dl.acm.org/doi/10.5555/645529.657802

Scikit-learn. (2024). Cross-validation: Evaluating estimator performance. *scikit-learn*. https://scikit-learn.org/1.5/modules/cross_validation.html

Shen, D., Zhang, J., Su, J., Zhou, G., & Tan, C.-L. (2004, July). Multi-criteria-based active learning for named entity recognition. https://aclanthology.org/P04-1075/

Siqueira, F. A., Vitório, D., Souza, E. P., & Santos, J. A. P. (2024, July). Ulysses tesemõ: A new large corpus for brazilian legal and governmental domain. https://www.researchgate.net/publication/384467812_Reconhecimento_de_Entidades_Nomeadas_e_Vazamento_de_Dados_em_Textos_Legislativos_Uma_Reavaliacao_da_Literatura

Souza, F., Nogueira, R., & de Alencar Lotufo, R. (2020, Outubro). Bertimbau: Pretrained bert models for brazilian portuguese. https://www.researchgate.net/publication/345395208_BERTimbau_Pretrained_BERT_Models_for_Brazilian_Portuguese

Tsuruoka, Y., Tsujii, J., & Ananiadou, S. (2008, November). Accelerating the annotation of sparse named entities by dynamic sentence selection. https://aclanthology.org/W08-0605.pdf

Assessing rule-based document segmentation and word normalization for legal ruling classification

Giliard Almeida de Godoi[a*], *Adriano* Rivolli[b] *Daniela* Lopes Freire[a], *Fabíola* Souza Fernandes Pereira[c], *Nubia* Regina Ventura[a], *Alex* Marino Gonçalves de Almeida[d], *Luís* Paulo Faina Garcia[e], *Márcio* de Souza Dias[f], *André* Carlos Ponce de Leon Ferreira de Carvalho[a]

[a]Institute of Mathematics and Computer Sciences (ICMC), University of Sao Paulo (USP) São Carlos - SP, Brazil.
E-mail: *giliard@usp.br**.

[b]Federal University of Technology - Paraná (UTFPR), Cornélio Procópio - PR, Brazil.

[c]Federal University of Uberlândia (UFU), Uberlândia - MG, Brazil.

[d]Ourinhos College of Technology, Ourinhos - SP, Brazil.

[e]University of Brasilia (UnB), Brasília - DF, Brazil.

[f]Federal University of Catalão (UFCAT), Catalão - GO, Brazil.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. The Brazilian judiciary has shown promising interest in applying Natural Language Processing (NLP) techniques to various legal tasks. One such application is classifying legal rulings by the topics of recurring appeals. This study investigates two key strategies for preprocessing legal documents, drawing on insights from legal domain experts: whether using specific sections of the document is more effective for legal ruling classification than analyzing the entire document, and which expressions can be normalized to standardize the document vocabulary. The experimental results indicate that combining normalization preprocessing with the extraction of the judge's manifestation section yields better performance, as measured by the F1 score. Additionally, we demonstrate how the Jaccard similarity index provides valuable insight into the impact of the preprocessing pipeline on the TF-IDF feature extraction method and, by extension, on document representation. This paper underscores the importance of leveraging domain expertise to guide an optimal set of preprocessing operations.

Keywords. Legal document classification, text preprocessing operations, document segmentation and legal terms normalization.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.948

1. Introduction

The Brazilian judiciary has shown a promising interest in developing system and applications that involves Natural Language Processing (NLP) tasks (CNJ, 2024). These efforts aim to process the huge amount of textual data produced by the judiciary and to improve its efficiency and overcome the heavy workload of prosecutions faced by courts across the country.

One relevant problem is the automatic classification of legal rulings by recurring appeal themes - also known as themes of general repercussion (Castro Júnior et al., 2022). These themes are complex legal questions shared by a profuse number of lawsuits and their resolution has the potential to impact thousands or even millions of similar cases. The main goal of this mechanism is to standardize legal agreement on fundamental issues and expedite the analysis of similar legal proceedings.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

While the theme judgment is carried on (e.i. the underlying legal case), the higher courts may order special measures for all related cases in lower courts (e.g. the suspension or pause of all related cases). Hence, the importance of correctly identifying such lawsuits. Traditionally, the court staff must read lengthy documents to determine whether a lawsuit fits a specific theme, a time consuming task. If there is a suspension order for that theme, all the time spent on this task is misused.

This study examines how different preprocessing techniques affect the F1 score metric for the theme classification. The dataset comprises almost 30.000 legal rulings (e.i. Acórdãos) issued by the São Paulo State Court of Justice. We analyze groups of preprocessing operations, one that segment the original document in its constituents sections, and other that standardize common legal expressions to a unique pattern. Then, we compare the effectiveness of such operations by classifying the documents using common Machine Learning algorithms.

Despite the recognized importance of the preprocessing stage, the techniques and operations involved are not standardized or well established (AlMasaud et al., 2024). And the best choice of steps and operations rely heavily on empirical experimentation (HaCohen-Kerner et al., 2020). In others words, there are no common guidelines to aid in selecting the most suitable preprocessing steps.

The language commonly used in the legal domain also has its own uniqueness: a specific vocabulary with precise meanings that may differ from common usage; written documents adhere to a more standardized organizational structure; long and redundant citations of previous similar cases; and the tendency of repeating the same reasoning throughout different documents. Such characteristics should be taken into account during the preprocessing stage.

This paper investigates preprocessing strategies based on expert insights and intuitions: (1) whether using segments of the document can be more effective for its classification rather than the entire content, and (2) whether normalizing specific terms and expressions also could benefit this task. Additionally, this study highlights the importance of incorporating domain knowledge from experts to guide the choices in the preprocessing stage.

Experimental results indicate that expression normalization was the most influential factor in improving classification performance. The document segmentation did not bring the expected performance increasing that we would expected. Still, when combined expression normalization and the extraction of the judge's manifestation segment, these two preprocessing pipelines together tend to outperform the others.

Each preprocessing pipeline produces a modified version of the dataset by altering the content of the original documents. As a result, the Term Frequency–Inverse Document Frequency (TF-IDF) algorithm, which extracts a vocabulary of unique and frequent words from the data, may yield different feature sets depending on the preprocessing applied. To analyze the impact of these pipelines on the feature extraction step, we compute the Jaccard index between the vocabularies sets generated by each pair of TF-IDF models. These pairwise comparisons are then visualized in a heatmap, allowing us to assess whether different preprocessing strategies could lead to distinct textual representations of the same documents.

Therefore, the main contributions of this study are twofold: first, to highlight the importance of incorporating domain expertise in data preparation—specifically, in designing the document preprocessing pipeline; and second, to propose a deeper investigation into feature extraction models, such as TF-IDF, by analyzing their vocabulary sets and visualizing Jaccard index variations through a heatmap. Although still in its early stages, this approach suggests that examining the behavior of feature extraction algorithms may offer valuable insights into selecting the most effective preprocessing operations—potentially reducing the need to exhaustively test all combinations of individual operations directly within classification models.

2. Related works

The preprocessing stage includes operations to clean irrelevant and noisy information for a subsequent task such as text classification. Although it is recognized as a critical step, assessing the impact of different operations is often underestimated (HaCohen-Kerner et al., 2020). The lack of clear guidelines for selecting an optimal set of preprocessing operations, and the need for extensive empirical experimentation may contribute to the limited exploration of different preprocessing pipelines (AlMasaud et al., 2024).

Uysal and Gunal, 2014, HaCohen-Kerner et al., 2020 and Siino et al., 2024 agree that no single combination consistently outperforms the others, and the impact on classification effectiveness highly depends on the problem domain and datasets characteristics. They emphasize the importance of thoroughly testing all possible combinations of preprocessing operations to determine an optimal set for each specific scenario. However, the number of required experiments can increase dramatically as the number of available operations grows.

In the literature, there are no common guidelines to chose the best set of preprocessing operations. For instance, Gôlo et al., 2019 test all combinations of feature extraction techniques and hyperparameter configurations to classify documents from several domains. While Brandão et al., 2023 test a small set of preprocessing pipelines, and Silva et al., 2023 come up with an intricate rule system to find out an optimal set of preprocessing operations. None of them considers to incorporate domain expertise knowledge in the process to choose the best set of preprocessing operations.

Despite the improvement of modern Neural Network Architectures (e.g. Transformers based models) extracting numeric features using Term Frequency - Inverse Document Frequency (TF-IDF) is still a competitive option for lengthy documents, such as in the legal domain. Costa et al., 2023 employed six BERT-derived models for feature extraction in a legal document classification task, and found that the traditional TF-IDF approach produced superior results compared to the BERT-based encoding.

Araújo et al., 2021 compared several supervised machine learning techniques for classifying legal documents. The study used a simple TF-IDF approach for feature extraction. Among the models tested, SVM delivered the best performance with an F1-score of 96.4%. Other methods, including Random Forest, Adaboost, Multilayer Perceptron, and K-Nearest Neighbors, also performed well, each achieving an F1-score above 90%.

Luz de Araujo et al., 2020 proposed the VICTOR dataset for two related tasks: document type classification and theme assignment. Once the dataset originated from scanned documents, they applied regular expressions to infer the text quality and remove OCR tags and special characters. In addition, they applied preprocessing operations such as stemming, stop-word removal, lowercasing, and tokenization of emails, URLs, and legislation citations.

Noguti et al., 2020 compares traditional machine learning approaches with Neural Network Architectures. They conclude that preprocessing operations are more impactful for feature extraction when using the TF-IDF approach rather than the word embedding used by Deep Learning models.

Although Aumiller et al., 2021 explore a more advanced techniques for document segmentation, framing the problem as topical change detection, simpler approaches can be used to test an hypothesis, such as in Feijó and Moreira, 2018 where legal ruling were manually segmented for testing summarization techniques with different parts of the document.

3. Preprocessing pipelines

This section provides a concise overview of the preprocessing pipelines and their respective operations. Firstly, we describe the word-level operations that modify the text itself. Then, we present the structural organization of a legal ruling and briefly discuss how each section was extracted using simple regular expressions patterns. These pipelines are then combined to explore more possibilities of preprocessing pipelines.

3.1. Textual operation

Initially, two sets of operations are conceived: firstly, the cleaned preprocessing pipeline (C) simply removes the document header and footers, line breaks and replaces other white-spaces for a single space character. The normalization pipeline (N) converts text to lowercasing, removes word accentuation, sentence punctuation, and stopwords. The stopword list comprises 416 general Portuguese stopwords, sourced from the spaCy library, and 31 legal terms identified by domain experts. Besides, it removes all words with less than three characters.

And more importantly, it standardizes special words and expressions to a uniform representation employing 156 regular expressions, based on a vocabulary of expressions, abbreviations and acronyms from the Standard Writing Guide of the Superior Court of Justice (Brasil. Superior Tribunal de Justiça, 2016).

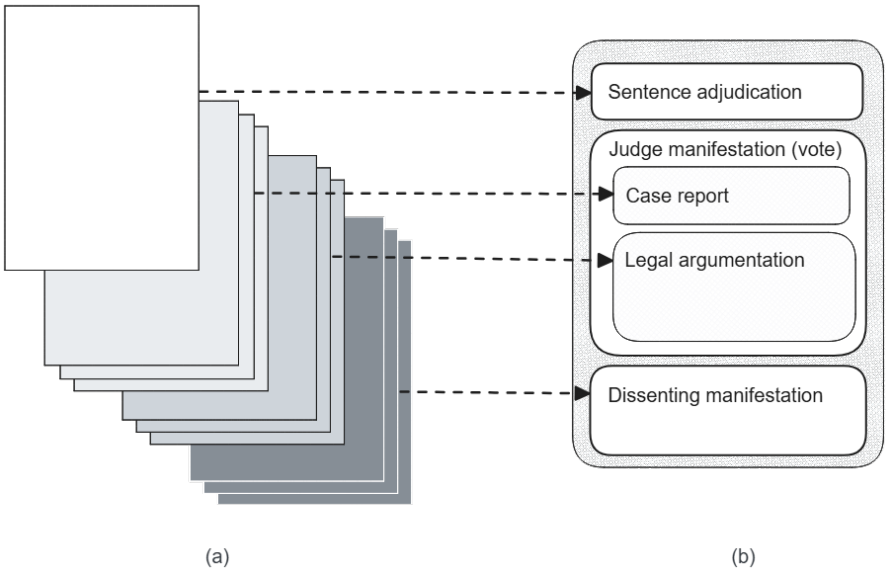


Fig. 1 – While a legal ruling can span several pages, such as illustrated in the left (a), the diagram in the right (b) shows how its internal sections are commonly organized.

For instance, both the name of the Brazilian Superior Court of Justice (e.i. Superior Tribunal de Justiça) and its abbreviation "STJ" are standardized to "`superior_tribunal_justica`." Citations of legislation and other regulatory orders (e.g. Laws, Decrees, Resolutions) are also standardized. In addition, prosecution codes, identification numbers, URLs, email addresses, monetary and percentage values, and other numeric patterns are also regularized.

Initial experiments showed that neither stemming nor lemmatization improved classification performance, so these operations were not included in the study. Furthermore, adapting these techniques to align with the regular expressions used in the normalization pipeline proved to be both complex and potentially counter-productive.

3.2. Document segmentation

In the Brazilian judiciary system, one of the primary roles of higher courts is to serve as appellate bodies, reviewing cases and rulings from lower court jurisdictions. Certain decisions are made by a panel of judges, and the ruling is referred to as an "Acórdão." Typically, the panel of judges is organized into chambers or sections, each composed of at least three members. Moreover, an authoring judge, known as the rapporteur, is appointed to analyze the case, decide on its admission, draft a formal opinion, and recommend the appropriate legal action.

For collegiate decisions, the panel of judges reviews the authoring judge's draft and decides whether to agree with it, aiming to form a majority. In cases of disagreement, the dissenting judge writes a separate opinion, presenting their reasons for disagreeing with the authoring judge's initial position . This dissenting opinion can significantly extend the document's length, as it provides counterarguments for each specific point of disagreement.

Although there is no entirely uniform structure, the legal ruling generally consists of three main parts, as illustrated in Figure 1: the adjudication of the sentence itself, the authoring judge's opinion and, eventually, a dissenting manifestation. The adjudication is found on the first page and contains the decision statement, the judges who participated in the judgment, and the authoring judge responsible for drafting the opinion. This is a more uniform section, which uses standard terms, making it ideal to extract information by applying regular expression.

The authoring judge's formal opinion, also known as vote, includes a summary of the case, references to relevant legislation, citations of previous ruling on similar issues, and suggests a legal action for the case. This

opinion is typically divided into at least two sections: the case report and the legal argumentation (see Figure 1). The case report summarizes information related to the specific case, while the argumentation section cites the legislation and precedent cases that support their decision. For similar cases, the judges tend to repeat the citations of legislation and the previous rulings, leading to documents that are alike to each other.

Legal domain experts suggest common terms and expressions that indicate the transition from one section to another. Hence, regular expressions are able to identify the beginning and the end of each section using this knowledge. Additionally, two strategies help in this process: a sequential section identification, using earlier information to aid the next section detection; and testing a wide list of regular expressions to spot each section.

For example, the authoring judge's name appears as a signature, in the last line of the decision adjudication part (first section) and also in the last line of his draft manifestation marking the beginning and the end of the judge manifestation. The first part of his manifestation is the case report, and common expressions mark the end of this section and the beginning of the legal argumentation. Notwithstanding, the authoring judge's name may differ along the signature lines, sometimes including an additional middle name or abbreviating it. In these circumstances it is necessary to programmatically adapt the regular expressions to accommodate possible variances.

It is worth mentioning the iterative refinement of each regular expression pattern. Whenever possible, two or more patterns are merged into a more powerful and efficient one. Although it shrinks the quantity of rules applied, it also increases its complexity for debugging purposes. Moreover, application of the rules goes from the more generically, that handle more expression variations, to the more restricting ones, aiming to speed up the verification procedure.

One may recognize that detecting one section depends on the success of the previous one. For instance, locating the argumentation section depends on successfully identifying the case report summary. If some segmentation is unsuccessful, we use the last identified section until we default to the entire document. For example, if we try to identify the argumentation section and it fails, we return the content of the judge's manifestation (summary case report plus the argumentation).

The segmentation strategy originates the datasets named Legal Argumentation (LA) corresponding only to the juridical argumentation, and Judge Manifestation (JM) that also includes the case report section. Both versions exclude the dissenting vote section. Furthermore, these two dataset went through the normalization preprocessing operations, obtaining its versions with expressions regularized, and indicated by signs $LA+N$ and $JM+N$, respectively.

The downside of this based-rule approach is that the regular expressions are specific to our collection of documents. Although some writing patterns are similar across judges and courts, adapting to other contexts might require additional effort. However, we use this procedure only to test the hypothesis whether using segments of the documents might be more efficient on legal ruling classification.

4. Experimental setup

In this study we evaluated at least seven machine learning algorithms across six versions of the dataset, each corresponding to a different preprocessing pipeline. The experiments were conducted in a Google Colab Pro environment. In the following we detail the dataset characteristics, the learning algorithms, and the experiment setup in detail.

4.1. The dataset

The dataset, developed under a broader research project funded by the São Paulo State Court of Justice, consists of 33,016 legal rulings considering Special Appeals in the Private and Consumer Law domains. Due to the project guidelines on sensitive information disclosure, we are not able to make the dataset publicly available.

A legal ruling might entail multiple themes, configuring a multiclass classification task. Table 1 shows the six themes of interest in this study, its definition and the number of positive instances for each class. Since we use algorithms that induce binary classification, we divided the original task into six binary classification tasks. This decision corresponds to the one-versus-all strategy, which is a feasible practice in such circumstances.

Tab. 1 – Positive class instances for each label in absolute values. Each theme is represented by a alphanumeric code. The letter S in some labels indicate whether the theme originates at STJ Brazilian Court, rather than the STF Court.

Label Code	Theme Definition	Positive Instances
S0929	Discussion on the conditions under which the double refund stipulated in Article 42 of the Consumer Defense Code (CDC) applies.	2479
S1101	Final date for the application of compensatory interest in collective and individual lawsuits seeking the restitution of inflationary purges in savings accounts.	2004
1011	Controversy regarding the legal interest of Caixa Econômica Federal in joining as a party or third-party intervenor in lawsuits involving housing loan insurance under the Housing Finance System, and, consequently, the jurisdiction of the Federal Court to process and adjudicate such cases.	1038
S1039	Establishment of the starting date for the prescription period of indemnity claims against insurers in contracts, whether active or terminated, within the Housing Finance System.	830
S1016	Validity of a contractual clause in a collective health plan that provides for adjustments based on age brackets; and burden of proof regarding the actuarial basis for the adjustment.	669
S0958	Validity of the charges in banking contracts for services provided by third parties, contract registration, and/or asset appraisal.	509

4.2. Feature extraction

Despite the improvement of modern Neural Network architectures and word embedding representation, Term Frequency - Inverse Document Frequency (TF-IDF) is still a competitive feature extraction option for lengthy document classification, as in the case of the legal domain. The scikit-learn implementation of the TF-IDF algorithms was employed. Previous experiments have shown a vocabulary size of 3,000 tokens and the use of unigrams and bigrams yields better results.

The TF-IDF algorithm selects the 3,000 tokens most frequent in corpus and computes the document frequency for each token, e.i. how many documents that token appear in the corpus. Then it calculates the term frequency of the token in each document and weighted this value by the inverse of the document frequency. Hence a document is encoded in a vector with dimension equal to the number of tokens in the vocabulary. These vector values can also be normalized by the sum of absolute values (l_1 normalization) or by the sum of squares of its elements (l_2 normalization) which was the selected option.

4.3. Classification algorithms

To evaluate the efficiency of the preprocessing pipelines, we use standard classification algorithms provided by the scikit-learn library Pedregosa et al., 2011: Decision Tree classifier (DT), Logistic Regression (LR), Support Vector Machine (SVM), Stochastic Gradient Descent (SGD), Random Forest (RF), and Extra Trees Classifier (ET). We also employed the Extreme Gradient Boosting (XGB) algorithm from the XGBoost library. We use the default parameters for all classifiers as recommended by the respective libraries.

We also employ cross-validation with five folds, using the stratified variation, and collect the precision, recall and F1-score for the test set. However, Tables 2 and 3 reports only the F1-score for conciseness. Therefore, seven machine learning algorithms were tested across six preprocessing versions of the same dataset of legal documents, for each of the six themes (or labels) considered in this study.

5. Results and discussion

Tables 2 and 3 show the average F1 scores obtained from the experiments. Table 2 contains the results solely from the document segmentation pipeline experiments, while Table 3 displays the results from the normalized

Tab. 2 – Average F1-score considering the document segmentation experiments. The preprocessing pipelines are: the cleaned text (C), legal argumentation only (LA), and all the judge manifestation (JM). The classification algorithms refer to Decision Trees (DT), Logistic Regression (LR), Support Vector Machine (SVM), Stochastic Gradient Descent (SGD), Random Forest Classifier (RF), Extra Trees Classifier (ET), and Extreme Gradient Boosting (XGB).

Label	Pipeline	DT	LR	SVM	SGD	RF	ET	XGB
S0929	C	0.8979	0.9452	0.9593	0.9506	0.9485	0.9463	**0.9686**
	LA	0.9079	0.9608	0.9748	0.9669	0.9580	0.9576	**0.9788**
	JM	0.9126	0.9613	0.9744	0.9671	0.9606	0.9607	**0.9828**
S1101	C	0.8232	0.7418	0.8304	0.8050	0.8432	0.8462	**0.9179**
	LA	0.8976	0.7909	0.9103	0.8019	0.9037	0.8842	**0.9352**
	JM	0.8843	0.7894	0.8888	0.8015	0.9051	0.8767	**0.9402**
1011	C	0.8081	0.8359	0.8611	0.8479	0.8449	0.8400	**0.8716**
	LA	0.7802	0.8456	**0.8658**	0.8462	0.8303	0.8284	**0.8634**
	JM	0.7753	0.8491	**0.8750**	0.8493	0.8492	0.8454	**0.8764**
S1039	C	0.8452	0.8944	0.9266	0.9193	0.8694	0.8612	**0.9300**
	LA	0.8530	0.8873	0.9189	0.9075	0.8369	0.8387	**0.9433**
	JM	0.8722	0.8976	0.9237	0.9241	0.8497	0.8588	**0.9493**
S1016	C	0.8878	0.9267	**0.9535**	0.9416	0.8929	0.9142	0.9395
	LA	0.8614	0.9152	**0.9348**	**0.9308**	0.8778	0.8818	**0.9326**
	JM	0.8983	0.9329	**0.9514**	0.9411	0.9061	0.9056	0.9436
S0958	C	0.6241	0.6815	0.7539	0.7252	0.6317	0.6332	**0.7816**
	LA	0.6662	0.7219	0.7828	0.7436	0.6176	0.6403	**0.7900**
	JM	0.6828	0.7293	0.7825	0.7415	0.6252	0.6386	**0.7946**

version of the datasets. The bold values indicate the highest value for each row, i.e. the highest value among the classifiers for a single pipeline. The shaded values indicate the highest value for a classifier across different pipelines (i.e. the highest value in the column) specifically for each label. Values are considered a tie if the first two decimal digits are equal–hence, all similar values are highlighted.

Table 2 suggests that there is no clear pattern indicating the best document segmentation pipeline for all classes. Nevertheless, the LA (Legal Argumentation) and JM (Judge Manifestation) preprocessing pipelines tend to perform better than the C (Cleaned) preprocessing, which considers the entire document.

The results in Table 3 indicate that the normalized version of the documents outperforms the non-normalized ones. Incorporating domain knowledge through standardized expressions is a promising approach for preprocessing legal documents. In this context, the JM (Judge Manifestation) preprocessing method performs better than the others, particularly for underrepresented classes such as 1011, S1039, S1016, and S0958.

For both cases (Table 2 and 3) the Extreme Gradient Boosting (XGB) achieved the best results in most scenarios (bolded values) followed by the SVM classifier. However, the variation between the best and worst results for the XGB algorithm is small, regardless of the preprocessing pipeline used. This suggests that XGB is not significantly affected by changes introduced through preprocessing.

The extraction of the legal argumentation segment (LA pipeline), although its high complexity, did not produce superior results than the JM pipeline. In other words, the judge's manifestation segment (i.e. removing the adjudication page and the dissenting vote declaration, when present) is preferable than the LA pipeline due to its lower complexity and cost. Additionally, associating the JM preprocessing with the expression normalization led to even better results, as shown in Table 3.

Essentially the results suggest that not all preprocessing pipeline produces significant differences on document representation. One way to visualize this situation is to plot a 2-dimension or 3-dimension scatter plot representing the embedding space, using a dimensionality reduction method such as Principal Component Analysis (PCA) or t-distributed Stochastic Neighbor Embedding (t-SNE)(Cao & Cui, 2016). However, this representation produces one plot for each dataset version that is difficult to compare them directly.

Tab. 3 – Average F1-score considering the same preprocessing before, plus the normalization preprocessing. Hence, the preprocessing pipelines are: cleaned content normalized (C+N), legal argumentation normalized (LA + N), and the judge manifestation normalzied (JM + N). The classification algorithms refer to Decision Trees (DT), Logistic Regression (LR), Support Vector Machine (SVM), Stochastic Gradient Descent (SGD), Random Forest (RF), Extra Trees Classifier (ET), and Extreme Gradient Boosting (XGB).

Label	Pipeline	DT	LR	SVM	SGD	RF	ET	XGB
S0929	C + N	0.9434	0.9559	0.9680	0.9613	0.9602	0.9587	**0.9721**
	LA + N	0.9331	0.9680	**0.9812**	0.9749	0.9634	0.9650	0.9794
	JM + N	0.9466	0.9702	**0.9834**	0.9768	0.9710	0.9698	**0.9867**
S1101	C + N	0.9041	0.7761	0.9177	0.8925	0.9241	0.9277	**0.9390**
	LA + N	0.9037	0.8081	0.9260	0.8099	0.9197	0.9215	**0.9338**
	JM + N	0.8985	0.8084	0.9277	0.8238	0.9046	0.8913	**0.9400**
1011	C + N	0.8204	0.8367	**0.8638**	0.8480	0.8475	0.8418	**0.8630**
	LA + N	0.8177	0.8457	0.8655	0.8492	0.8311	0.8380	**0.8777**
	JM + N	0.8343	0.8523	**0.8768**	0.8527	0.8542	0.8513	**0.8774**
S1039	C + N	0.9032	0.9126	0.9308	0.9285	0.9001	0.8958	**0.9495**
	LA + N	0.8850	0.9170	0.9399	0.9266	0.8729	0.8708	**0.9549**
	JM + N	0.9132	0.9209	0.9469	0.9365	0.8870	0.8914	**0.9716**
S1016	C + N	0.8887	0.9357	**0.9553**	0.9459	0.9212	0.9168	0.9438
	LA + N	0.8772	0.9202	**0.9375**	0.9331	0.9019	0.9083	**0.9338**
	JM + N	0.8893	0.9369	**0.9568**	0.9476	0.9185	0.9197	0.9422
S0958	C + N	0.7001	0.7672	0.7896	0.7791	0.6630	0.6927	**0.7926**
	LA + N	0.6904	0.7611	**0.8049**	0.7761	0.6451	0.6781	0.7854
	JM + N	0.7461	0.7829	**0.8322**	0.8005	0.6881	0.6984	0.8082

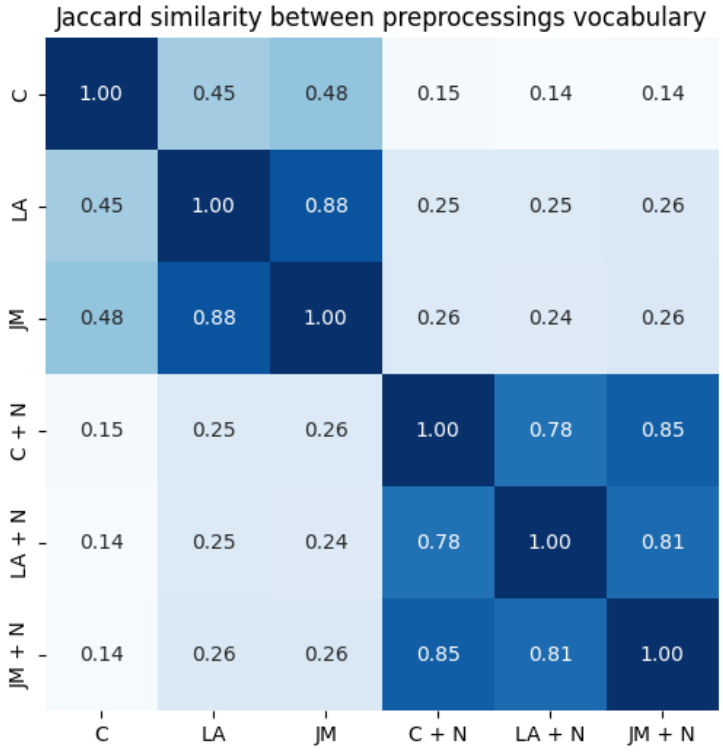


Fig. 2 – Jaccard index heatmap comparing vocabulary overlap across all pairs of preprocessing pipelines based on the TF-IDF algorithm.

Therefore, we propose analyzing the Jaccard similarity index between the vocabulary sets generated by the TF-IDF algorithm for each preprocessing pipeline. This index is calculated as the ratio of the number of elements in the intersection to the number of elements in the union of two distinct sets. Although the Jaccard index does not account for word frequency, it still offers valuable insights into how preprocessing operations influence the vocabulary computed by the TF-IDF algorithm and, consequently, the document representation.

The results are presented in Figure 2. The non-normalized preprocessing group (C, LA, and JM) and their

normalized counterparts (C+N, LA+N, and JM+N) exhibit high similarity within their respective groups but differ significantly from each other. This pattern aligns with the findings in Tables 2 and 3, where the F1-score does not vary as much within each table.

6. Conclusion

In this study, we examined the impact of various preprocessing pipelines on the classification of legal documents, focusing on judicial decisions in the Brazilian legal system. The normalization of legal expressions consistently enhanced classification performance, demonstrating the importance of tailored preprocessing in legal domain. Segmenting documents considering its constituent sections, particularly the judge's manifestation pipeline, enhance the classification performance, yielding better results than using the full text with only basic cleansing operations.

Moreover, we emphasize the importance of examining how preprocessing operations influence feature extraction models and the resulting feature sets. Although the literature provides no clear guidelines for selecting the most appropriate preprocessing strategies, analyzing their impact on feature extraction algorithms (e.g. TF-IDF) can offer valuable insights into this decision-making process. To illustrate this point, we propose investigating the vocabulary sets generated by each preprocessing pipeline by calculating the pairwise Jaccard index over the outputs of the feature extraction model. This type of analysis can be further extended through alternative visualizations and techniques, which we consider promising directions for future work.

Acknowledgement

- **Funding or Grant**: The refered project was funded by the São Paulo State Court of Justice, whom the authors are grateful for the institutional and financial support. The first author is currently supported by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES (process number 88887.084310/2024-00) whom would like to thank for the financial support.
- **Data/Software Access Statement**: Due to the project agreement, we are not able to release the compiled version of the dataset. However, the preprocessing pipeline and scripts for the experiments are available at https://github.com/giliardgodoi/tj-datasets.
- **Contributor Statement**: Giliard Godoi is responsible for conceptualization, methodology, investigation, software, formal analysis, visualization, and writing the original draft. Adriano Rivolli, Daniele Lopes Freire and Núbia Regina Ventura contributed to methodology discussion, software, investigation and writing (review and editing). Fabíola Souza Fernandes Pereira, Alex Marino Gonçalves de Almeida, Luís Paulo Faina Garcia, and Márcio de Souza Dias contributed to methodology discussion and writing (review and editing). André C. P. L. F. de Carvalho contributed to supervision, funding acquisition and resource, and writing (review and editing).
- **Use of AI**: During the preparation of this work, the author(s) used *ChatGPT* AI in order to improve the text fluency for the first draft. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

AlMasaud, A., Sampaio, S., & Sampaio, P. (2024). Mining Data Wrangling Workflows for Design Patterns Discovery and Specification. *Information Systems Frontiers*. DOI: https://doi.org/10.1007/s10796-023-10458-7.

Araújo, D. C., Lima, A., Lima, J. P., & Costa, J. A. (2021). A Comparison of Classification Methods Applied to Legal Text Data. In G. Marreiros, F. S. Melo, N. Lau, H. Lopes Cardoso, & L. P. Reis (Eds.), *Progress in artificial intelligence* (pp. 68–80). Springer International Publishing.

Aumiller, D., Almasian, S., Lackner, S., & Gertz, M. (2021). Structural text segmentation of legal documents. *Proceedings of the Eighteenth International Conference on Artificial Intelligence and Law*, 2–11. DOI: https://doi.org/10.1145/3462757.3466085.

Brandão, M., Silva, M., Oliveira, G., Hott, H., Lacerda, A., & Pappa, G. (2023). Impacto do Pré-processamento e Representação Textual na Classificação de Documentos de Licitações. *Anais do XXXVIII Simpósio Brasileiro de Bancos de Dados*, 102–114. DOI: https://doi.org/10.5753/sbbd.2023.231658.

Brasil. Superior Tribunal de Justiça. (2016). *Manual de padronização de textos do STJ* (2nd ed.). STJ. Brasília.

Cao, N., & Cui, W. (2016). Overview of Text Visualization Techniques. In *Introduction to text visualization* (pp. 11–40). Atlantis Press. DOI: https://doi.org/10.2991/978-94-6239-186-4_2.

Castro Júnior, A. P., Wainer, G. A., & Calixto, W. P. (2022). Application of Artificial Intelligence in the automatic identification and classification repetitive demand resolution incident in the Brazilian Court of Justice. *Revista da Faculdade de Direito da UFG*, *45*(2). DOI: https://doi.org/10.5216/rfd.v45i2.70086.

CNJ. (2024). *Justice 4.0 program* (tech. rep.). Conselho Nacional de Justiça. Brasília.

Costa, J. A. F., Dantas, N. C. D., & Silva, E. D. S. A. (2023). Evaluating Text Classification in the Legal Domain Using BERT Embeddings. In *Lecture notes in computer science* (pp. 51–63). Springer Nature Switzerland. DOI: https://doi.org/10.1007/978-3-031-48232-8_6.

Feijó, D. d. V., & Moreira, V. P. (2018). RulingBR: A Summarization Dataset for Legal Texts. In A. Villavicencio, V. Moreira, A. Abad, H. Caseli, P. Gamallo, C. Ramisch, H. Gonçalo Oliveira, & G. H. Paetzold (Eds.), *Computational processing of the portuguese language* (pp. 255–264). Springer International Publishing.

Gôlo, M., Marcacini, R., & Rossi, R. (2019). Uma extensa avaliação empírica de técnicas de pré-processamento e algoritmos de aprendizado supervisionado de uma classe para classificação de texto. *Anais do Encontro Nacional de Inteligência Artificial e Computacional (ENIAC 2019)*, 262–273. DOI: https://doi.org/10.5753/eniac.2019.9289.

HaCohen-Kerner, Y., Miller, D., & Yigal, Y. (2020). The influence of preprocessing on text classification using a bag-of-words representation (W. Zhang, Ed.). *PLOS ONE*, *15*(5), e0232525. DOI: https://doi.org/10.1371/journal.pone.0232525.

Luz de Araujo, P. H., de Campos, T. E., Ataides Braz, F., & Correia da Silva, N. (2020, May). VICTOR: a Dataset for Brazilian Legal Documents Classification. In N. Calzolari, F. Béchet, P. Blache, K. Choukri, C. Cieri, T. Declerck, S. Goggi, H. Isahara, B. Maegaard, J. Mariani, H. Mazo, A. Moreno, J. Odijk, & S. Piperidis (Eds.), *Proceedings of the twelfth language resources and evaluation conference* (pp. 1449–1458). European Language Resources Association. https://aclanthology.org/2020.lrec-1.181

Noguti, M. Y., Vellasques, E., & Oliveira, L. S. (2020). Legal Document Classification: An Application to Law Area Prediction of Petitions to Public Prosecution Service. *2020 International Joint Conference on Neural Networks (IJCNN)*, 1–8. DOI: https://doi.org/10.1109/IJCNN48605.2020.9207211.

Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., Blondel, M., Prettenhofer, P., Weiss, R., Dubourg, V., Vanderplas, J., Passos, A., Cournapeau, D., Brucher, M., Perrot, M., & Duchesnay, E. (2011). Scikit-learn: Machine Learning in Python. *Journal of Machine Learning Research*, *12*, 2825–2830.

Siino, M., Tinnirello, I., & La Cascia, M. (2024). Is text preprocessing still worth the time? A comparative survey on the influence of popular preprocessing methods on Transformers and traditional classifiers. *Information Systems*, *121*, 102342. DOI: https://doi.org/10.1016/j.is.2023.102342.

Silva, M. D., Santana, E., Lobato, F., & Jr., A. J. (2023). Preprocessing Applied to Legal Text Mining: analysis and evaluation of the main techniques used. *Anais do XX Encontro Nacional de Inteligência Artificial e Computacional (ENIAC 2023)*, 1010–1021. DOI: https://doi.org/10.5753/eniac.2023.234555.

Uysal, A. K., & Gunal, S. (2014). The impact of preprocessing on text classification. *Information Processing & Management*, *50*(1), 104–112. DOI: https://doi.org/10.1016/j.ipm.2013.08.006.

Automating Test Design Using LLM - Results from an Empirical Study on the Public Sector

Artur Raffael Cavalcanti[a], *Luan* Accioly[b], *George* Valença[c], *Sidney* C. Nogueira[d*], *Ana* Carolina Morais[e], *Antônio* Oliveira[f], *Sérgio* Gomes[g],

[a]Computer Science Department, Federal Rural University of Pernambuco, UFRPE, Brazil, artur.raffael@ufrpe.br, 0009-0005-9079-766X.

[b]Computer Science Department, Federal Rural University of Pernambuco, UFRPE, Brazil, luan.accioly@ufrpe.br

[c]Computer Science Department, Federal Rural University of Pernambuco, UFRPE, Brazil, george.valenca@ufrpe.br, 0000-0001-9375-5354.

[d]Computer Science Department, Federal Rural University of Pernambuco, UFRPE, Brazil, sidney.nogueira@ufrpe.br, 0000-0002-8817-5029.

[e]Tribunal de Contas do Estado de Pernambuco, TCE-PE, Brazil, anacarolina@tcepe.tc.br

[f]Tribunal de Contas do Estado de Pernambuco, TCE-PE, Brazil, antoniolira@tcepe.tc.br

[g]Tribunal de Contas do Estado de Pernambuco, TCE-PE, Brazil, sergiogomes@tcepe.tc.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. An efficient test process can detect failures earlier in software development, contributing to the quality of software produced by governmental entities and bringing the potential to improve government service delivery. Due to the high cost and the reduced resources available, the automation of the test activities plays a strategic role in improving testing efficiency. Designing test cases from user stories is a common approach to assessing the quality of a system under testing. This paper reports on the research, implementation, and evaluation of a tool that automatically generates system test designs from user stories with the support of Generative Pre-trained Transformer 4 (GPT-4) in the context of a public sector organization. The tool has been conceived to match the needs and particularities of the organization's test process. Such a tool reads user stories from the Redmine tool, interacts with GPT-4 using a prompt that outputs test cases, and stores the automatically designed tests in the Squash TM test management tool. Organization test analysts stated that the tool produces good quality tests and reduces the effort to create tests. As a consequence, analysts can put more energy into other activities related to testing. Moreover, comparing the tests designed manually by test analysts with the tests designed by the tool shows that both have the same functional coverage. The paper discusses the impacts of the approach in the process, limitations, and related and future work.

Keywords. automated test design, LLM, user story, system test cases
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1025

1. Introduction

Software solutions are an essential part of the services provided by public sector organizations. In such a context, software testing (Myers & Sandler, 2004) is necessary to assess the quality of software products and reduce operational costs due to software failures. Failures detected later cost much more to be corrected than

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

those detected earlier (Kushwaha & Misra, 2008). Improving the quality of software produced by governmental entities has the potential to improve government service delivery. The cost of software testing may be higher than 50% of the total cost of software development (Myers & Sandler, 2004). Due to such high costs and reduced testing resources, the automation of test activities plays a strategic role in improving testing efficiency. Surveys (Garousi & Varma, 2010; Ng et al., 2004) conducted in the public sector show that automation of test activities is a demand to make the testing process more efficient. Moreover, testing methodologies (Nomura et al., 2013; Sivaji et al., 2011) and quality models (Kushwaha & Misra, 2008; S Al- Tarawneh & Al-Tarawneh, 2022) have been proposed to improve the effectiveness of testing in the public sector. Propositions recommend the use of automation as a tool to improve the test process.

Test cases are vital in testing (Myers & Sandler, 2004); each test is an experiment that defines the inputs provided during test execution and the expected outputs produced by the System Under Testing (SUT). The demand for tests increases proportionally to the size of the application. Test design is a critical activity in software testing that focuses on creating test cases; it is not trivial and demands specialized skills. It is present in almost all testing levels and testing types (Sommerville, 2007). A well-designed test case increases the chance of finding important issues in the system's behavior. The automation of test design is a relevant approach to improving test effectiveness. System testing is a testing level where the test cases mimic the final test analyst interaction with the SUT. At such a level, tests are created based on the system's specifications (black box approach). Thus, system testing design requires interpreting existing documentation that functions as the test basis. Notably, user stories (Sommerville, 2007) are a fundamental component of agile software development; they are lightweight for capturing and managing requirements. User stories are a standard test basis for test design in agile processes.

The context of the current research is the software development process of a public sector organization that works with auditing and accountability, namely Tribunal de Contas do Estado de Pernambuco (TCE-PE)[1]. Such an organization produces web systems that support its services to the population. In the TCE's software development process, test analysts receive user stories as the main input for the design of system-level test cases that are executed to validate the correct behavior of the produced software. Furthermore, the organization lacks sufficient resources to design and execute tests for its systems. The demand for testing is greater than the number of existing human resources (Lins et al., 2023). The partial automation of test design would reduce the effort in the design so that test analysts would put more effort into running the tests and detecting defects to be corrected as early as possible.

Previous works have explored test generation from user stories for producing system tests (Chinnaswamy et al., 2024; Granda et al., 2021; Mollah & van den Bos, 2023; Pallavi Pandit, 2015). However, the existing solutions differ in the format for the user stories, the format and the purpose of the produced tests, and the approach used for test generation. Moreover, related work has not been motivated or evaluated in the context of a public organization, as in the current work.

The current paper addresses three research questions.

R1 How to build a tool that reads user stories and automatically designs system test cases?
R2 How do the test cases designed by the tool compare to the tests designed by the test analysts?
R3 What are the test analysts' perceptions of the tool and the automatically designed test cases?

To answer the first question, we created a prototype for a tool that uses an LLM to automate the design of system tests for manual execution, considering the tools used for testing the software produced by the public organization of this study. The proposed prototype interacts with ("GPT-4", 2025) to obtain system tests by inputting user stories. The interaction uses a prompt following the few-shot technique crafted with examples of user stories and the respective test cases in the desired format; then, original test cases are yielded by the LLM based on user stories that have not been provided as examples. Such a tool has been implemented in Python and provides a command line interface that allows test analysts to generate system test designs from user stories that are read from the Redmine tool, and the automatically designed tests are stored in the Squash TM (*Squash TM*, 2025) test management tool. To answer the second question, we compared the tool-designed tests with the existing ones with respect to the number of tests, steps, and functional coverage. It could be verified that the functional coverage of the tests designed by the tool is similar to that designed by the analysts. Moreover, the number of tests and steps is very similar to those created by the analysts. To answer

[1] https://www.tcepe.tc.br/internet/

the third question, we created an anonymous questionnaire to collect the perceptions of the test analysts and also conducted a meeting to collect complementary feedback for the tool. After using the tool to support test design in their habitual process and environment for about a month, test analysts stated the tool reduced the overall effort for test design by 60% significantly improving efficiency. It also simplifies the use of Squash TM by automating mechanical tasks, which are often a significant obstacle for analysts, as noted in their feedback. The feedback also included points for improving the tool.

The remainder of this paper is organized as follows. The next section introduces the organizational context of this work and the main concepts that outline this work. Section 3 overviews the steps of the research method. It describes our eight-step process followed in this research. Subsequently, Section 4 details the tool's architecture and the tool workflow from the point of view of the test analyst. Afterward, Section 5 presents details on the evaluation and key findings supported by collected data. Then, Section 6 discusses the research questions in light of the evaluation results and their implications. Finally, Section 7 summarizes contributions, presents related work, and discusses future work.

2. Context and conceptual background

This section overviews the relevant portion of the testing process of the organization in the public sector that contextualizes this research. In such a process, the project is organized as sprints, as shown in (Augustine, 2005). On each sprint, requirement analysts create user stories and store them in Redmine. Then, developers and test analysts use the stories as the basis for coding the application and for designing test cases using Squash TM, respectively. Moreover, Squash TM is used by test analysts to create an execution plan with a list of tests to be executed. After the developers release a version for testing, the test analysts execute the tests following the execution plan and keep a record of the status of each individual test. Failed tests are reported to the developers to fix the software. Failing tests are re-executed after the fixes. After releasing a software version that passes the tests, the product owner validates the new version, which can lead to new bugs and fixes. After successive interactions, the software has all its features implemented and can be deployed for the end users of the public organization. In what follows, we show the format for user stories and test cases and the tools used to manipulate these artifacts.

This paper does not exhibit internal artifacts of the TCE-PE software development process for confidentiality reasons. The user story and test cases presented in this section follow the format of the real artifacts; however, they do not relate to a real system.

2.1. User stories and Redmine

A user story (US) facilitates communication between technical teams and end test analysts, ensuring that the development process remains user-centric and aligned with stakeholder needs. The Redmine tool (*Redmine*, 2006) is an open-source project management and issue-tracking tool that supports agile workflows and efficiently organizes sprints and user stories. Also in Redmine, it is possible to define user stories and link them to sprints, creating an organized flow.

Figure 1 shows a sample US, a simplified version of the format used in the public organization that contains the relevant fields for test case design. The US in Figure 1 specifies the behavior for the system login page. Each US is identified by a unique ID, in the sample, the ID equals 00001. This information is relevant for relating tests to the respective source US. The US title (displayed in the first line of the figure offers a quick reference to the purpose of the US, helping to identify the area of functionality the tests will cover. The title is preceded by the `PROJ` prefix, which is a sample acronym for the project that the US belongs to. The description provides context about the user's goal and the functionality's purpose. The scenarios field outlines the flows of the SUT behavior. In the sample US, there are two scenarios, the first scenario evaluates the system's ability to authenticate a registered user with valid credentials, ensuring successful login and redirection to the homepage. The second scenario tests the system's response to invalid credentials, verifying that an appropriate error message is displayed, preventing unauthorized access while providing clear user feedback. Acceptance criteria specify the expected outcomes and requirements that must be met; in the sample, there are four. A test analyst must design test cases to verify the condition described in each criterion of a US.

User Story #00001

PROJ - *As a registered user, I want to be able to log in to the platform to access my profile and exclusive content.*

Description
This feature enables registered users to securely log into the platform, providing access to personalized content and their profiles. If users enter incorrect credentials, a clear error message is displayed, and if they forget their password, a reset option is available.

Scenarios

1. **Successful login with valid credentials:**
   - Given a registered user with valid credentials, when the user enters their correct username and password and clicks the login button, then the user is successfully authenticated and redirected to the platform's homepage, where exclusive content is accessible.
2. **Login with invalid credentials:**
   - Given a registered user attempts to log into the platform, when the user enters an incorrect username or password and clicks the login button, then a clear error message is displayed, indicating that the login information is incorrect.

Acceptance Criteria
a) As a registered user, I want secure access to the platform to view my profile and personalized content.
b) I want to enter my username and password to log into my account.
c) After successfully logging in, I want to be redirected to the platform's homepage, where I can begin exploring the exclusive content available to me.
d) If I enter invalid credentials, I expect to receive a clear error message indicating that my login information is incorrect.

Fig. 1 – User Story

2.2. Test cases and Squash TM

A classical format for a test case design for system testing (Sommerville, 2007) specifies preconditions (pre-requisites) and execution steps. Preconditions specify the necessary conditions (setup actions) to start the test. Each step contains the inputs provided to the SUT and the expected outcomes. The execution of a test case is an experiment to verify that the SUT meets its specification. If some step fails during the execution, we say the test fails and the execution evidences a defect in the SUT. A defect is a deviation from the expected behavior described in the US. If no step fails, the SUT passes the test.

Key requisites for a good test case include clarity, repeatability, and traceability to user stories. A set of test cases covers the functionality of a set of user stories if there is at least one test case to verify the scenarios and criteria specified in the stories. Figures 2 display tests in the interface of Squash TM that cover the US shown in Figure 1.

Figure 2 presents the key fields of tests in Squash TM, with non-essential fields omitted. At the top of the figure, the title field is highlighted in green. The title should clearly identify a test. Each test has a unique ID that appears in the Figure 2 as `CT-PROJ-2`. This tag is the composition of the prefix `CT` with the project acronym (in the sample `PROJ`) and a number. The test status and prerequisites are displayed below the title; they are followed by the actions (inputs) and the expected results. The test analyst is responsible for verifying that these actions comprehensively cover the scenarios and meet the acceptance criteria established in the related US.

In Squash TM, test cases can be organized in folders. A helpful structure is to create a folder of test cases for each Sprint. There is also the Requirement field, which includes a reference to the user stories that are used as the basis for writing the test case. This field allows linking tests to user stories, ensuring traceability.

3. Overview of the research method

This research seeks to answer the three research questions listed in the introduction. For this purpose, it followed eight steps.

1. Selection of existing user stories and test cases to be used as references.

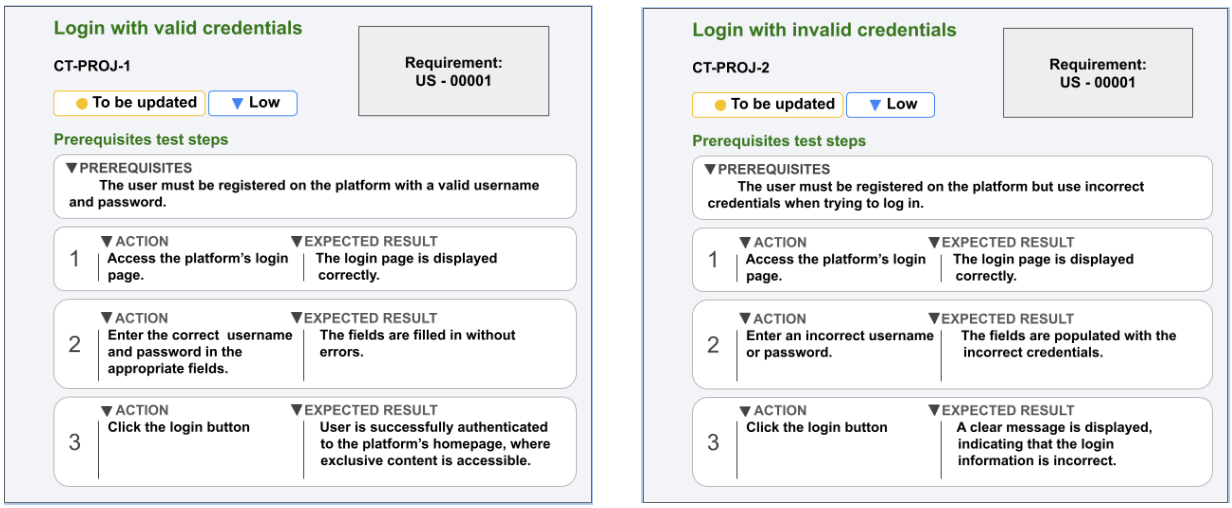


Fig. 2 – Tests created by the US2Test Tool for US 00001

2. Implementing the tool US2Test to automatically design tests from user stories using LLM.
3. Comparing the test cases designed by the tool to the existing test cases.
4. Sharing comparison results with test analysts to collect feedback about the automatically designed tests.
5. Distributing US2Test to the test analysts.
6. Collecting feedback from test analysts using an anonymous survey.
7. Scheduling a meeting with the test analysts to collect direct feedback.
8. Analysis of the results.

We explain the above step. First, the organization's quality assurance team provided reference artifacts consisting of well-designed test cases created to cover a predefined set of user stories. The reference artifacts follow the organization patterns and guidelines for having good-quality user stories and test cases. Such artifacts have been used in previous versions of software developed by the organization. The second step was to develop the US2Test tool that uses LLM to generate tests from the US. The implemented tool interacts with GPT-4 using OpenAI API to design test cases. The third step focused on using the tool to design tests automatically and compared this suite to the test suite designed by test analysts (provided in the first step).

The fourth step consisted of sharing the comparison results with analysts to gather their impressions before they start using the tool. Based on the feedback received, we could enhance the tool and distribute the binaries to the test analysts (fifth step) for their daily use. In this way, they could design tests using the tool by themselves. The sixth and seventh steps involved collecting further feedback after the analysts had actively used the tool. Initially, feedback was gathered anonymously, and the forms were distributed approximately one month after the test analysts gained access to the tool. About two months after accessing the tool, a meeting was scheduled to collect more direct and detailed insights. Finally, we analyzed all the data and started writing this paper.

4. Tool for automatic test design using LLM

The automatic test generation approach introduced in this section is tailored for use in the test process of TCE-PE (presented in Section 2). Therefore, the development follows the particularities of the organization's testing process. Figure 3 illustrates the proposed test generation approach implemented by a tool called US2Test. In the figure left-hand side (in cyan) are the primary inputs for test generation: examples of user stories stored in Redmine (`Example US (Redmine)`) with their respective test case (`Example US (Redmine)`) and the user stories that we want to generate new tests (`Input user stories (Redmine)`). Examples are retrieved from Redmine and Squash TM using the APIs for such tools. User stories and tests follow the format introduced in Section 2 (refer to Figures 1 and 2). The inputs are translated into JavaScript Object Notation (JSON) format (blue color) and processed by a Python script that creates a prompt that is the input for the GPT-4 API. The GPT-4 model processes the prompt and yields a set of test cases encoded in JSON format for the desired user stories. The set of test cases is then pushed to the appropriate location in the API of the Squash TM tool.

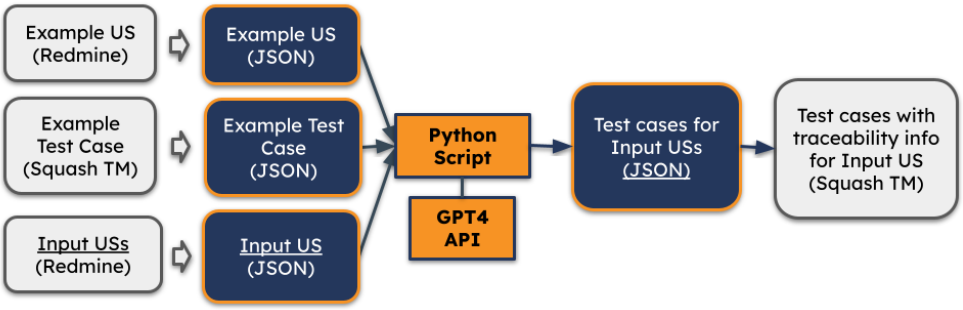


Fig. 3 – Workflow for the US2Test tool

The tool performs (Bahrami et al., 2023) to guarantee that the automatically designed test cases follow the classical test case format, which is one of the formats accepted by the Squash TM tool. Moreover, by providing examples of user stories and test cases, we help the model understand the match between the user stories and test cases so that tests designed for the input user stories follow a predefined style for the tests.

Listing 1 illustrates the prompt used in our approach to generate tests. This prompt follows the RTF (Role Task Format) format, which instructs the prompt on its role, the task it will perform, the rules it will follow, the format for the inputs, and the format for the expected response. The prompt specifies rules to maintain consistency, such as ensuring that each test step has a corresponding expected result. Additionally, each test case must have preconditions, and only the JSON with the test cases should be returned without extra information. The placeholders `<EXAMPLE USER STORIES>`, `<EXAMPLE TEST CASES>`, and `<USER STORIES>` represent, respectively, the sample user stories, test cases for the sample user stories, and the stories we want to generate new tests. Such placeholders are replaced by JSON objects representing content retrieved from Redmine and Squash TM. Likewise, the prompt instructs the model to use specific black-box testing techniques, such as Equivalence Class and Boundary Analysis (Myers & Sandler, 2004). These techniques are employed to design tests that verify significant cases and edge cases for the scenarios described in the input user stories.

Listing 1 – Few-shot Prompt

```
You will act as a test case creator. You will receive a user story in JSON format and should
    return enough test cases to cover the user story, considering the use of black-box techniques
     such as equivalence class and boundary values. The result must be returned in JSON format (
    RFC 8259). Some rules: For each test step, there must be an expected result; The number of
    steps and expected results must be the same, so that an expected result is linked to a step;
    Steps that consist of verifying something must be in the expected result field; Each test
    case must contain preconditions; You should return only the JSON with the Automatically
    designed test cases, without any additional information.
Here is an example of a user story: <EXAMPLE USER STORIES>
The test cases for this user story are: <EXAMPLE TEST CASES>
Generate test cases for the following use stories: <USER STORIES>
```

The code snippets in Listings 2 and 3 are JSON objects that represent the US and the test cases introduced in Section 2.1. The snippets are abbreviated for conciseness. The placeholders `OTHER CRITERIA`, `OTHER SCENARIO`, and `SECOND TEST HERE` indicate the points that have been omitted. The omitted criteria require successful login, redirection upon authentication, and access denial for incorrect credentials. The concealed scenario specifically examines failed login attempts, while the hidden test verifies that access is denied following this scenario.

Listing 2 – Sample US enconded in JSON

```
{
  "title": "As a registered user, I want to be able to log in to the platform to access my
      profile and exclusive content.",
  "description": "This feature enables registered users to securely log into the platform,
      providing access to personalized content and their profiles. If users enter incorrect
      credentials, a clear error message is displayed, and if they forget their password, a reset
       option is available.",
```

```
  "acceptance_criteria": [
    "As a registered user, I want secure access to the platform to view my profile and
        personalized content.",
    < ~OTHER CRITERIA~ >
  ],
  "scenarios": [ {
     "title": "Successful login with valid credentials",
     "Given a registered user with valid credentials, when the user enters their correct username
          and password and clicks the login button, then the user is successfully authenticated
         and redirected to the platform's homepage, where exclusive content is accessible."
    },
    { ~OTHER SCENARIO~ } ]
}
```

Listing 3 – Sample Test Case enconded in JSON

```
"US00001": {
  "test_cases": [ {
     "title": "Login with valid credentials",
     "pre_conditions": ["The user must be registered on the platform with a valid username and
         password."],
     "steps": [
       "Access the platform's login page.",
       "Enter the correct username and password in the appropriate fields.",
       "Click the login button."
     ],
     "expected_result": [
        "The login page is displayed correctly.",
        "The fields are filled without errors.",
        "User is successfully authenticated and redirected to the platform's home page where the
            exclusive content is accessible."
        ]
     }, { ~SECOND TEST HERE~ } ] }
```

The tool stores generated tests in a particular folder of Squash TM as exhibited in Figure 4. The tests in this figure represent the tests depicted in Figure 2.

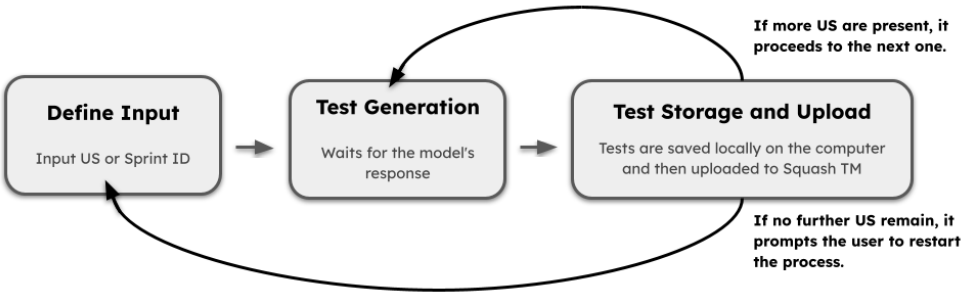


Fig. 4 – Test analyst workflow

We explain the steps to use the tool. The tool´s command line interface follows a structured process, as outlined in Figure 4. Before starting to use the tool, the test analyst needs to include the credentials for Redmine and Squash TM in a configuration file. As the first step, the test analyst needs to define the inputs for the test design. It can choose between generating tests from individual user stories or sprints. Using the first option, the test analyst can manually input one or more IDs for user stories. In the second option, the test analyst can provide a sprint ID, and the tool will yield tests for all user stories associated with the sprint.

After the test analyst defines the inputs, the tool initiates the test generation process for each US. This step is typically the most time-consuming, as it relies on the LLM. Errors can occur during the generation, even if the inputs respect all formatting rules. The model generates malformed outputs, so the tool needs to verify

whether the tests are syntactically valid. If errors are detected, the tool automatically initiates a new interaction with the model to redesign the tests, with up to five attempts.

Once the test generation has finished successfully, the test cases are locally stored on the computer and then uploaded to Squash TM. For the upload, the test analyst should provide the target folder in Squash TM (mandatory) and, optionally, the project acronym (default value is PROJ if not specified) and the test number (default value is one if not provided).

Finally, after processing one US, the tool checks if there are more user stories to process. If so, it proceeds to the next one and starts a new iteration for preparing new tests. Otherwise, it restarts the process by asking the test analyst to provide new inputs.

5. Evaluation

This section presents the execution of the evaluation as well as its results in the public sector organization, which is the context of this work. It further details the third to the seventh steps of the research method presented in Section 3.

5.1. Evaluating the tests designed by the tool

A very relevant part of the evaluation is to compare the test cases designed by the LLM to the existing test cases and to collect feedback for the automatically designed tests from the test analysts. This section reports on both parts.

The comparison used as a reference the set of seven US provided by the quality assurance team (see Section 3). Such a set was split into two disjoint subsets: a set with three user stories (and its respective test cases) to be used as examples for the prompt (see Section 4), and the second set containing four user stories used as input to create new tests using the tool US2Test. The tests designed by the tool have been compared to those designed by the test analysts.

For each reference US, we collected two measures and one metric to compare tests produced by the tool and those created by the analysts.

Number of Tests Records the total number of tests designed for a particular US. The number of tests indicates the number of separate test cases developed to verify the user stories. It reflects the test suite's depth to cover different scenarios through distinct tests. A very small number of tests would increase the risks of potential defects not being detected (Myers & Sandler, 2004). On the other hand, many tests are not welcome since they cannot be feasible for test execution due to resource availability.

Number of Steps This measure represents the sum of the number of steps of the tests designed for a particular US. The number of steps in each test case provides insight into the level of detail and granularity of the actions required to carry out each test. This measures the complexity and thoroughness of each test case, reflecting how procedural actions are broken down.

Test suite coverage Stands for the coverage of a test suite. Let TS be the sum of the number of scenarios and acceptance criteria for a particular US, and CS represent the number of test scenarios covered by a test suite created for the same US. This metric is obtained by the expression $CS/TS * 100$ that records the percentage of scenarios and criteria of a given US that are addressed by at least one test in the test suite. This metric is essential to evaluate the quality of a test suite. Complete (100%) or near-complete coverage ensures that the test cases address all functional paths and requirements, minimizing the risk of missed defects.

Table 1 shows the measures for the tests designed by the analysts (MDT — Manually Designed Tests) and for those designed using the tool (ADT — Automatically Designed Tests). The table consists of four columns: US, Manually designed tests, Automatically designed tests, and Difference. The US column represents the ID of each US used in the evaluation. The columns Manually designed tests and Automatically designed tests refer to tests created by analysts and the tool, and the Difference column refers to the difference in the metrics between MDT and ADT. The last three columns are further divided into two sub-columns: Test and Steps. These sub-columns refer to the total number of tests and steps.

US	Manually designed tests		Automatically designed test		Difference	
	Tests	Steps	Tests	Steps	Tests	Steps
1	2	4	2	6	0	2
2	2	4	4	16	2	12
3	2	2	2	7	0	5
4	2	2	2	6	0	4
Sum	8	12	10	35	2	23

Tab. 1 – Tests comparison table

Table 1 shows differences in the number of tests and steps in MDT and ADT. The difference shows that while the test quantity typically remains consistent between the two methods, the number of steps is often higher in the ADT. Despite this difference, all tests and steps in ADT are related to some tests and steps in MDT. We report the main differences noted between the number of test steps in ADT and MDT.

1. Tests in MDT benefit from the analyst's knowledge of the system's user interface (UI), enabling the definition of optimized sequences of actions to execute. In contrast, tests in ADT are solely based on the US content since the prompt is not fed with UI information; thus, designed tests occasionally include intermediate navigation steps the LLM deems necessary to reach the appropriate screen.
2. Tests in ADT systematically include a final step to confirm the save operation to persist changes. While save actions are left implicit in the analyst-created tests.

Similar observations can explain the difference in the number of tests in ADT and MDT for US 2. The first suite contains four tests, and the second two. Putting the tests of both suites side by side, we could observe that the four tests in the first suite, if merged, would yield the two tests in MDT. Such tests could be merged since they can be executed on the same application page. The model does not have information about the UI, and created independent tests that could form a unique test to be executed on the same application page.

These differences highlight how the LLM prioritizes a detailed and explicit description of each action, even at the cost of increasing the number of steps. This approach contrasts with the optimized methodology adopted by analysts, who leverage system knowledge to streamline the test execution process.

The coverage metric is not included in Table 1 since MDT and ADT achieved 100% coverage for each US listed in the table. The collection of coverage was conducted by one of the authors of this paper, who looked for each criterion and scenario in each US and looked for the tests in the suite to find if some steps were referring to the criterion and scenario. This leads to the calculation of 100% coverage of the user stories by ADT and MDT. This means both test suites have completely covered the input user stories used for designing the tests. Consequently, both test suites demonstrate adherence to the acceptance criteria and defined scenarios for each US.

In the meeting to collect feedback with the test analysts (refer to step four in Section 3), despite the differences noted in the number of tests and steps, the analysts considered the tests in ADT as "good tests", since they are coherent to user stories, are easy to follow and have a clear language. Test analysts reported being motivated to use the tool in their daily activities to better assess its functionality and the quality of the generated test cases.

Despite not interacting directly with the system's interface, the approach proved highly effective, accurately executing and validating actions, including screen interactions.

5.2. Collecting survey data

As part of our research method, an evaluation was conducted through an anonymous survey answered by analysts who used the tool US2Test. The survey included questions to assess the tool's usability, effectiveness, and impact on their workflow. Additionally, it has questions to collect the perception of the test cases designed by the tool. The questions in the survey are:

Q1 Does the US2Test tool have any impact on the efficiency of your daily work?

Q2 How much do you consider the tool facilitates the manual test creation process?
Q3 How much do you consider the tool facilitates the process of sending to Squash TM?
Q4 List points you liked and disliked about the tool.
Q5 Are the automatically designed tests clear and easy to understand?
Q6 The automatically designed tests adequately cover the user story scenarios?
Q7 The automatically designed tests can help identify potential errors or issues?
Q8 What aspects of the automatically designed tests could be improved to better meet your needs?

The first four questions assess the tool's effectiveness, while the last four questions evaluate the quality of the automatically designed tests. Two questions are open-ended (questions four and eight), and the others are multiple-choice. The multiple-choice questions were designed following the (*Likert scale*, 2006), a popular method for measuring attitudes or opinions. On this scale, respondents rate each statement on a scale from one to five, where one means they completely disagree or find it unhelpful, and five means they agree entirely or find it highly helpful. Number three means a neutral opinion.

The survey was distributed by email to a group of four test analysts: this is the total number of test analysts available to use US2Test. Represents the analysts of a particular project inside the public organization. Moreover, filling out the survey was not mandatory. The answers for the multiple-choice questions of a group of three test analysts are recorded in Table 2. The responses to the open-ended questions are exhibited in the Appendix.

Questions	Test analyst 1	Test analyst 2	Test analyst 3
Q1	4	3	5
Q2	4	3	5
Q3	5	3	5
Q5	4	4	5
Q6	4	4	5
Q7	4	4	5

Tab. 2 – Test analysts' opinion about the tool and its tests

Each column in the table represents the opinion of a different test analyst, with responses based on a Likert scale. Analyzing the responses to the first three questions, we observed that most of the feedback was positive or neutral. One test analyst was neutral and totally agreed that the tool offered significant assistance. Therefore, concerning the tool's effectiveness, we can observe that it is helpful but not a complete paradigm shift in daily routines. In the subsequent three questions, two-thirds of the respondents indicate that the tests are clear and beneficial, while one-third find them exceptionally clear.

Reading the responses to Q4 and Q8 in the Appendix, we identify different test analyst perspectives. Test analysts state the tool is useful, and at the same time, there is a consensus on the need for improvements, especially regarding fixing errors during the automatic creation of tests. For the eighth question, the feedback highlights that the effectiveness of test creation is closely tied to the quality of user stories. There is room for improvement in the tools' ability to cover all scenarios in more complex user stories.

Data in Table 2 indicates significant potential for improvement in the tool. The automatically designed tests are currently satisfactory, adhering to predefined scenarios, aiding in error identification, and being clear and comprehensible.

5.3. Feedback meeting

To complement the anonymous feedback, we conducted a meeting to gather additional feedback from the test analysts. This meeting was about one month after the responses to the survey had been collected. Thus, reflects a possible more mature opinion about the tool's impacts. During the meeting, it was clearly stated that the tool prototype had demonstrated productivity gains and is frequently used by at least two team members. After that, one analyst reported that the tool reduces up to 60% of the effort in creating tests. Although the tests designed by the tool require further adjustments to be ready for test execution, it was agreed that the tests are a quality starting point for creating tests with quality.

Addressing environmental issues that prevent some analysts from using the tool (for instance, an anti-virus that blocks the tool from working properly) and fixing defects was identified as a priority. Furthermore, during the meeting, the analysts emphasized the desire for the tool to create tests for all the sprints in a given project. Currently, the tool generates tests for all user stories in a sprint but does not generate tests for all sprints in a project.

Finally, implementing a simple graphical user interface was proposed to enhance the overall test analyst experience by reducing repetitive data entry. The meeting concluded with a consensus that the specific requirements for this interface will be discussed with the tool test analysts later.

6. Discussion

Considering the evaluation presented in Section 5, we can go back to discuss the research questions introduced in Section 1.

6.1. [R1] How to build a tool that reads user stories and automatically designs system test cases?

The response to this answer is detailed in Section 4. Thanks to the capabilities of LLMs in natural language processing, the automation of tasks that involve input and output of textual content is facilitated by the current LLMs, such as GPT-4, which has been used in this research. We made a relatively small effort to set a prompt and refine it until we got to the version presented in this study. A greater amount of time was dedicated to the automation of the approach presented in Figure 3, which requires integration with Redmine and Squash TM and the construction of a simple command-line tool. From this experience, we believe LLMs can facilitate the construction of different tools to support software testing activities.

6.2. [R2] How do the test cases designed by the tool compare to the tests designed by the test analysts?

The results exhibited in Section 5.1 bring interesting points for discussion. It could be observed that all ADT tests are related to some MDT tests and that ADT has complete coverage in the same way as MDT does. Despite that, there are differences in the number of tests and steps in both suites. The test cases automatically designed by the tool (ADT) produce a larger number of test cases and steps compared to the tests designed by the test analysts (MDT). As reported in Section 5.1, some tests in ADT, if merged, would bring similar tests in MDT. The increase in the number of steps is justified by the fact that the tests in ADT have detailed and explicit descriptions that add extra steps for the tests. While tests in MDT are more concise since they leave some points implicit. Even considering the differences, test analysts considered tests in ADT to be acceptable since they are coherent with user stories, easy to follow, and have a clear language.

A point for future investigation is to analyze the effect on the tests of ADT if UI information is provided as context information to the model. A hypothesis to be observed would be to observe whether the model would produce a smaller number of tests: possibly, individual tests would be put together because they can be executed on the same page of the SUT.

A positive aspect of the ADT tests that was not explored in the study is that the ADT tests do not contain grammatical or spelling errors. This is a positive aspect of the tests generated by the model that contributes to the quality of the tests. Moreover, due to the rules in the prompt and the format validation performed by the tool, designed tests consistently match the expected format for test cases, ensuring uniformity of tests.

6.3. [R3] What are the test analysts' perceptions of the tool and the automatically designed test cases?

Data presented in Sections 5.2 (survey answers) and 5.3 (feedback meeting) help in the discussion of the third research question. We have two dimensions to consider in this question: the perceptions about the impacts of adopting the tool and the perceptions about the tests produced by the tool.

Impacts of adopting the tool Looking at the survey answers, two-thirds of the test analysts agreed the tool has positive impacts on the efficiency of their activities, in the creation of tests, and in the process of publishing the tests into Squash TM. Considering there was a month between the initial contact with the tool and the

answers in the survey, it was a very short period for the respondents to formulate an opinion about the tool. An indication of this is the answer of Test Analyst 3 to the eighth question in the survey (refer to Appendix). This respondent explicitly states that he has just started using the tool. Conversely, by the time of the feedback meeting, the test analysts had been in contact with the tool for about two months. During the meeting, they expressed that the tool reduces up to 60% of the effort in creating tests. Also, they provide a rationale for this reduction: the tests designed by the tool are a very good starting point, but require further adjustments to be ready for test execution. This reinforces the feeling that LLMs are productivity tools rather than substitutes for human skills (Ross et al., 2023).

Perceptions about the produced tests In the last four questions on the survey, all respondents agreed that the tests designed by the tool were clear and easy to understand, they covered scenarios and acceptance criteria of the user stories, and they helped identify issues in the SUT. Regarding coverage of the tests, the respondents' perception matches with the complete coverage reached by the automatically designed test in the evaluation reported in Section 5.1. By the time test analysts answered the survey, they had the opportunity to use the tool to input user stories of different projects and reach adequate coverage for the tests. It gives a complementary indication that the tests generated by the tool have good coverage for a variety of user stories. The issue reported by test analysts when attempting to generate test cases occurred in user stories that present a specific character. Following test analyst feedback, the root cause was identified and fixed in the new version of the tool.

7. Conclusion

The paper introduces US2Test, a tool designed to automate the generation of system test cases from user stories using Large Language Models. It integrates with existing systems to suit the test process of a particular public organization. The empirical evaluation of the tool involving the organization's test analysts demonstrated that the tool effectively helps the design of test cases. A more effective test process can contribute to the quality of software produced by governmental entities and has the potential to improve government service delivery.

7.1. Related work

Previous works have considered user stories for the derivation of tests. For instance, the authors in (Pallavi Pandit, 2015) propose a systematic approach to manually design acceptance tests from the user stories. Additionally, the work (Granda et al., 2021) introduces a model-driven framework that inputs user stories, such that the acceptance criteria are described using the GWT (Given-When-That) structure, and produces automatic test scripts for desktop applications. The authors in (Mollah & van den Bos, 2023) present a step-by-step method to manually transform user stories into automatic test cases. The format for the user stories and the tests that are produced for these related works differs from ours, which accepts a less structured story and produces system tests in the format of a test management tool.

Domain-specific textual formats have also been used to produce tests. The works (Carvalho et al., 2015) and (Nogueira et al., 2019) follow a model-based testing approach (Dias Neto et al., 2007). The authors in (Carvalho et al., 2015) proposed a strategy to automatically generate test cases from Natural Language requirements (NAT2TEST - NATural language requirements to TEST cases). This approach inputs requirements in a Controlled Natural Language (CNL) that follows a well-defined grammar and vocabulary to allow the extraction of a formal model for automatic verification of requirements and the extraction of test cases. A test case is a sequence of test vectors that is the input for some external tool that formats the test for a particular context. The work (Nogueira et al., 2019) proposes a model-based approach to generate test cases for manual execution from well-structured use-case models with well-defined semantics. Use case flows are defined using a tabular format and specified as a mix of natural language and a special CNL. The produced test cases are suitable for manual execution and follow a format very similar to the format proposed by this work.

Natural language processing (NLP) Raharjana et al., 2021 has been extensively used to analyse user stories. One of the applications of NLP is to produce tests (Chinnaswamy et al., 2024; Leotta et al., 2024). More recently, large language models (LLM) have been explored to generate tests from different textual formats (Ng et al., 2004). For instance, the work (Mathur et al., 2023) proposes an approach that uses machine learning models like T5 and GPT-3 to automate the test case generation process. The input for the approach is a statement in natural language. Such a statement is not structured as a US. Moreover, the output is an unstructured test.

7.2. Threats to validity

We discuss some of the threats to the validity of this research.

Construct Validity: The proposed approach for test generation (introduced in Section 4) feeds the GPT-4 model with a fixed prompt with a fixed set of examples of user stories. The prompt structure can influence the results. Moreover, this prompt contains examples that can potentially influence test generation and limit the generalization of the results.

Internal Validity: Since analysts frequently discussed the tool before and during the evaluation, there is the possibility of an unstructured knowledge transfer between them. This informal learning process may have biased how analysts used and evaluated the tool, as their understanding was shaped by prior interactions rather than independent exploration. Consequently, this could influence perceived usability and effectiveness, potentially limiting the objectivity of the evaluation.

Conclusion Validity: The absence of statistical tests directly resulted from the small and homogeneous set of user stories. Thus, no statistical analysis could be performed in the evaluation, as the dataset lacked sufficient samples and variation to support meaningful statistical analysis. Another threat to conclusion validity is that LLM produces varying outputs for the same input, and the evaluation in this study did not control the temperature parameter, nor collected several responses.

7.3. Future work

So far, the quality of the designed test has been evaluated solely on its static properties (clarity, coverage, etc). Validating the efficacy of the designed test suites in detecting bugs is a complementary and essential aspect of the evaluation. Furthermore, recording and comparing the differences in the effort while adopting the tool needs new investigations.

We chose the GPT-4 model because it was the one made available to us by the public service. Possibly using different models such as (*Gemini*, 2025) and (*Claude*, 2025) could lead to diverse results. This is left as a future investigation.

Another future direction is to identify and control the factors that influence the quality of the tests. A complementary effort is to plan a more robust evaluation with a significant number and variety of user stories. Such a larger amount of input would facilitate the application of comprehensive statistical analysis.

The tool was designed to operate solely in the Redmine and Squash TM tools settings, so it must be updated to operate in different settings. Despite the setting's particularity, the core methodology may be applied to other settings. Adaptations to different environments and reusing the core methodology are important for future work.

Acknowledgment

We thank the test and business analysts who supported our project, as well as TCE-PE for providing space for our research team and offering financial resources that enabled the research and supported the involvement of faculty and students.

Contributor statement

Artur Raffael Cavalcanti (ARC): Conceptualization, Data Curation, Formal analysis, Investigation, Methodology, Software, Visualization, Writing – Original Draft; Luan Accioly (LA): Conceptualization, Software; George Valença (GV): Methodology, Project administration, Writing - Review & Editing; Sidney C. Nogueira (SCN): Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Writing – Original Draft, Writing - Review & Editing; Ana Carolina Morais (ACM): Project administration, Resources; Antônio Oliveira (AO): Project administration, Resources; Sérgio Gomes (SG): Project administration, Resources;

Conceptualization: SCN, ARC, LA; Data Curation: ARC; Formal analysis: SCN, ARC; Investigation: SCN, ARC; Methodology: SCN, ARC, GV; Project administration: GV, ACM, AO, SG; Software: ARC, LA; Supervision: SCN; Resources: ACM, AO, SG; Visualization: SCN, ARC, GV; Writing – Original Draft: SCN, ARC; Writing - Review & Editing: SCN, GV.

Use of AI

During the preparation of this work, the author(s) used GRAMMAR and GPT-4 in order to correct grammatical errors. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict of interest (COI)

There is no conflict of interest.

References

Augustine, S. (2005). *Managing agile projects*. Prentice Hall PTR.

Bahrami, M., Mansoorizadeh, M., & Khotanlou, H. (2023). Few-shot learning with prompting methods. *2023 6th International Conference on Pattern Recognition and Image Analysis (IPRIA)*, 1–5. DOI: https://doi.org/10.1109/IPRIA59240.2023.10147172.

Carvalho, G., Barros, F., Carvalho, A., Cavalcanti, A., Mota, A., & Sampaio, A. (2015). Nat2test tool: From natural language requirements to test cases based on csp. In R. Calinescu & B. Rumpe (Eds.), *Software engineering and formal methods* (pp. 283–290). Springer International Publishing.

Chinnaswamy, A., Sabarish, B. A., & Deepak Menan, R. (2024). User story based automated test case generation using nlp. In M. L. Owoc, F. E. Varghese Sicily, K. Rajaram, & P. Balasundaram (Eds.), *Computational intelligence in data science* (pp. 156–166). Springer Nature Switzerland.

Claude. (2025). https://claude.ai/

Dias Neto, A. C., Subramanyan, R., Vieira, M., & Travassos, G. H. (2007). A survey on model-based testing approaches: A systematic review. *Proceedings of the 1st ACM International Workshop on Empirical Assessment of Software Engineering Languages and Technologies: Held in Conjunction with the 22nd IEEE/ACM International Conference on Automated Software Engineering (ASE) 2007*, 31–36. DOI: https://doi.org/10.1145/1353673.1353681.

Garousi, V., & Varma, T. (2010). A replicated survey of software testing practices in the canadian province of alberta: What has changed from 2004 to 2009? [Interplay between Usability Evaluation and Software Development]. *Journal of Systems and Software*, *83*(11), 2251–2262. DOI: https://doi.org/https://doi.org/10.1016/j.jss.2010.07.012.

Gemini. (2025). https://gemini.google.com/app

Gpt-4. (2025). https://openai.com/index/gpt-4/

Granda, M. F., Parra, O., & Alba-Sarango, B. Towards a model-driven testing framework for gui test cases generation from user stories. In: In *Proceedings of the 16th international conference on evaluation of novel approaches to software engineering - enase*. INSTICC. SciTePress, 2021, 453–460. ISBN: 978-989-758-508-1. DOI: https://doi.org/10.5220/0010499004530460.

Kushwaha, D. S., & Misra, A. K. (2008). Software test effort estimation. *SIGSOFT Softw. Eng. Notes*, *33*(3). DOI: https://doi.org/10.1145/1360602.1361211.

Leotta, M., Yousaf, H. Z., Ricca, F., & Garcia, B. (2024). Ai-generated test scripts for web e2e testing with chatgpt and copilot: A preliminary study. *Proceedings of the 28th International Conference on Evaluation and Assessment in Software Engineering*, 339–344. DOI: https://doi.org/10.1145/3661167.3661192.

Likert scale. (2006). https://conjointly.com/kb/likert-scaling/

Lins, L., Accioly, L., Nogueira, S., Valença, G., Machado, A., Lira, A., & Gomes, S. (2023). Evolução do processo de testes do tce-pe: Resultados preliminares de um projeto de bpm. *Anais Estendidos do XIX Simpósio Brasileiro de Sistemas de Informação*, 120–122. DOI: https://doi.org/10.5753/sbsi_estendido.2023.229378.

Mathur, A., Pradhan, S., Soni, P., Patel, D., & Regunathan, R. (2023). Automated test case generation using t5 and gpt-3. *2023 9th International Conference on Advanced Computing and Communication Systems (ICACCS)*, *1*, 1986–1992. DOI: https://doi.org/10.1109/ICACCS57279.2023.10112971.

Mollah, H., & van den Bos, P. (2023). From user stories to end-to-end web testing. *2023 IEEE International Conference on Software Testing, Verification and Validation Workshops (ICSTW)*, 140–148. DOI: https://doi.org/10.1109/ICSTW58534.2023.00036.

Myers, G. J., & Sandler, C. (2004). *The art of software testing*. John Wiley & Sons, Inc.

Ng, S., Murnane, T., Reed, K., Grant, D., & Chen, T. (2004). A preliminary survey on software testing practices in australia. *2004 Australian Software Engineering Conference. Proceedings.*, 116–125. DOI: https://doi.org/10.1109/ASWEC.2004.1290464.

Nogueira, S., Araujo, H., Araujo, R., Iyoda, J., & Sampaio, A. (2019). Test case generation, selection and coverage from natural language. *Science of Computer Programming*, *181*, 84–110. DOI: https://doi.org/https://doi.org/10.1016/j.scico.2019.01.003.

Nomura, N., Kikushima, Y., & Aoyama, M. (2013). Business-driven acceptance testing methodology and its practice for e-government software systems. *2013 20th Asia-Pacific Software Engineering Conference (APSEC)*, *2*, 99–104. DOI: https://doi.org/10.1109/APSEC.2013.122.

Pallavi Pandit, S. T. (2015). Agileuat: A framework for user acceptance testing based on user stories and acceptance criteria. *International Journal of Computer Applications*, *120*(10), 16–21. DOI: https://doi.org/10.5120/21262-3533.

Raharjana, I. K., Siahaan, D., & Fatichah, C. (2021). User stories and natural language processing: A systematic literature review. *IEEE Access*, *9*, 53811–53826. DOI: https://doi.org/10.1109/ACCESS.2021.3070606.

Redmine. (2006). https://www.redmine.org/

Ross, S. I., Martinez, F., Houde, S., Muller, M., & Weisz, J. D. (2023). The programmer's assistant: Conversational interaction with a large language model for software development. *Proceedings of the 28th International Conference on Intelligent User Interfaces*, 491–514. DOI: https://doi.org/10.1145/3581641.3584037.

S Al- Tarawneh, E., & Al-Tarawneh, L. k. (2022). Introducing comprehensive software quality model for evaluating and development e-government websites in jordan using fuzzy analytical hierarchy process. *Webology*, *19*(1), 890–902.

Sivaji, A., Abdullah, A., & Downe, A. G. (2011). Usability testing methodology: Effectiveness of heuristic evaluation in e-government website development. *2011 Fifth Asia Modelling Symposium*, 68–72. DOI: https://doi.org/10.1109/AMS.2011.24.

Sommerville, I. (2007). *Software engineering*. Addison-Wesley. http://books.google.ie/books?id=B7idKfL0H64C

Squash tm. (2025). https://tm-en.doc.squashtest.com/latest/

Appendix A

Answers for Q4

- **Test analyst 1:** "I liked the integration it has with Squash TM and Redmine, the formatting of the test case (this helps a lot since it creates the steps and prerequisites). I liked how it generates multiple test cases for the same story, considering both positive and negative scenarios. What I didn't like is that sometimes the tool doesn't generate test cases for all the stories."
- **Test analyst 2:** "The tool manages to create some scenarios, but it presents many errors before doing so. I believe it requires some improvement in certain areas."
- **Test analyst 3:** "Very useful."

Answers for Q8

- **Test analyst 1:** "In my opinion, the tool effectively explores test creation based on what is written in the stories. This highlights the need to continuously improve the content of the stories themselves. Just as a suggestion, it could enhance the created prerequisites, perhaps by providing more information and training to better identify these conditions."
- **Test analyst 2:** "I'm not sure if it could be improved, but in some scenarios, only the basics are created, even when the story is very detailed."
- **Test analyst 3:** "I recently started using it, and I'm still testing it in my activities."

Comparing Machine Learning and an Expert System for Legal Document Classification

José Jorge de Queiroz Santos Filho[a*], *Filipe* Araújo Dantas[b], *Melquezedeque* da Silva Lima[c], *Shirley* Barbosa dos Santos[d], *Galileu* Genesis[e], *Maria Gabriely* Lima da Silva[f], *Álvaro* Farias Pinheiro[g], *Erayl-son* Galdino da Silva[h]

[a]University of Pernambuco - UPE, Recife, Pernambuco, Brazil, jjqsf@ecomp.poli.br, 0009-0004-6613-7752.

[b]University of Pernambuco - UPE, Recife, Pernambuco, Brazil, fad@ecomp.poli.br, 0000-0003-2452-2076.

[c]UFPE, Recife, Pernambuco, Brazil, msl5@cin.ufpe.br, 0009-0005-6308-8681.

[d]The Office of the State Attorney General of Pernambuco, Recife, Pernambuco, Brazil, 0009-0006-0286-3020.

[e]The Office of the State Attorney General of Pernambuco, Recife, Pernambuco, Brazil, galileugenesis@gmail.com, 0000-0003-2452-2076.

[f]University of Pernambuco - UPE, Recife, Pernambuco, Brazil, mgls@ecomp.poli.br, 0000-0002-3056-3985.

[g]The Office of the State Attorney General of Pernambuco, Recife, Pernambuco, Brazil, alvarofpinheiro@gmail.com, 0000-0002-6254-7293.

[h]University of Pernambuco - UPE, Recife, Pernambuco, Brazil, egs@ecomp.poli.br, 0000-0003-4287-9749 .

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. This study assesses the performance of machine learning models and a rule-based expert system in classifying legal documents, specifically in distinguishing relevant from irrelevant cases. The evaluated models include Random Forest, Naive Bayes, XGBoost, SVM, and Decision Tree, alongside an expert system developed by a State Attorney from PGE-PE. The datasets, representing *Alvará*, *Arrolamento*, and *Inventário* legal processes, contain labeled instances of legal cases. The models were assessed based on accuracy, precision, recall, and F1-score. The results suggest that while machine learning models—particularly Random Forest—achieve higher accuracy and precision, the expert system outperforms in recall and F1-score, ensuring that no relevant cases are overlooked. The choice between machine learning models and expert systems depends on the legal context, requiring a balance between efficiency (reducing false positives) and reliability (capturing all relevant cases).

Keywords. machine learning, legal document classification, expert systems, overfitting, natural language processing
Research paper, DOI: https://doi.org/10.59490/dgo.2025.947

1. Introduction

The Office of the State Attorney General of Pernambuco (in Portuguese, *Procuradoria Geral do Estado de Pernambuco* - PGE-PE) is the government agency responsible for representing the State of Pernambuco in both judicial and extrajudicial matters. Currently, it operates with a limited staff to manage over 600,000 cases, where the efficient handling of this workload aims to protect the rights and interests of the State. This large volume of cases, combined with a workforce that partially lacks legal training, makes the proper distribution of these cases a challenge. Additionally, not all cases that go through the judiciary and involve the Attorney General's Office hold significant financial or social relevance, which affects the extent of public administration efforts. Proper classification of these cases facilitates the appropriate transfer of assets within the Attorney General's Office and ensures the protection of public funds.

This context underscores the critical need for developing an automated system capable of managing the intricate and specialized nature of legal texts, thereby enhancing operational efficiency and directing limited

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

resources toward high-priority cases. One solution lies in implementing a system specifically designed for the classification of legal documents. The literature identifies two primary approaches to building such systems. The first approach involves rule-based expert systems (RBS), which rely on a knowledge base consisting of a set of rules written by experts(Masri et al., 2019). The second approach utilizes machine learning (ML) models, allowing the system to identify patterns that define each document category (Magalhães et al., 2022).

RBS present both advantages and limitations when applied to the classification of legal documents. On the positive side, these systems offer simplicity and transparency, as their deterministic "if-then" rules make the decision-making process straightforward to understand and validate (Sasikumar, 2007). This level of transparency is particularly advantageous in legal contexts, where explainability is essential to fostering user trust and ensuring compliance (Zhou et al., 2023). However, this approach also comes with significant challenges. As the rule base expands, maintaining the system becomes increasingly complex, leading to difficulties in managing rule interdependencies and preserving operational efficiency. Additionally, constructing the knowledge base is a resource-intensive process, requiring extensive input from legal experts to accurately codify rules. This dependency on expert knowledge can be a significant limitation during system development(Westermann et al., 2019).

Machine learning (ML) models offer a dynamic solution to the limitations of rule-based systems in legal document classification. Unlike static rule-based approaches, ML models learn patterns directly from data, enabling adaptation to evolving legal standards and new case types without extensive manual updates. They generalize across diverse document formats, identify nuanced patterns, and efficiently handle large datasets with minimal human intervention after training. This adaptability and scalability position ML models as an alternative or complement to traditional rule-based systems(Prentzas & Hatzilygeroudis, 2007; Westermann et al., 2019).

In this context, this research was conducted with the objective of answering two key questions: (1) Are the evaluated models capable of learning the patterns embedded in legal documents and performing accurate classifications? and (2) Can machine learning models outperform rule-based expert systems developed by domain specialists when evaluated on key classification performance metrics such as accuracy, precision, recall, and F1-score? By addressing these questions, the study conducts a comparative analysis of machine learning models commonly used in document classification, such as XGBoost (Chari et al., 2021), Support Vector Machines (SVM) (Al Hasan et al., 2022), Random Forest (Bento & Teive, 2023), Naive Bayes (Dias & Cavalcante, 2023), and Decision Tree (Gêda et al., 2021), in comparison to a rule-based system built using expert-defined rules.

The comparison evaluates the performance of these approaches in classifying the relevance of document cases related to the Tax on Inheritance and Donation of Goods or Rights, which is referred to in Brazil as ICD (in Portuguese, *Imposto sobre Transmissão Causa Mortis e Doação de quaisquer Bens ou Direitos* - ICD). This domain presents unique challenges due to the legal and procedural complexity of the documents, as well as their substantial volume. These challenges include varying page layouts within the same case, processes of different lengths, and the specialized vocabulary of legal documents. The objective is to identify the approach that provides the most reliable and efficient solution for optimizing resource allocation and supporting decision-making within legal institutions. The main contributions of this study can be summarized as follows:

- This study provides a comprehensive comparative analysis of various classification models and a rule-based expert system, evaluating their performance in classifying the relevance of processes within the context of ICD documents.
- It was verified that the use of machine learning models enhances accuracy and precision but struggles with recall, highlighting a trade-off that must be considered in legal document classification.
- To the best of our knowledge, this is the first work to compare the use of machine learning models with a rule-based expert system in the context of ICD.
- This work sheds light on the challenges machine learning models face in surpassing expert systems, highlighting their limitations in recall and generalization despite achieving higher accuracy and precision.

The remainder of this article is structured as follows: Section 2 reviews related work, providing context and background for our study. Section 3 introduces the proposed methodology and details the experimental protocol applied. Section 4 presents and discusses the results, offering insights into models performances. Finally,

Section 5 concludes the paper by addressing research limitations and outlining potential directions for future work.

2. Related Works

Several studies have addressed the challenge of applying machine learning to document classification in legal contexts, highlighting its potential for improving efficiency and accuracy. The classification of legal documents has greatly advanced with the development of machine learning and natural language processing (NLP) techniques. These technologies facilitate the efficient analysis and categorization of vast amounts of legal texts, streamlining processes and significantly reducing the manual workload for law firms and judicial institutions (Noguti et al., 2020).

For instance, (Magalhães et al., 2022) conducted an experimental analysis using machine learning techniques to group and classify judicial decisions. The study examined a dataset of 430,000 decisions from the Regional Labor Court, employing text representation models based on BERT alongside clustering algorithms such as K-Means. The findings demonstrated that these methods effectively capture the semantic nuances of legal texts, offering significant support for decision-making processes within Brazil's judicial system. This research highlights the potential of advanced ML techniques to enhance the organization and analysis of complex legal data.

The work of (Polo et al., 2021) evaluated the performance of several classifiers combined with different feature extraction approaches to classify Brazilian court cases into three status categories: archived, active, and suspended The study achieved an accuracy of over 93% in the classification tasks, highlighting the effectiveness of XGBoost, MLP, and LSTM models when integrated with feature extraction methods such as BERT and TF-IDF.

Serras and Finger, (Serras & Finger, 2022) conducted a study on the use of attention-based algorithms to automate the categorization of Brazilian legal documents. The authors highlighted several challenges in the classification of legal documents, including redundancy, the use of generic terms, inconsistencies in vocabulary, and poorly defined syntactic structures within and between terms. These challenges are also present in ICD legal documents, a context in which this study aims to evaluate machine learning models.

The works found in the literature corroborate the argument that machine learning approaches can enhance the analysis and classification of legal documents. To the best of our knowledge, this is the first study to investigate the use of machine learning models for classifying the relevance of legal documents in the ICD context within a governmental organization. Furthermore, it compares these models with an expert system based on rules developed by a State Attornes.

3. Methodology and Experimental Protocol

The methodology used to build machine learning models for legal document classification consists of two main steps: preprocessing and modeling training.

3.1. Preprocessing

In the preprocessing stage, data cleaning, normalization and standardization, outlier detection and treatment, and data transformation techniques were applied. This step is crucial for improving data quality, thereby contributing to the accuracy, efficiency, and reliability of the analyzed models. The goal is to prepare raw data for analysis, ensuring it is clean, consistent, and suitable for modeling algorithms or subsequent analyses. This is essential because raw data often contains issues such as missing values, inconsistencies, noise, or inappropriate formats, which can negatively impact the results.

As previously mentioned, during the data preparation stage, a conversion function was used to transform classifications into binary values, enabling the use of vectorization with term frequency-inverse document frequency (TF-IDF). TF-IDF is a measure that combines the local importance of a word in a specific document (TF) with the global importance of that word across a collection of documents (IDF)(Cahyani & Patasik,

2021). The interpretation of TF-IDF provides insights into the relative significance of words within a specific document compared to the entire corpus. The higher the TF-IDF value, the more important the word or term.

Words with higher TF-IDF values can serve as key terms that help distinguish different documents or define the primary topics or themes of a document. These words can be used to summarize document content and construct classification models. In the TF-IDF implementation, we included only tokens that appeared in at least five documents and excluded those with a frequency greater than 90% across the corpus. Another consideration in this technique was limiting the total vocabulary size to 25,000 tokens, which corresponds to the total number present in the analyzed dataset.

3.2. Model Training

For the classification of legal texts using Machine Learning, we studied the application of five models. The first was SVM (Support Vector Machine), a supervised learning algorithm that utilizes a decision boundary, known as a hyperplane, to segregate the analyzed data and define different classes (Al Hasan et al., 2022). A notable observation about this model is that it can become inefficient when dealing with large datasets.

Another model used was Naive Bayes, a probabilistic algorithm based on Bayes' theorem that assumes feature independence. This simplification facilitates classification by analyzing only the presence or absence of specific features, which can also lead to inaccuracies in its results (Dias & Cavalcante, 2023).

Moving on to tree-based models, we also employed Decision Tree, which generates an inverted tree to make predictions. At its nodes, questions about data features are asked, branching based on the answers (Gêda et al., 2021). A critical limitation of this algorithm is its tendency toward overfitting.

The fourth model used was Random Forest. This classifier combines multiple decision trees, each trained on a random sample of the data, and considers a random subset of features to predict classifications through majority voting (Bento & Teive, 2023). However, a drawback of this algorithm is its high computational cost.

Finally, we employed XGBoost (Extreme Gradient Boosting), a tree-based algorithm where multiple weak trees are combined sequentially to create a strong model (Chari et al., 2021). This method is also prone to overfitting and requires careful tuning of its numerous hyperparameters to achieve optimal performance.

Due to the limitation of computational resources, hyperparameter optimization was not performed. For this reason, we used the values reported in the literature. The hyperparameters for these models are detailed in Table 1.

Tab. 1 – Hyperparameters used in model configurations

Model	**Hyperparameter**	**Value**
XGBoost	max_depth	2
	learning_rate	0.1
	n_estimators	600
	random_state	42
	scale_pos_weight	11.5
SVM	C	0.01
	gamma	0.001
	kernel	'linear'
Random Forest	n_estimators	980
	max_depth	48
Naive Bayes	var_smoothing	1e-9
	priors	None
Decision Tree	max_depth	10

The rule-based system developed utilizes a dictionary created by State Attorneys from the Succession and Donation Division of PGE-PE, the department responsible for overseeing the collection of taxes on inheritances

and donations from individuals and legal entities. In this dictionary, weights were assigned to words and expressions such as legal terms, assets, and values, indicating the degree of relevance of these terms, thus contributing to the final classification of the processes.

3.3. Datasets

The processes utilized in this study originate from the Succession and Donation Division (NSD) of the Pernambuco State Attorney General's Office (PGE-PE), a department responsible for monitoring the collection of taxes on successions and donations from individuals and legal entities in the state of Pernambuco.

For this study, three distinct datasets were analyzed, each containing cases labeled as RELEVANT and IRRELEVANT. Each dataset corresponds to a judicial class: *Inventário*, characterized as the formal process of asset division among heirs; *Alvará*, representing a formal authorization issued by an authority for specific activities related to the inventory; and *Arrolamento*, a streamlined inventory process for low-value cases.

In the *Inventário* dataset, which includes 11,839 records, a total of 11,566 RELEVANT cases and 273 IRRELEVANT cases were identified. In the *Arrolamento* dataset, containing 647 records, 354 RELEVANT cases and 293 IRRELEVANT cases were detected. In the *Alvará* dataset, with 392 records, 58 RELEVANT cases and 334 IRRELEVANT cases were recorded.

For the *Alvará* cases, the average word count per case was 6,849.64, with a maximum of 11,251 words and a minimum of 920 words. For the *Arrolamento* cases, the average word count per case was 7,637.70, with a maximum of 11,710 words and a minimum of 1,051 words. For the *Inventário* cases, the average word count per case was 8,341.11, with a maximum of 22,714 words and a minimum of 1 (one) word.

To conduct the experiment, the datasets were divided into training and testing sets, with **80%** allocated for training and **20%** for testing.

3.4. Performance Metrics

The system evaluation uses metrics already applied in the literature for classification tasks, which include: Accuracy – used to determine the proportion of correct predictions relative to the total predictions made; Precision – measures the proportion of true positives among all positive predictions; Recall – identifies the proportion of true positives correctly identified among all actual positive samples; F1-Score – defines the harmonic mean between Precision and Recall. However, this metric does not account for the class proportions in the dataset; and Confusion Matrix – used to graphically visualize the model's performance in classifying each class, displaying true positives, true negatives, false positives, and false negatives.

In this study, we classify processes as RELEVANT for the positive class (P) and IRRELEVANT for the negative class (N). Thus, TP (True Positive) refers to the number of samples correctly classified as positive; TN (True Negative) is the number of samples correctly classified as negative; FP (False Positive) represents the number of samples incorrectly classified as positive, and FN (False Negative) is the number of samples incorrectly classified as negative.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{1}$$

$$Precision = \frac{TP}{TP + FP} \tag{2}$$

$$Recall = \frac{TP}{TP + FN} \tag{3}$$

$$F1 - Score = 2 \cdot \frac{Precision \cdot Recall}{Precision + Recall} \tag{4}$$

4. Experiments and Results

To address the question, "Are the evaluated models capable of learning the patterns embedded in legal documents and performing accurate classifications?" the performance of the classifiers was assessed using both training and test samples for each dataset. This evaluation aimed to determine their ability to generalize beyond the data on which they were trained.

Table 2 show the performance of the models on the *Alvará* dataset. Regarding accuracy, most models, including XGBoost, Random Forest, and Naive Bayes, achieve comparable results on the test set (0.88). Accuracy measures the proportion of correctly classified instances across all classes and provides a general overview of the model's performance. However, the *Alvará* dataset exhibits an imbalanced class distribution, with only 18.47% of instances belonging to the relevant class. Therefore, metrics such as Precision and Recall are more critical for evaluating the models' effectiveness in identifying relevant instances.

The precision metric evaluates the proportion of correctly identified relevant instances among all instances retrieved by the model, with higher values indicating a lower rate of false positives. In this regard, the Random Forest and Naive Bayes models achieved the best performance, each with a precision of 94% on the test sample. On the other hand, the recall metric measures the proportion of relevant instances correctly identified by the model out of all relevant instances in the dataset, with higher values reflecting a lower rate of false negatives. For this metric, the Decision Tree model demonstrated the best performance, achieving a recall of 0.72.

When comparing the training and testing results, it is evident that most models achieved a perfect performance on the training sample. However, this performance dropped drastically on the test sample, indicating that the models were significantly affected by the overfitting problem.

To address the second question, "Can machine learning models outperform rule-based expert systems developed by domain specialists when evaluated on key classification performance metrics such as accuracy, precision, recall, and F1-score?", the performance of the classifiers was evaluated using test samples from each dataset and compared against the performance of an expert system developed by a State Attorney from the PGE-PE.

Model	**Training**				**Testing**			
	Accuracy	**Precision**	**Recall**	**F1-Score**	**Accuracy**	**Precision**	**Recall**	**F1-Score**
XGBoost	1.0000	1.0000	1.0000	1.0000	**0.8861**	0.8459	0.6592	0.7034
SVM	0.8675	0.4338	0.5000	0.4645	0.8481	0.4241	0.5000	0.4589
Random Forest	1.0000	1.0000	1.0000	1.0000	**0.8861**	**0.9408**	0.6250	**0.7685**
Naive Bayes	1.0000	1.0000	1.0000	1.0000	**0.8861**	**0.9408**	0.6250	0.6685
Decision Tree	1.0000	1.0000	1.0000	1.0000	0.8228	0.6791	**0.7245**	0.6962

Tab. 2 – Performance metrics of models on the *Alvará* dataset during training and testing, with the best results for each metric highlighted in bold.

Model	**Training**				**Testing**			
	Accuracy	**Precision**	**Recall**	**F1-Score**	**Accuracy**	**Precision**	**Recall**	**F1-Score**
XGBoost	1.0000	1.0000	1.0000	1.0000	0.7154	0.7168	0.6957	0.6982
SVM	0.5581	0.2791	0.5000	0.3582	0.5692	0.2846	0.5000	0.3627
Random Forest	1.0000	1.0000	1.0000	1.0000	**0.7462**	**0.7438**	**0.7314**	**0.7347**
Naive Bayes	0.9948	0.9942	0.9954	0.9948	0.5923	0.5778	0.5000	0.5377
Decision Tree	0.9793	0.9821	0.9766	0.9789	0.7077	0.7050	0.6911	0.6935

Tab. 3 – Performance metrics of models on the *Arrolamento* dataset during training and testing, with the best results for each metric highlighted in bold.

For the *Arrolamento* dataset, Table 3 presents the performance metrics of the models during training and testing. In this case, the Random Forest model achieved the best results across all evaluated metrics. However, it is evident that overfitting also affected the models in this dataset. For example, the Naive Bayes model

achieved a performance above 0.99 on the training sample but dropped to approximately 0.60 on the testing sample.

Model	Training				Testing			
	Accuracy	**Precision**	**Recall**	**F1-Score**	**Accuracy**	**Precision**	**Recall**	**F1-Score**
XGBoost	0.9958	0.9978	0.9143	0.9520	0.9764	0.6553	0.5087	0.5113
SVM	0.9754	0.4877	0.5000	0.4938	0.9768	0.4884	0.5000	0.4941
Random Forest	0.9959	0.9979	0.9171	0.9538	**0.9772**	**0.9886**	0.5091	0.5121
Naive Bayes	0.9879	0.8352	0.9938	0.8983	0.9700	0.5725	**0.5320**	**0.5430**
Decision Tree	0.9835	0.9834	0.6685	0.7469	0.9709	0.5639	0.5236	0.5326

Tab. 4 – Performance metrics of models on the *Inventário* dataset during training and testing, with the best results for each metric highlighted in bold.

Table 4 show the performance of the models on the *Inventário* dataset. The Random Forest model demonstrated a superior performance with the highest accuracy (0.9772) and precision (0.9886), highlighting its ability to correctly identify relevant cases. For the Recall and F1-Score, the best results are achieved by the Naive Bayes, demonstrating its ability to effectively balance the trade-off between precision and recall, particularly in identifying relevant instances in the dataset. When comparing the training and testing results, it is possible to observe that the accuracy metric values are relatively close in both samples. However, when analyzing the Precision and Recall results, the impact of overfitting becomes evident in most of the models. This highlights the importance of evaluating models using multiple metrics to gain a comprehensive understanding of their performance.

Addressing the first research question that guided this study, the results suggest that while the evaluated models exhibit the capacity to learn patterns in legal documents, their practical utility is constrained by certain limitations. The high accuracy achieved across models highlights their potential for the task of legal document classification; however, the reliance on this metric alone can be misleading, particularly in imbalanced datasets where metrics such as precision and recall are more indicative of real-world performance. Furthermore, the significant drop in performance from training to testing data underscores the pervasive issue of overfitting, raising concerns about the models' ability to generalize beyond the training set.

Dataset	Model	Accuracy	Precision	Recall	F1-Score
Alvará	XGBoost	**0.8861**	0.8459	0.6592	0.7034
	SVM	0.8481	0.4241	0.5000	0.4589
	Random Forest	**0.8861**	**0.9408**	0.6250	0.6885
	Naive Bayes	**0.8861**	**0.9408**	0.6250	0.6685
	Decision Tree	0.8228	0.6791	0.7245	0.6962
	Expert System	0.7595	0.8557	**0.7595**	**0.7883**
Arrolamento	XGBoost	0.7154	0.7168	0.6957	0.6982
	SVM	0.5692	0.2846	0.5000	0.3627
	Random Forest	**0.7462**	**0.7438**	**0.7314**	**0.7347**
	Naive Bayes	0.5923	0.5778	0.5702	0.5677
	Decision Tree	0.7077	0.7050	0.6911	0.6935
	Expert System	0.7000	0.6977	0.7000	0.6985
Inventário	XGBoost	0.9764	0.6553	0.5087	0.5113
	SVM	0.9768	0.4884	0.5000	0.4941
	Random Forest	**0.9772**	**0.9886**	0.5091	0.5121
	Naive Bayes	0.9700	0.5725	0.5320	0.5430
	Decision Tree	0.9709	0.5639	0.5236	0.5326
	Expert System	0.9624	0.9658	**0.9624**	**0.9658**

Tab. 5 – Comparison of model performance with the Expert System on the test set for the datasets *Alvará*, *Arrolamento* and *Inventário*, with the best results for each metric highlighted in bold.

To address the second question, "Can machine learning models outperform rule-based expert systems devel-

oped by domain specialists when evaluated on key classification performance metrics such as accuracy, precision, recall, and F1-score?", the performance of the classifiers was evaluated using test samples from each dataset and compared against the performance of an expert system developed by a State Attorney from the PGE-PE.

For the *Alvará* dataset, Random Forest, Naive Bayes, and XGBoost achieve the highest accuracy (88.61%), outperforming the Expert System (75.95%). This suggests that the ML models are generally better at correctly classifying cases across all classes. However, the Expert System achieves the highest recall (0.7595) and F1-score (0.7883), indicating that it is more effective in identifying relevant legal cases (i.e., those that should be classified as positive). This could be due to the rule-based nature of the Expert System, which is likely designed with legal expertise to minimize false negatives—ensuring that important cases are not overlooked. In contrast, while ML models have higher precision (Random Forest and Naive Bayes: 0.9408), their lower recall (0.6250) means they may fail to capture some relevant cases. This trade-off is critical, higher precision reduces false positives but may lead to missed relevant cases, whereas higher recall ensures that fewer important cases are ignored.

For the *Arrolamento* dataset, Random Forest outperforms the Expert System across all metrics, achieving the highest accuracy (0.7462), precision (0.7438), recall (0.7314), and F1-score (0.7347). This suggests that, for this dataset, the ML model is not only more consistent in correctly classifying cases overall, but it also maintains a better balance between precision and recall. The Expert System achieves slightly lower but comparable performance across all metrics (accuracy: 0.7000, precision: 0.6977, recall: 0.7000, and F1-score: 0.6985). This indicates that for *Arrolamento* cases, the ML model is more effective than the rule-based system, likely because legal patterns in this dataset are more learnable from the data than from fixed rules. The fact that ML models can optimize both precision and recall in this case suggests they may be better suited for handling the complexities of classification in this specific legal context.

For the *Inventário* dataset, Random Forest achieves the highest accuracy (0.9772) and precision (0.9886), meaning it is highly effective at reducing false positives, which is crucial when the goal is to ensure that only highly relevant cases are classified as such. However, the Expert System achieves the highest recall (0.9624) and F1-score (0.9658), meaning it is more effective at capturing all relevant cases—even at the cost of slightly lower precision. However, the Expert System achieves the highest recall (0.9624) and F1-score (0.9658), meaning it is more effective at capturing all relevant cases—even at the cost of slightly lower precision. This suggests that, for the *Inventário* dataset, the Expert System ensuring that relevant cases are not ignoreted, which is particularly important in legal contexts where missing a critical instance could have significant consequences.

Addressing the second research question, the results indicate that ML models generally achieve higher accuracy and precision, making them valuable for reducing false positives—an essential factor if the legal system aims to streamline case classification and avoid unnecessary workload on legal professionals. However, the Expert System often performs better in recall and F1-score, suggesting it is more cautious and prioritizes the inclusion of all potentially relevant cases. This is particularly important in legal contexts where missing a relevant case (false negatives) could have serious consequences, such as delays in legal proceedings or overlooked claims.

Ultimately,it can be inferred that the choice between ML models and the Expert System depends on the legal priorities for classification. If efficiency and reducing false positives are the primary goals, ML models—particularly Random Forest—are superior. However, if ensuring that no relevant case is missed is more critical, the Expert System remains highly competitive, particularly in recall-focused applications.

Furthermore, in this study, the models were evaluated using a baseline pipeline, applying TF-IDF for text embedding and implementing classical classifiers with hyperparameters derived from the literature. However, the results indicate that, despite achieving higher performance in metrics such as accuracy and precision across most datasets, the models were significantly affected by overfitting and failed to attain high performance in recall and F1-score, which are crucial for identifying relevant cases.

Thus, to enhance the performance of these models in legal document classification, future research should prioritize mitigating overfitting through advanced regularization techniques (Moradi et al., 2020), the use of contextual document embeddings (Morris & Rush, 2024), under-sampling or over-sampling strategies (Taha

et al., 2021), use of hybrid approach Villena Román et al., 2011, and hyperparameter fine-tuning (Bischl et al., 2023). Effectively addressing these challenges would improve the models' generalization to unseen data, ultimately making them more practical, reliable, and well-suited for real-world legal applications.

5. Conclusion

This study evaluated the performance of machine learning models and a rule-based expert system in classifying legal documents, specifically in categorizing relevant and irrelevant cases. The evaluated models included Random Forest, Naive Bayes, XGBoost, SVM, and Decision Tree, alongside an expert system developed by a State Attorney from PGE-PE. The datasets, representing *Alvará*, *Arrolamento* and *Inventário* legal processes, contained labeled instances of legal cases. The models were assessed based on accuracy, precision, recall, and F1-score, providing a comprehensive assessment of their effectiveness.

The findings of this study reinforced the potential of machine learning models for legal document classification, particularly in terms of precision and accuracy. The Random Forest, Naive Bayes, and XGBoost models achieved promising performance, with accuracy rates ranging from 74.62% to 97.72% across different datasets. However, as observed in previous research on machine learning in the legal domain, these models exhibited susceptibility to overfitting, particularly in recall and F1-score, emphasizing the need for techniques that could address this issue.

In contrast, the rule-based expert system demonstrated superior recall and F1-score, ensuring the identification of most relevant cases, a crucial aspect in legal contexts where false negatives could be highly problematic. However, consistent with findings in the literature, this approach had limitations regarding flexibility and precision, particularly when applied to large-scale unstructured data.

Despite the advancements presented in this study, some limitations needed to be acknowledged. First, the models were trained and tested on a specific dataset, and their generalizability to other legal domains might have required additional fine-tuning. Additionally, the absence of advanced class-balancing techniques may have influenced the recall and F1-score of the machine learning models. Future research should focus on mitigating these challenges by exploring enhanced regularization, contextual embeddings, sampling methods, hybrid approaches, and hyperparameter tuning to improve performance and robustness.

By addressing these challenges, machine learning models could become even more efficient and reliable for practical applications in the legal sector, contributing to the automation and optimization of legal document classification.

References

Al Hasan, S., Hussain, M. G., Protim, J., Rahman, M. M., Fahim, N., Chowdhury, M. Z., & Pritom, A. I. (2022). Classification of multi-labeled text articles with reuters dataset using svm. *2022 International Conference on Science and Technology (ICOSTECH)*, 01–05.

Bento, F. M., & Teive, R. C. G. (2023). Classificação de documentos jurídicos utilizando a arquitetura transformer: Uma análise comparativa com algoritmos tradicionais de machine learning e chatgpt. *Brazilian Journal of Development*, *9*(6), 20208–20224.

Bischl, B., Binder, M., Lang, M., Pielok, T., Richter, J., Coors, S., Thomas, J., Ullmann, T., Becker, M., Boulesteix, A.-L., et al. (2023). Hyperparameter optimization: Foundations, algorithms, best practices, and open challenges. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, *13*(2), e1484.

Cahyani, D. E., & Patasik, I. (2021). Performance comparison of tf-idf and word2vec models for emotion text classification. *Bulletin of Electrical Engineering and Informatics*, *10*(5), 2780–2788.

Chari, H., Aswale, S., Pawar, V. N., Shetgaonkar, P., & Kumar, K. C. (2021). Advertisement click fraud detection using machine learning techniques. *2021 International Conference on Technological Advancements and Innovations (ICTAI)*, 109–114.

Dias, L. C. M., & Cavalcante, L. G. M. (2023). Aplicação do classificador naive bayes para detecção de fraudes. *Ciência Da Computação: Avanços E Tendências Em Pesquisa*, *1*, 9–26.

Gêda, B. M., et al. (2021). Classificação de textos de decisões judiciais.

Magalhães, D., Pozo, A., & Machado, S. (2022). Técnicas de aprendizado de máquinas aplicadas à classificação de decisões judiciais. *Revista de Estudos Empíricos em Direito*, *9*.

Masri, N., Sultan, Y. A., Akkila, A. N., Almasri, A., Ahmed, A., Mahmoud, A. Y., Zaqout, I., & Abu-Naser, S. S. (2019). Survey of rule-based systems. *International Journal of Academic Information Systems Research (IJAISR)*, *3*(7), 1–23.

Moradi, R., Berangi, R., & Minaei, B. (2020). A survey of regularization strategies for deep models. *Artificial Intelligence Review*, *53*(6), 3947–3986.

Morris, J. X., & Rush, A. M. (2024). Contextual document embeddings. *arXiv preprint arXiv:2410.02525*.

Noguti, M. Y., Vellasques, E., & Oliveira, L. S. (2020). Legal document classification: An application to law area prediction of petitions to public prosecution service. *2020 International joint conference on neural networks (IJCNN)*, 1–8.

Polo, F. M., Ciochetti, I., & Bertolo, E. (2021). Predicting legal proceedings status: Approaches based on sequential text data. *Proceedings of the Eighteenth International Conference on Artificial Intelligence and Law*, 264–265.

Prentzas, J., & Hatzilygeroudis, I. (2007). Categorizing approaches combining rule-based and case-based reasoning. *Expert Systems*, *24*(2), 97–122.

Sasikumar, M. (2007). A practical introduction to rule based expert systems.

Serras, F. R., & Finger, M. (2022). Verbert: Automating brazilian case law document multi-label categorization using bert. *arXiv preprint arXiv:2203.06224*.

Taha, A. Y., Tiun, S., Abd Rahman, A. H., & Sabah, A. (2021). Multilabel over-sampling and under-sampling with class alignment for imbalanced multilabel text classification. *Journal of Information and Communication Technology*, *20*(3), 423–456.

Villena Román, J., Collada Pérez, S., Lana Serrano, S., & González Cristóbal, J. C. (2011). Hybrid approach combining machine learning and a rule-based expert system for text categorization.

Westermann, H., Šavelka, J., Walker, V. R., Ashley, K. D., & Benyekhlef, K. (2019). Computer-assisted creation of boolean search rules for text classification in the legal domain. In *Legal knowledge and information systems* (pp. 123–132). IOS Press.

Zhou, X., Du, H., Sun, Y., Ren, H., Cui, P., & Ma, Z. (2023). A new framework integrating reinforcement learning, a rule-based expert system, and decision tree analysis to improve building energy flexibility. *Journal of Building Engineering*, *71*, 106536.

Data-Driven Analysis for Improving Educational Policies: A Case in Brazil's Textbook Program

André Araújo[a], *Rafael* Araújo[a,b], *Luciano* Cabral[a,c], *Luciane* Silva[a,b], *Hilario* Tomaz[a,d], *Emerson* Martins[a,b], *Diego* Dermeval[a,e], *Álvaro* Sobrinho[a,f*], *Alan Pedro da* Silva[a,g], *Leonardo* Marques[a,e], *Filipe* Recch[h], *Sebastian* Munoz-Najar Galvez[e], *Seiji* Isotani[a,e,i], *Ig* Ibert Bittencourt[a,e]

[a]Center for Excellence on Social Technology (NEES), Federal University of Alagoas, Maceió, Alagoas, Brazil.

[b]Federal University of Uberlândia, Uberlândia, Minas Gerais, Brazil.

[c]Federal Institute of Pernambuco, Recife, Pernambuco, Brazil.

[d]Federal Institute of Espírito Santo, Serra, Espírito Santo, Brazil

[e]Harvard Graduate School of Education, Cambridge, Massachusetts, United States

[f]Federal University of the Agreste of Pernambuco, Garanhuns, Pernambuco, Brazil. Email: alvaro.alvares@ufape.edu.br.

[g]University of Oxford, Oxford, Oxfordshire, United Kingdom.

[h]University of Pittsburgh, Pittsburgh, PA, United States.

[i]University of São Paulo, São Carlos, São Paulo, Brazil.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. Data analytics can support evidence-based decision-making in public policies by enabling the identification of patterns, forecasting needs, and prioritizing actions. Consequently, data-driven analysis can aid policymakers in redesigning and enhancing educational policies, such as textbook distribution for public schools. However, there is no consensus on a structured approach for descriptive analytics in this context. This study presents a descriptive approach to textual data analysis aimed at improving policy implementation and monitoring, with a focus on effort, productivity, and quality of reviews produced by textbook evaluators. Through a case study, we apply natural language processing techniques to analyze thousands of answers to rubrics during the pedagogical evaluation of a public call for literary works under the Brazilian textbook program (Programa Nacional do Livro e do Material Didático - PNLD). The PNLD is one of the most extensive textbook policies, impacting millions of students. Our findings shed light on challenges related to the effort involved and the quality of written reports in the pedagogical evaluation process. Analyzing reports, which reflect some desired and undesired behaviors of evaluators, can offer policymakers insights for making informed decisions and improving textbook programs worldwide. Our descriptive approach to textual data analysis leverages insights to enhance transparency, inform improvements, and guide policy implementation through real-time monitoring.

Keywords. Official Approval, Data Science, Descriptive Analysis, PNLD.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1023

1. Introduction

A data science process consists of descriptive, predictive, and prescriptive steps, supporting the entire cycle of data-driven analysis and decision-making (Delen, 2019; Sharda et al., 2018). Thus, data-driven analysis has been recognized as a significant approach for supporting governments and public organizations, for instance, in developing and improving educational policies (Badrul Hisham et al., 2024; Kulal et al., 2024). Data analytics enables governments and public organizations to make evidence-based decisions by leveraging large

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

volumes of data to identify patterns, predict future needs, and prioritize actions (Kulal et al., 2024). Analytical techniques, such as those driven by Artificial Intelligence (AI), can impact public resource allocation and tackle modern governance challenges (Santoso et al., 2024).

In education, data analytics can inform educational policies to reduce inequalities and improve access (Pencheva et al., 2020). Data-driven analysis can also assist policymakers in redesigning and developing educational policies (Badrul Hisham et al., 2024). The Brazilian textbook program (Programa Nacional do Livro e do Material Didático - PNLD) evaluates educational materials, including literary works, to ensure high-quality tools that support learning for millions of public school students. By maintaining a structured pedagogical and technical evaluation process, the PNLD plays an important role in aligning these materials with national educational objectives (Sobrinho et al., 2023). The PNLD is an example of an educational public policy that can benefit from data-driven analysis to enhance monitoring processes and support policy reformulations.

This paper emphasizes descriptive analytics, where we analyze past events to lay the foundation for future predictive and prescriptive steps. While data-driven analysis has proven to be a relevant approach in supporting educational public policies, such as the PNLD, there is no consensus on a structured approach for conducting descriptive analytics in this context. More standardized guidelines are needed for integrating data analysis into policies, resulting in heterogeneous and context-specific approaches (Pencheva et al., 2020). We contribute to the state-of-the-art by proposing a descriptive approach to textual data analysis that supports improving policies for distributing educational materials. Our case study focuses on the PNLD 2024 public call for literary works, analyzed from three key aspects: effort, productivity, and quality. We investigate the PNLD program by analyzing the evaluation process of educational materials.

Providing well-designed educational materials to every student is a significant need that may influence learning performance (Liu, 2023; UNESCO, 2016). Public policies related to educational materials such as textbooks and literary works must include robust evaluation processes to ensure content and editorial quality. The PNLD comprises steps for enrollment/validation, pedagogical evaluation, technical qualification, choice (by public school principals and teachers), negotiation, acquisition, and distribution of educational materials (Sobrinho et al., 2023). This paper depicts the pedagogical evaluation process of PNLD, which considers the quality of contents. We expect that the data analysis from evaluation reports can support policy-makers in making informed decisions to improve this type of program.

Despite a comprehensive and centralized process, which includes steps to evaluate the educational materials rigorously, the PNLD program's pedagogical evaluation process encounters challenges that could compromise the distribution time of educational materials to students and the process quality (Silva et al., 2024).These challenges include high evaluator effort, textual inconsistencies, and report quality issues, which can compromise the program's efficiency and delay the timely distribution of materials. This issue transcends the PNLD program and potentially has implications in the countries that conduct official evaluations with similar characteristics. In the context of the Brazilian textbook policy, the pedagogical evaluation process is started when a public call for educational materials is issued, outlining the evaluation criteria to ensure quality. The call guides a rigorous blind evaluation procedure, where a series of questions and justifications are considered, leading to a partial report. A pedagogical and technical committee then thoroughly reviews this report to ensure compliance with the evaluation criteria, culminating in a final report. The evaluation process teams include five key actors: Evaluator 1, Evaluator 2, Assistant Coordinator, Pedagogical Advisor, and Pedagogical Coordinator. The involvement of multiple materials and actors adds complexity, mainly due to the hierarchical evaluation structure extending from the evaluators to the pedagogical coordinator.

We examine the relationships among the documents generated by each participant to analyze issues related to effort, productivity, and quality. As a case study, we pre-process data and analyze reports from evaluators, assistant coordinators, pedagogical advisors, and pedagogical coordinators involved in the PNLD 2024 public call for literary works. We leverage natural language processing techniques, such as text similarity analysis (Wang & Dong, 2020), to handle thousands of answers to rubrics and gain deeper insights into the challenges encountered during the evaluation process of this particular public call. Few researchers have thoroughly analyzed these complexities before textbooks and literary works receive (or fail to receive) official approval (Clark et al., 2024). Among the potential causes for the lack of data on this process may be the unavailability of comprehensive government data since this process might not be digitalized or be restricted to internal stakeholders. As partners of the Brazilian Ministry of Education, the authors have the authorization to research and innovate in the platform (PNLD-Avaliação) that supports the official approval of the textbooks.

2. Methodology

2.1. Descriptive Approach to Textual Data Analysis

We structured our descriptive approach to textual data analysis by defining our goals, Research Questions (RQs), and metrics to support the answers to the RQs. Our initial goal (Table 1) focuses on comprehending the report writing efforts of the pedagogical and technical committee. The final report serves as a written explanation of the committee's decision regarding the literary works' approval (or rejection). We identified six metrics based on text similarity (Wang & Dong, 2020) and text length, aimed at answering three RQs.

Tab. 1 – Goal 1. Understand report writing efforts from analyzing previous works of the assistant coordinator, pedagogical advisor, and pedagogical coordinator.

Question Description	Metric
(RQ1.1) What is the effort level of the assistant coordinator when reusing and editing the peer revision?	**(M1.1)** Similarity between reports from double-blind revisions and assistant coordinator.
	(M2.1) Total length of reports from double-blind revisions and assistant coordinator.
(RQ2.1) What is the effort level of the pedagogical advisor when reusing and editing the report from the assistant coordinator?	**(M3.1)** Similarity between reports from the assistant coordinator and pedagogical advisor.
	(M4.1) Total length of reports from the assistant coordinator and pedagogical advisor.
(RQ3.1) What is the effort level of the pedagogical coordinator when reusing and editing the report from the pedagogical advisor?	**(M5.1)** Similarity between reports from the pedagogical advisor and coordinator.
	(M6.1) Total length of reports from the pedagogical advisor and coordinator.

Our second goal (Table 2) centers on assessing the productivity of the pedagogical and technical committee during the report writing process. We established three metrics based on the time taken to complete tasks to achieve this goal, aiming to address three specific RQs.

Tab. 2 – Goal 2. Understand the productivity in report writing from analyzing previous works of the assistant coordinator, pedagogical advisor, and pedagogical coordinator.

Question Description	Metric
(RQ1.2) What is the productivity level of the pedagogical coordinator?	**(M1.2)** The time the pedagogical coordinator completes tasks.
(RQ2.2) What is the productivity level of the pedagogical advisor?	**(M2.2)** The time the pedagogical advisor completes tasks.
(RQ3.2) What is the productivity level of the assistant coordinator?	**(M3.2)** The time the assistant coordinator completes tasks.

Our third goal (Table 3) concentrates on evaluating the quality of partial reports provided by evaluators regarding compliance, partial compliance, and non-compliance with evaluation criteria. These partial reports serve as textual explanations of the evaluator's decisions. Quality refers to how easy the text is to understand, providing grammatically correct evaluations. To address the four RQs related to this goal, we established seven metrics based on text readability[1], complexity[2], spelling quality, length, and similarity.

Tab. 3 – Goal 3. Understand the quality of partial reports from analyzing previous works of evaluators.

Question Description	Metric
(RQ1.3) What is the writing quality of partial reports?	**(M1.3)** Readability of partial reports.
	(M2.3) The spelling quality of partial reports.
(RQ2.3) What is the level of detail in partial reports?	**(M3.3)** The total length of partial reports.
	(M4.3) The level of complexity of partial reports.
(RQ3.3) What is the level of uniqueness of partial report contents?	**(M5.3)** Similarity of reports of the same evaluator across different documents.
(RQ4.3) What is the agreement level between evaluators?	**(M7.3)** Similarity between partial reports of two evaluators of the same document.

Our fourth and fifth goals (Table 4), respectively, concentrate on the efforts and productivity of evaluators when writing partial reports regarding compliance, partial compliance, and non-compliance with evaluation criteria. We consider four levels of effort, which refer to how laborious it is to produce a text based on previous reports. No effort occurs when no changes are required from the previous reports. For instance, the assistant coordinator reused all text produced by a specific evaluator (i.e., 100% similarity, the same total length, and zero difference between the strings). Minor effort occurs when some changes are required from the previous reports. For instance, the assistant coordinator changed the writing style from the text produced by a specific evaluator. Major effort occurs when significant changes are required from the previous reports. For instance, the assistant coordinator changed the report by mentioning specific external documents, such as laws. Full

[1] Text readability refers to how easily a reader can comprehend a reporting text.
[2] The complexity of the report text is influenced by external references (e.g., laws and national curriculum).

effort occurs when changes in decisions are required from the previous reports. For instance, the assistant coordinator changed the decision from conditionally approved to reproved. Conversely, productivity measures the value generated per hour worked. To address the two RQs associated with these goals, we established three metrics based on task completion time, text length, and text complexity.

Tab. 4 – Goals 4 and 5. Understand the efforts and productivity of writing partial reports from analyzing previous works of evaluators.

Question Description	Metric
(RQ1.4) What is the effort level when writing partial reports?	**(M1.4)** Total length of partial reports.
	(M2.4) The level of complexity of partial reports.
(RQ1.5) What is the productivity level of the evaluators?	**(M1.5)** The time the evaluator completes tasks.

Our sixth goal (Table 5) centers on assessing evaluators' quality of question responses regarding compliance, partial compliance, and non-compliance with evaluation criteria. This analysis is essential because evaluators objectively state one of these three fixed possibilities for each evaluation criterion. To address the two RQs related to this goal, we defined two metrics based on the Kappa index (Cohen, 1960; McHugh, 2012).

Tab. 5 – Goal 6. Understand the quality of questions responses from analyzing previous works of evaluators.

Question Description	Metric
(RQ1.6) What is the agreement level between evaluators?	**(M1.6)** Kappa concordance between two evaluators' answers to the same literary work questions.
(RQ2.6) What is the agreement level of each evaluator with the pedagogical coordinator?	**(M2.6)** Kappa concordance between the evaluator's answer to questions and the final report.

Our seventh and eighth goals (Table 6) concentrate on evaluating the quality of justifications (associated with questions from the sixth goal) and the efforts expended by evaluators in writing them, respectively. Each evaluator produces a textual justification for the responses to the questions. To address the three RQs associated with these goals, we established six metrics based on text readability, spelling quality, length, and complexity.

Tab. 6 – Goals 7 and 8. Understand the quality of justifications and efforts in writing them from analyzing previous works of evaluators.

Question Description	Metric
(RQ1.7) What is the writing quality of justifications?	**(M1.7)** Readability of justifications.
	(M2.7) The spelling quality of justifications.
(RQ2.7) What is the level of detail in justifications?	**(M3.7)** The total length of justifications.
	(M4.7) The level of complexity of justifications.
(RQ1.8) What is the effort level when writing justifications?	**(M1.8)** Total length of justifications.
	(M2.8) The level of complexity of justifications.

2.2. Datasets

To answer our RQs, we gathered data from reports submitted during the 2024 PNLD public call for literary works (focused on the final educational years). Thus, based on the data gathered from the Brazilian Ministry of Education database, we defined four datasets to conduct our analysis: **2024_3_functions_report dataset** (1450 instances, comprising 396 reports from assistant coordinators, 491 from pedagogical advisors, and 563 from pedagogical coordinators), **2024_3_evaluators_report dataset** (927 instances, comprising reports from 181 evaluators), **2024_3_functions_question dataset** (125465 instances, comprising 42226 responses from assistant coordinators, 34821 from pedagogical advisors, and 48418 from pedagogical coordinators), and **2024_3_evaluators_question dataset** (79838 instances, comprising responses from 181 evaluators).

The original datasets contained more than 30 data fields. However, we reduced this to 15 fields to better understand the efforts and capacities of evaluators, assistant coordinators, pedagogical advisors, and pedagogical coordinators. For each dataset, we used the following data fields to conduct our analyses: **CO_call** (identification of the public call), **DS_call** (description of the public call), **CO_object** (identification of the object related to the public call), **DS_object** (description of the object related to the public call), **CO_evaluation_team** (evaluation team alphanumeric code), **DS_function** (description of function - i.e., assistant coordinators, pedagogical advisors, or pedagogical coordinators), **CO_work** (identification of the literary work), **CO_form_block** (identification of a block of an evaluation form), **CO_form_eval** (identification of an evaluation form), **CO_question** (identification of an objective question of the evaluation form), **DS_question** (description of an objective question of the evaluation form), **CO_question_response** (identification of a response to an objective question of

the evaluation form), **DS_question_response** (description of a response to an objective question of the evaluation form), **DS_question_justification** (justification for responding to an objective question of the evaluation form), and **CO_evaluator** (identification of the education professional - i.e., evaluator).

2.3. Data Pre-processing and Analysis

Our data pre-processing procedure comprises seven steps (Figure 1): data verification, data adequacy, dimensionality reduction, encoding, content verification, justification adjustment, and creation of auxiliary data fields. These steps were crucial to enable our data analysis.

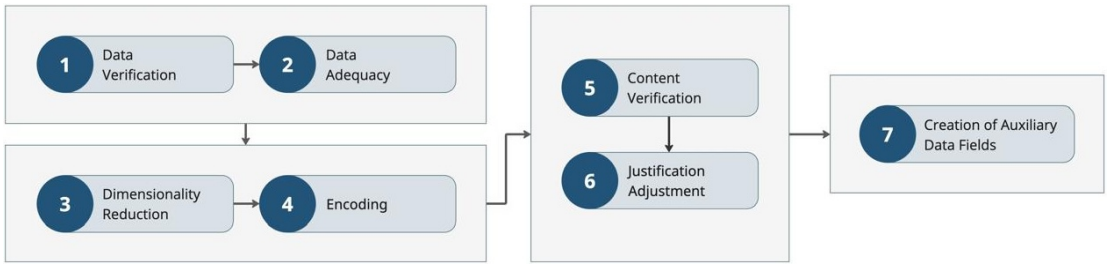


Fig. 1 – Data pre-processing steps.

We checked if the data conformed to the database structure (Step 1). A missing column label was almost always, which caused data inconsistency. We identified the issue and added two labels after the CREATED_AT and UPDATED_AT fields, ensuring the structure is correct (Step 2). Another important task was removing columns with zero or null data (Step 3). We conducted encoding tests to maintain the standard, which is almost always UTF-8. However, there were cases where the encoding only worked with Latin1, making it the extraction encoding used (Step 4). Even with the correct encoding, some columns contained terms with strange characters, which were corrected (Step 5). When a question was not justified (recorded a single space or a period), we included a default text: "Justification not recorded by evaluator" (Step 6). Additionally, when a question was unanswered, we marked it as "Not Answered". Finally, we included new columns to assist in subsequent data analyses (Step 7): **DS_JUST_CLEAN** (content without the tags in cases where the justification is in a mixed HTML + STRING format), **CHAR_COUNT** (number of characters in the justification), **WORD_COUNT** (number of words in the justification), **SENTENCE_COUNT** (number of sentences in the justification), **DS_DAYS_SPENT** (a delta between the "UPDATED_AT" and "CREATED_AT" fields, indicating the number of days worked), and **Q_EVALUATIONS_WORKED** (number of evaluations the stakeholder worked on in the public call).

Our textual transformation to numeric data relied on the Tfidfvectorizer function from the sci-kit-learn library. Additionally, we applied the Cosine, Jaccard, Spacy, and SBERT methods to analyze similarities. The Cosine similarity represents the degree of similarity between two documents (Kwangil Park & Kim, 2020). The Jaccard similarity represents the ratio of the size of the intersection over union (Verma & Aggarwal, 2020). We relied on the Cosine and Jaccard as syntactic similarity measures. Conversely, Spacy relies on word vectors to capture semantic relationships (Honnibal & Montani, 2017). Embedding is usually pre-trained on large corpora, and the Cosine calculates the similarity (Equation 2). Finally, SBERT similarity relies on sentence embeddings from a fine-tuned Bidirectional Encoder Representations from Transformers (BERT) model (Reimers & Gurevych, 2019). Similarly to Spacy, calculating similarity relies on the Cosine method. We relied on the Spacy and SBERT similarities as semantic similarity measures.

3. Results and Discussion

3.1. Effort Levels by Function

3.1.1. Assistant Coordinators

The assistant coordinators review the reports from the blind evaluations conducted by the evaluators. To understand the similarity between an assistant coordinator's report and each evaluator assigned to the same literary work, grouping by conditionally approved and reproved, we applied the Cosine, Jaccard, Spacy, and

SBERT methods. We also calculated the mean, median, and Standard Deviation (SD) by grouping all assistant coordinators, considering the public call and evaluation results.

Based on Table 7, the text similarities between assistant coordinators and evaluators' reports for reproved and conditionally approved literary works were compared using four different methods. For the Cosine method, the conditionally approved literary works show a higher mean similarity (0.98) than the reproved literary works (0.66). The median is also higher for conditionally approved literary works (1.00 vs. 0.67). However, the SD is lower for the reproved literary works (0.26 compared to 0.13), indicating that, while the mean similarity is lower, there is greater variability in the conditionally approved group. For the Jaccard method, the conditionally approved literary works again show a higher mean similarity (0.99) compared to reproved literary works (0.83), and the median is significantly higher (1.00 vs. 0.86). The SD is also slightly lower for conditionally approved literary works (0.08 vs. 0.14), indicating more consistent results in the conditionally approved group. The Spacy method shows that conditionally approved literary works have higher similarity metrics, with a mean of 0.99 and a median of 1.00, compared to a mean of 0.94 and a median of 0.97 for the reproved literary works. Additionally, the SD is smaller for conditionally approved literary works (0.04 vs. 0.07), reflecting a higher consistency in the results. Finally, for the SBERT method, the conditionally approved literary works exhibit a higher mean (0.99) and median (1.00) compared to the reproved literary works (mean of 0.91 and median of 0.93). The SD is lower for the conditionally approved literary works (0.05 vs. 0.10), indicating that the similarities for conditionally approved literary works are not only higher but also more consistent. Across all methods, the conditionally approved literary works generally show higher and more consistent similarity scores compared to the reproved literary works.

Tab. 7 – Comparison of text similarities between assistant coordinators and evaluators reports for conditionally approved and rejected literary works.

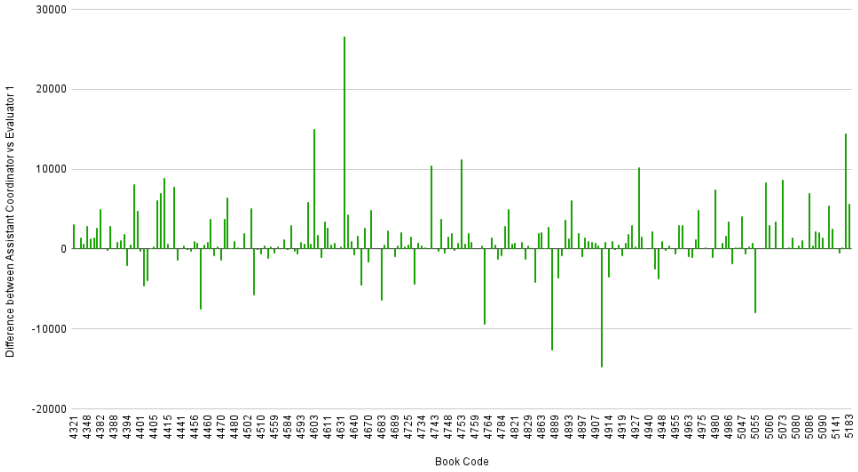
	Reproved			Conditionally Approved		
Metric	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
Cosine	0.66	0.67	0.26	0.98	1.00	0.13
Jaccard	0.83	0.86	0.14	0.99	1.00	0.08
Spacy	0.94	0.97	0.07	0.99	1.00	0.04
SBERT	0.91	0.93	0.10	0.99	1.00	0.05

We applied the Student's t-test to determine whether there are statistically significant differences between the Cosine and Jaccard similarities of the reproved and conditionally approved literary works. For the reproved literary works, we obtained a p-value of 0 for both the Cosine vs. Jaccard and Spacy vs. BERT similarities at a significance level of 0.05. This indicates a significant difference between the means of the two samples, suggesting that the observed variations in similarity metrics are statistically significant. The difference in similarity between the Spacy and SBERT methods can be attributed to two factors. The first is the different approaches each method uses to calculate text similarity. While Spacy relies on basic syntactic and semantic features of words and sentences, SBERT uses pre-trained sentence representations in high-dimensional vector spaces, capturing more complex semantic nuances. These differences result in distinct assessments of how semantically close the texts are, with Spacy perceiving greater proximity and SBERT indicating a more considerable distance. The second factor is the writing style of the assistant coordinator and the evaluator.

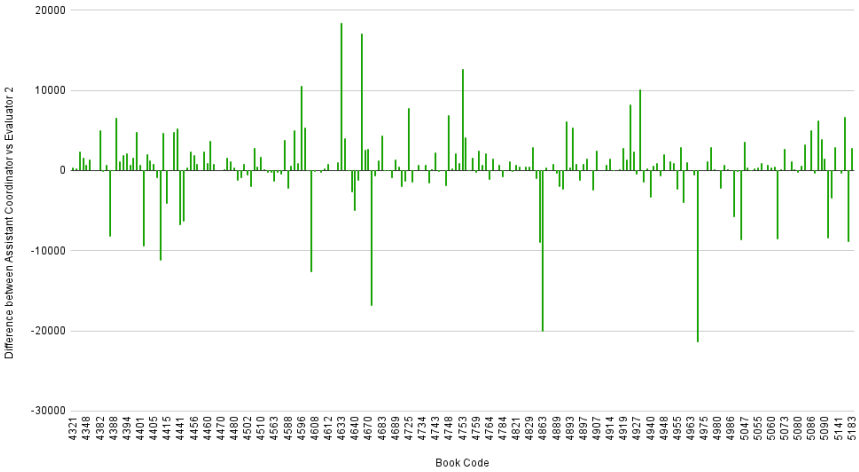
For the conditionally approved literary works, we obtained a moderate p-value (0.4987) for the Cosine and Jaccard similarities based on the Student's t-test. This indicates no significant difference between the means of the two samples for these similarity metrics. Furthermore, the calculated t-statistic value of -0.0156 and the corresponding t-distribution value of 0.4938 support the conclusion that the observed differences are not statistically significant. Conversely, the Student's t-test results, when comparing the Spacy and BERT similarities, presented a high p-value (0.8031), indicating no significant difference between the means of the two samples. The calculated t-statistic value of -0.0151 and the corresponding t-distribution value of 0.4940 confirm that the observed differences are not statistically significant. In general, the high mean values of the semantic similarity metrics indicate relatively high agreement between the assistant coordinators' and evaluators' reasoning. We further explored the Cosine and Jaccard results.

We also analyzed the textual differences between the assistant coordinators' and evaluators' reports by comparing the contents of the reproved literary works. We filtered out literary works with only one evaluation and removed duplicated reports. Figure 2 illustrates the differences between the assistant coordinators' answers to rubrics (for specific literary work) and the evaluators' during the peer review process. For 65 literary

works (Figure 2a), the assistant coordinator either removed or modified some text produced by the evaluator.



(a) Assistant coordinator vs evaluator 1.



(b) Assistant coordinator vs evaluator 2.

Fig. 2 – Difference between the texts of assistant coordinators and the evaluators for reproved literary works.

The assistant coordinator added new text for 156 literary works by incorporating text from another evaluator or creating new content. There was no difference in the answers to rubrics for 12 literary works. In contrast, when considering the second evaluator (Figure 2b), the assistant coordinator removed or modified text from the evaluator for 76 literary works and added text for 147 literary works. For instance, for literary work 4415, the assistant coordinator reused part of Evaluator 1's text (resulting in a text similarity of almost 1.0 across all metrics) while removing or altering some text from Evaluator 2. The texts were also similar.

The previous discussion on text similarities and total length (word count) suggests varying levels of effort by assistant coordinators in adjusting the evaluators' answers to rubrics: no effort, minor effort, major effort, and full effort. However, to increase confidence in answering RQ1.1, it is necessary to investigate specific instances of literary works evaluations to understand better what typically leads to a major or full effort. Thus, we conducted an n-gram analysis to guide our investigation, with n up to 7.

Figure 3 combines a Kernel Density Estimate (KDE) plot (center) with a bivariate contour plot (top and side) for reproved literary works. It displays the joint distribution of two variables: n_gram (X-axis) and jaccard_sims_ngrams (Y-axis). In the central KDE plot, shades of blue indicate varying density levels, with darker areas representing higher data point density. The KDE plot reveals a higher density of points within the 0.0 to 0.2 range for Jaccard similarity, regardless of the n-gram.

This suggests a possible discrepancy in reports produced between the assistant coordinators and evaluators for disapproved works, as the Jaccard similarity is dense. Additionally, a minor density around 1.0 indicates

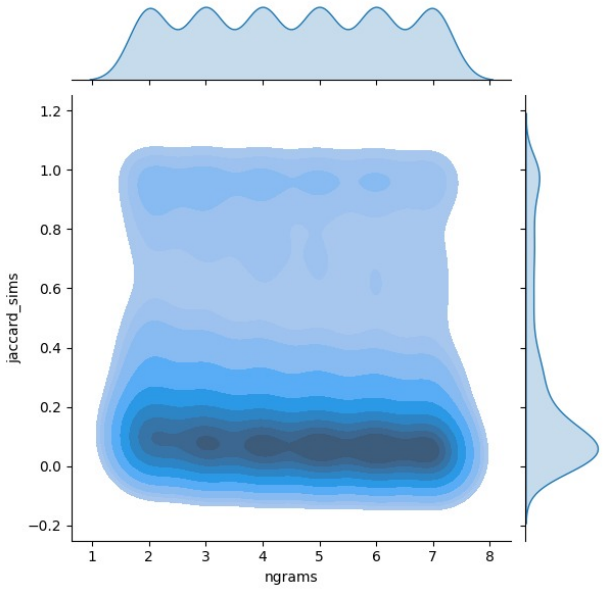


Fig. 3 – KDE plot (center) with a bivariate contour plot (top and side) for reproved literary works.

that some reports are similar, with some being literal copies. We used the visualizations presented in Figures 2 and 3 to focus our analysis on specific problematic cases, aiming to understand the evaluation issues better.

We used the same procedure to analyze the conditionally approved literary works. In the same sense as Figure 2, Figure 4 illustrates the differences between the assistant coordinators' answers to rubrics and the evaluators' during the peer review process, considering conditionally approved literary works. Some of the assistant coordinators' reports (49 in total) removed some text produced by Evaluator 1. Similarly, for Evaluator 2, 44 reports had such removals. Considering both evaluators, for 129 reports, there was no difference between the assistant coordinators' and evaluators' answers to rubrics, showing that, in many cases, assistant coordinators reuse all of the evaluators' produced text. Figure 5 also combines a KDE plot (center) with a bivariate contour plot (top and side) for conditionally approved literary works.

We used the visualizations in Figures 4 and 5 to focus our analysis on specific problematic cases from the conditionally approved. For instance, in literary works 4398 and 4449, the assistant coordinator removed the text from both evaluators and produced new text. The evaluators reproved or approved the literary work. However, the assistant coordinator reverted the decision, producing a different report (i.e., low text similarity).

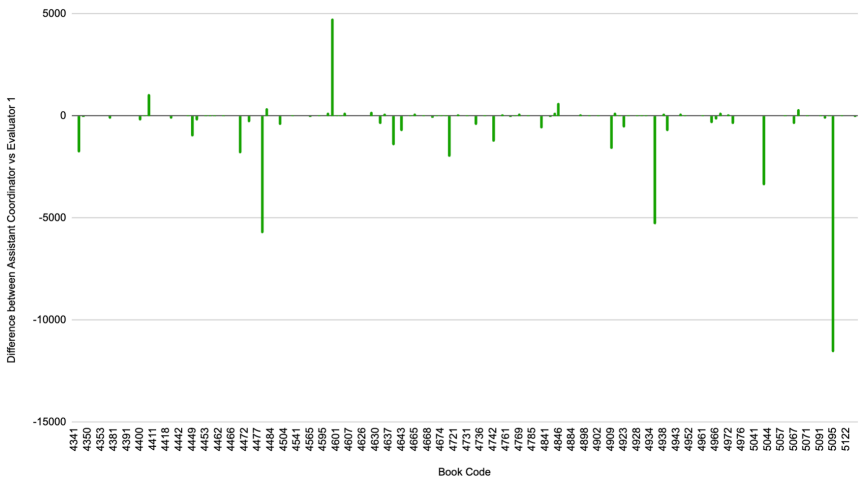
Assistant coordinators' efforts tended to be significant (sometimes full effort) for the reproved literary works, involving removing or adding text from the evaluators' reports. Conversely, no effort or minor effort tends to be required when reusing at least one of the evaluators' reports for conditionally approved literary works.

3.1.2. Pedagogical Advisors and Coordinators

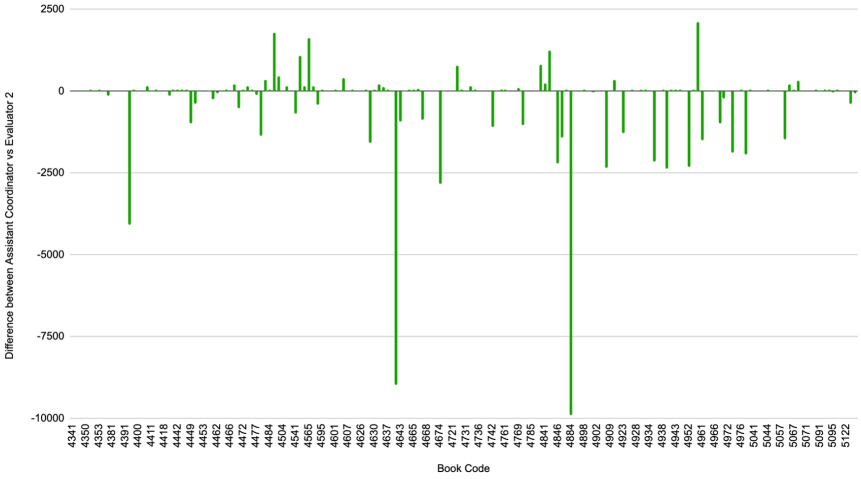
After the assistant coordinator finished analyzing the blind evaluations, 50 literary works were approved, 233 were reproved, and 180 were conditionally approved. Table 8 compares the similarities of the assistant coordinators' and pedagogical advisors' mean, median, and SD. Such results evidence that assistant coordinators and pedagogical advisors agree in their evaluations, with very few differences in the answers to rubrics.

Moreover, Table 9 compares the mean, median, and SD of similarities between the pedagogical advisors' and coordinators' reports. Similar to the previous case, the pedagogical coordinators usually reuse most of the text the pedagogical advisors produce, with only a few adjustments. However, the mean similarities of the reproved literary works slightly decreased for the pedagogical advisors' and coordinators' reports.

Thus, these two phases of the evaluation process typically require a minor effort to consolidate the final report



(a) Assistant coordinator vs evaluator 1.



(b) Assistant coordinator vs evaluator 2.

Fig. 4 – Difference of the answers of assistant coordinators and the evaluators for conditionally approved.

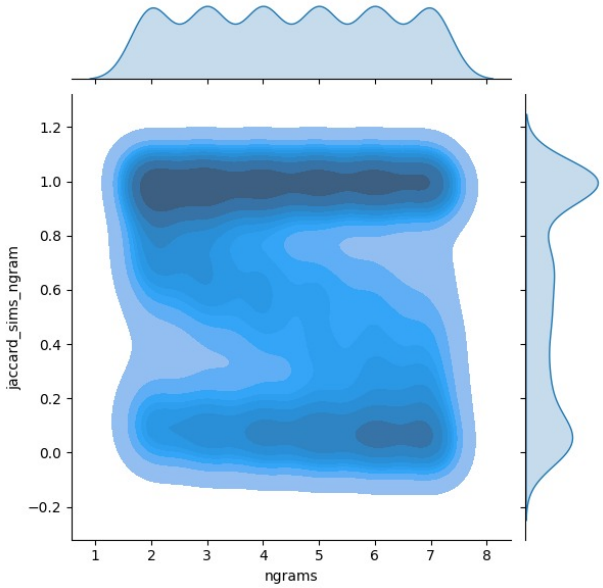


Fig. 5 – KDE plot (center) with a bivariate contour plot (top and side) for conditionally approved literary works.

Tab. 8 – Comparison of text similarities between assistant coordinators and pedagogical advisors' reports for conditionally approved and rejected literary works.

	Reproved			Conditionally Approved		
Metric	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
Cosine	0.90	1.00	0.18	0.93	1.00	0.20
Jaccard	0.95	1.00	0.08	0.97	1.00	0.10
Spacy	0.99	1.00	0.03	0.98	1.00	0.06
SBERT	0.97	1.00	0.05	0.98	1.00	0.06

Tab. 9 – Comparison of text similarities between pedagogical advisors and pedagogical coordinators' reports for conditionally approved and rejected literary works.

	Reproved			Conditionally Approved		
Metric	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
Cosine	0.83	0.90	0.18	0.93	1.00	0.18
Jaccard	0.92	0.95	0.09	0.96	1.00	0.11
Spacy	0.97	0.99	0.04	0.98	1.00	0.05
SBERT	0.95	0.98	0.07	0.98	1.00	0.07

(RQ2.1 and RQ3.1). Only a few specific cases demand a significant effort.

3.2. Productivity Levels by Function

We address RQ1.2, RQ2.2, and RQ3.2 (productivity in report writing) by analyzing the previous works of the assistant coordinator, pedagogical advisor, and pedagogical coordinators. Thus, we computed the value generated per hour worked as the ratio of the number of words of reports and the number of worked days. We analyzed the productivity of the assistant coordinators, pedagogical advisors, and pedagogical coordinators who worked in the 2024 PNLD public call for literary works. Our datasets contain software logs that record the coordinators' access from the first update to the last. The assistant coordinators' value generated per hour worked had a mean of 8.32, a median of 2.69, and an SD of 15.01. The pedagogical advisors' value generated per hour worked had a mean of 4.88, a median of 1.74, and an SD of 8.33. Finally, the pedagogical coordinators' value generated per hour worked had a mean of 3.84, a median of 1.43, and an SD of 6.11. We cannot affirm that such values evidence low productivity. This data does not accurately represent the daily work distribution. A low output value per hour worked may indicate that some evaluations are concentrated on answers to rubrics on specific days by a particular role, which is not the desired behavior (RQ1.2, RQ2.2, and RQ3.2). The Brazilian Ministry of Education staff oversees the pedagogical evaluation process team and requires frequent updates from the assistant coordinator, pedagogical advisor, and pedagogical coordinators. Higher-level functions can request the removal of lower-level functions. For instance, a pedagogical coordinator can ask for the assistant coordinator to be removed. Any function can request to be removed. During monitoring, the Ministry of Education staff or a specific function decides whether to maintain or remove personnel.

3.3. Writing Quality by Evaluators

3.3.1. Readability

We applied the Flesch and Gunning Fog indexes to understand better the readability levels of the evaluators' answers to rubrics. The Flesch index indicates reading levels as follows: 5th to 6th grade (scores 5-6), 7th to 8th grade (scores 7-8), 9th to 10th grade (scores 9-10), 11th to 12th grade (scores 11-12), college-level (scores 13-16), and graduate level (scores 17+). In contrast, the Gunning Fog index classifies texts as very easy (scores 90-100), easy (scores 80-89), fairly easy (scores 70-79), standard (scores 60-69), moderately difficult (scores 50-59), difficult (scores 30-49), and very difficult (scores 0-29).

Table 10 presents an overview of our readability analysis results using the above two measures. Values in parentheses represent the SD, and N is the number of partial reports. The readability of the partial reports varies significantly, with a difference in complexity levels. For instance, the reports for approved literary works are relatively less complex, as indicated by their lower Gunning Fog Index (mean = 19.53, SD = 3.43),

compared to the conditionally approved literary works (mean = 21.61, SD = 3.89). Reports for rejected literary works show a moderate level of complexity (mean = 16.07, SD = 5.49). This variation suggests that the less complex reports for approved and conditionally approved literary works tend to include more direct texts stating the approval, whereas the more complex ones, particularly for conditionally approved literary works, tend to be longer and include excessive detail that may not add substantial value to the decision-making process. Overall, the variation in readability indexes highlights that some texts are more challenging to read than others. This disparity arises from the inconsistent levels of detail in the reports, coupled with the evaluators' diverse writing styles. Consequently, this increases the risk of writing answers to rubrics that are less accessible and harder to interpret, which could hinder the evaluation process and decision-making.

Tab. 10 – Summary of the mean (and SD) readability measures using the Flesch and Gunning Fog indexes.

Result	N	Flesch Index	Gunning Fog Index
Rejected	66	39.6 (19.07)	16.07 (5.49)
Approved	176	34.63 (9.12)	19.53 (3.43)
Conditionally Approved	22	31.9 (19.5)	21.61 (3.89)

When analyzing spelling, the 17 answers to rubrics for approved literary works contained the fewest errors, with only three punctuation mistakes. The 115 answers to rubrics for conditionally approved literary works contained 16 errors, averaging approximately 0.14 errors per text: seven orthographic, six grammatical, and three punctuation errors. The 675 answers to rubrics for rejected literary works exhibited the highest number of errors, totaling 107 errors, averaging about 0.16 errors per text: 53 orthographic, 32 grammatical, and 22 punctuation errors. While the errors increased with the number of reports, the average errors per text remained low, indicating good writing quality in terms of orthographic, grammatical, and punctuation accuracy.

3.3.2. Level of Detail

To enhance our discussion regarding the quality, we used metrics for total length and complexity. Complexity refers to the number of citations of external documents, such as laws and the national curriculum. The total length of evaluation reports for approved literary works had a mean of 269.68, a median of 176.00, and an SD of 350.10. For conditionally approved literary works, the evaluation reports had a mean of 565.52, a median of 220.00, and an SD of 1253.28. The evaluation reports for rejected literary works had a mean of 2656.64, a median of 1219.00, and an SD of 4098.70. Thus, the evaluation reports for approved literary works are relatively short. The conditionally approved literary works show more detailed partial reports than the approved ones, while the rejected literary works partial reports are longer. This higher level of detail in rejection reports is expected, as it enhances confidence in evaluators' decisions and provides robust justification, especially considering that rejections may be subject to appeals. However, a high total length value may indicate redundant or less relevant text. We complement this analysis by using the complexity of reports, as the criteria for approvals and rejections rely on different external documents. We used regular expressions to identify mentions of external documents in the reports, relying on specific keywords (e.g., ABNT NBR) and regular expressions.

The partial reports for approving literary works had a mean of 0.42, with an SD of 0.50. Conversely, the partial reports for conditionally approving literary works had a mean of 0.50, with an SD of 0.50. The reports for rejecting works had a mean of 2.40, with an SD of 3.35. These results suggest that reports for rejecting works provide higher levels of detail due to their greater total length and number of mentions of external documents. Although the conditionally approved generally had longer partial reports than the approved literary works, they contained fewer mentions of external documents. The results suggest that evaluations could provide more details on the criteria used to approve, conditionally approve, or reject literary works (RQ2.3).

3.3.3. Level of Uniqueness

We examined the similarities in partial reports provided by the same evaluator across different literary works (RQ3.3). We organized the reports by grouping those from the same evaluator according to the classifications

of approval, conditional approval, and rejection. Grouping all reports related to approvals and the evaluators who wrote them, we observed that reports had a mean Jaccard similarity of 0.83, a median of 1, and a standard deviation (SD) of 0.29. For conditionally approved, the reports showed a mean similarity of 0.85, a median of 1, and an SD of 0.28. On the other hand, reports for rejected works presented a mean similarity of 0.48, a median of 0.45, and an SD of 0.19. Based on the results from the previous RQs, the high similarity in reports for approvals and conditional approvals was expected, as they typically consist of straightforward statements of approval or partial approval, with minimal details and nearly identical content. However, the moderate mean similarity observed in reports for rejections (approximately 50%) was unexpected, as these reports are generally the most detailed and should be unique, displaying low similarity (RQ3.3).

3.3.4. Agreement Level Between Two Evaluators

Table 11 presents the evaluators' answers to rubrics similarities for approved, conditionally approved, and reproved literary works during the peer review. The metrics indicate that the partial report texts for approved literary works have varying levels of similarity. The Cosine similarity metric shows moderate similarity, while Jaccard, Spacy, and SBERT metrics indicate higher similarities, with Spacy reaching the highest values. The SD is relatively low for the Cosine, Spacy, and SBERT metrics, suggesting a consistent pattern in the text similarities. This indicates that while the texts may differ in structure or specific terms (Cosine and Jaccard), they share semantic content (Spacy and SBERT). For conditionally approved literary works, the similarity levels are generally high, with Cosine, Jaccard, Spacy, and SBERT metrics showing comparable results. The SD values for Cosine suggest more variation in text structure and specific term usage, but the other metrics indicate consistent semantic overlap across the texts. Regarding reproved literary works, the similarity metrics also show high levels of agreement for Jaccard, Spacy, and SBERT. The SD values for the metrics suggest consistency among the reports. Overall, the level of agreement is high during the peer review process (RQ4.3).

Tab. 11 – Evaluators' answers to rubrics similarities for approved, conditionally approved, and reproved literary works during the peer review.

	Approved			Conditionally Approved			Reproved		
Metric	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
Cosine	0.65	0.85	0.32	0.67	0.85	0.30	0.48	0.48	0.15
Jaccard	0.82	0.95	0.21	0.82	0.95	0.20	0.75	0.77	0.13
Spacy	0.92	0.97	0.13	0.91	0.96	0.13	0.90	0.93	0.10
SBERT	0.84	0.91	0.15	0.88	0.91	0.14	0.86	0.88	0.11

3.4. Efforts and Productivity of Evaluators

By analyzing evaluators' previous works, we address RQ1.4 and RQ1.5 (efforts and productivity in writing partial reports). Thus, we reused the total length and complexity of the partial reports previously discussed to assess the effort involved in answers to rubrics. The partial reports tend to be brief and less complex for approved literary works. The partial reports for rejected literary works are generally longer. Their complexity is higher than that of approved and conditionally approved literary works. As the evaluation criteria become more stringent and the need for explanations increases, the partial reports' length and complexity rise significantly, indicating a greater effort required from the evaluators.

Moreover, we computed the value generated per hour worked as the ratio of the number of words of partial reports and the number of worked days. The evaluator 1 presented a mean of 8.30, a median of 2.55, and an SD of 19.69. The evaluator 2 presented a mean of 9.97, a median of 2.97, and an SD of 23.19. Again, this data may not accurately reflect the daily work distribution, as evaluators might concentrate tasks on specific days.

3.5. Quality of Questions Response by Evaluators

We address RQs 1.6 and 2.6 (quality in answering objective questions) by analyzing the previous work of evaluators. We calculated the Cohen's Kappa index to assess the level of agreement during the peer review

process. The average Kappa index (with SD) between the first and second evaluators was 0.61 (0.49). We also calculated the index to evaluate the agreement between the evaluators' opinions and the final decisions. The average Kappa index (with SD) between the first evaluators and the final results was 0.70 (0.46). Similarly, the average Kappa index (with SD) between the second evaluators and the final results for the same literary work was 0.68 (0.47). These results indicate a reduced level of agreement across the analyses of evaluators vs evaluators of the same literary work. There is an increase in concordance when considering the evaluators and the final decision. This finding is consistent with our earlier results, highlighting existing disagreements in evaluations, such as cases where a rejection was later changed to a conditional approval (or the contrary).

3.6. Quality of Justifications and Effort from Evaluators

We address RQ1.7, RQ2.7, and RQ1.8 by analyzing previous works of evaluators. We analyzed 79,838 questions across 467 literary works to assess the quality and effort in writing justifications. Among these, 12,363 questions lacked justifications. For approved literary works, the readability of the justifications showed a mean Flesch index of 42.48 (22.11) and a mean Gunning Fog index of 8.39 (4.59). For conditionally approved literary works, the readability scores had a mean Flesch index of 25.60 (21.18) and a mean Gunning Fog index of 9.71 (5.12). For rejected literary works, the justifications had a mean Flesch index of 33.61 (18.59) and a mean Gunning Fog index of 9.10 (5.15). The readability scores indicate that justifications for approved, conditionally approved, and rejected literary works are generally complex to read.

When analyzing spelling quality, the reproved literary works related to 2480 questions, with a mean total length of 283,28 words. The justifications presented 2165 mistakes, of which 1672 were orthographic, 411 were grammatical, and 82 were punctuation. The conditionally approved literary works were related to 307 questions (mean total length of 51,07 words), and the justifications presented 28 mistakes, of which 17 were orthographic, nine were grammatical, and two were punctuation. The approved literary works related to more than 63,845 questions, of which we analyzed 10% of them as a significant sample (mean total length of 109,6 words). The justifications presented 5712 mistakes, of which 4341 were orthographic, 1211 were grammatical, and 161 were punctuation. The number of errors increased with the number of questions. However, similar to our previous results, the number of errors was relatively low, indicating good writing quality regarding orthographic, grammatical, and punctuation accuracy.

Considering the level of detail and effort, we used total length and complexity. For approved literary works (48 and 2 outliers), the mean total length of the justifications was 152,77 words (419.02). These justifications generally exhibited low complexity, with an average of 0.40 (0.49) mentions. For conditionally approved works (181), the mean total length was 140.07 (264,81) words, and the justifications were slightly more complex than those for approved works, with an average of 0.44 (0,63) mentions. For rejected works (235), the mean total length of the justifications was 738,68 (1012,39) words. These justifications were more complex than those for approved and conditionally approved works, with an average of 1.47 (2.69) mentions. The level of detail and effort in justifications seems to increase as the decision is towards a rejection. However, the justifications present a few mentions of external documents, which may decrease clarity.

3.7. Threats to Validity

Evaluating the quality, productivity, and effort involved in writing responses to rubrics entails a degree of subjectivity. To address this problem, we provided clear definitions of these concepts. Productivity is the most challenging aspect to assess, as measuring value generated per hour—based on the number of words written—may not fully capture the complexity of evaluators' behavior. Future research may further refine these definitions to enhance objectivity. Moreover, generalizing these findings to other contexts requires a broader range of analyses, including different public calls for educational materials and textbook programs. As such, some results may not be directly applicable to educational material evaluation programs in other countries or cultural contexts without a more in-depth analysis that takes local specificities into account.

4. Conclusions

Our descriptive approach to textual data analysis enables valuable insights that can drive innovations in public policies and provide strategies to support policymakers in their decision-making processes for educational

material distribution programs. The insights fall within three key dimensions of analysis: effort, productivity, and quality of textual productions/evaluations. Answers to rubrics can reveal desirable or undesirable behaviors that directly influence the quality and efficiency of educational policies, either positively or negatively. Thus, the insights acquired from these answers to rubrics help identify critical points in evaluation processes, enhance transparency, and guide adjustments to improve policy implementation. Additionally, the approach supports monitoring, providing actionable data to inform improvements. The proposed metrics—focused on effort, productivity, and quality—support the principles of digital government by enabling real-time monitoring of the evaluation process through business intelligence tools. This contributes to increased transparency, data-driven decision-making, and greater efficiency in the management of public educational programs. When applied to actual policy implementation, our approach can help shape new processes, procedures, and rules that encourage desired behaviors while discouraging undesired ones.

The case study revealed that the peer review process for evaluating literary works during the 2024 public call was effective despite reduced agreement levels between evaluators. Assistant coordinators showed slightly higher alignment with evaluators' reasoning but played a significant role in refining reports for rejected works, often requiring substantial modifications. While productivity levels were challenging to interpret due to uneven daily work distribution, text readability emerged as a concern, particularly for rejected works, where diverse writing styles and detailed justifications increased complexity. Reports for rejections were more prolonged and more thorough, reflecting the need to enhance confidence in decisions subject to appeals. In contrast, less detailed reports for approvals and conditional approvals may risk reducing transparency, a critical aspect of public policy. Overall, collaboration between roles like assistant coordinators, pedagogical advisors, and coordinators exhibited high agreement, indicating fewer issues in this level of evaluation.

These findings present new research opportunities for process improvement, human resource training, and AI applications. For example, policymakers could leverage AI interventions to enhance the capabilities of evaluators and other roles while also reducing their workload. Generative AI-based chatbots could assist with various tasks, from fundamental analyses like spelling checks to providing text suggestions for report writing. Future research can explore the use of generative AI to improve the quality of evaluation reports.

Funding

The authors acknowledge the support of the Brazilian Ministry of Education through the Decentralized Execution Term (Termo de Execução Descentralizada – TED) No. 10965.

Data Access Statement

Data generated during the study are available from the corresponding author upon reasonable request.

Contributor Statement

André Araújo: Conceptualisation, Data Curation, Funding Acquisition, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Rafael Araújo: Conceptualisation, Data Curation, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Luciano Cabral: Conceptualisation, Data Curation, Formal Analysis, Investigation, Validation Methodology, Writing-Original Draft, Writing - Review & Editing. Luciane Silva: Conceptualisation, Data Curation, Formal Analysis, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Hilario Tomaz: Conceptualisation, Data Curation, Formal Analysis, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Emerson Martins: Data Curation, Validation, Writing - Review & Editing. Diego Dermeval: Conceptualisation, Data Curation, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Álvaro Sobrinho: Conceptualisation, Data Curation, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Alan Pedro da Silva: Conceptualisation, Data Curation, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Leonardo Marques: Conceptualisation, Data Curation, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Filipe Recch: Data Curation, Validation, Writing - Review & Editing. Sebastian Munoz-Najar Galvez: Conceptualisation, Data Curation, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing. Ig Ibert Bittencourt: Conceptualisation, Data Curation, Investigation, Validation, Methodology,

Writing-Original Draft, Writing - Review & Editing. Seiji Isotani: Conceptualisation, Data Curation, Investigation, Validation, Methodology, Writing-Original Draft, Writing - Review & Editing.

Use of AI

During the preparation of this work, the author(s) used ChatGPT in order to conduct orthographic correction. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Badrul Hisham, A. A., Mohamed Yusof, N. A., Salleh, S. H., & Abas, H. (2024). Transforming governance: A systematic review of ai applications in policymaking. *Journal of Science, Technology and Innovation Policy*, *10*(1), 7–15.

Clark, P., Llewellyn, K., Capó García, R., & Clifford, S. (2024). Context matters in history textbook studies: A call to address the socio-political landscape of textbook production. *Historical Encounters*, *11*(1), 136–150.

Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, *20*(1), 37–46.

Delen, D. (2019). *Prescriptive analytics: The final frontier for evidence-based management and optimal decision making*. FT Press.

Honnibal, M., & Montani, I. (2017). Spacy 2: Natural language understanding with bloom embeddings, convolutional neural networks and incremental parsing.

Kulal, A., Rahiman, H. U., Suvarna, H., Abhishek, N., & Dinesh, S. (2024). Enhancing public service delivery efficiency: Exploring the impact of ai. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*, 100329.

Kwangil Park, J. S. H., & Kim, W. (2020). A methodology combining cosine similarity with classifier for text classification. *Applied Artificial Intelligence*, *34*(5), 396–411.

Liu, X. (2023). Effects of free textbooks on academic performance: Evidence from china's compulsory education. *Review of Development Economics*, *27*(4), 2518–2537.

McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochem Med (Zagreb)*, *22*(3), 276–282.

Pencheva, I., Esteve, M., & Mikhaylov, S. J. (2020). Big data and ai in education policy: Addressing inequality through technological adoption. *Policy and Internet*, *12*(3), 256–276.

Reimers, N., & Gurevych, I. (2019). Sentence-BERT: Sentence embeddings using siamese BERT-networks. *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing and the 9th International Joint Conference on Natural Language Processing (EMNLP-IJCNLP)*, 3982–3992.

Santoso, A., Kartika, D., Lestari, P., & Yusof, Z. B. (2024). Reimagining public resource allocation: Insights into ai and analytical techniques to address governance challenges in the 21st century. *Journal of Applied Smart Healthcare Informatics*, 66–72.

Sharda, R., Delen, D., & Turban, E. (2018). *Business intelligence, analytics, and data science: A managerial perspective*. pearson.

Silva, A. S., Araújo, A., Palomino, P., Araújo, R., & Dermeval, D. (2024). Mastering requirements volatility: Strategies for dynamic environments and multiple stakeholders in government software projects. *IEEE Access*, *12*, 183060–183077.

Sobrinho, A., Ibert Bittencourt, I., Carvalho Melo da Silveira, A., Pedro da Silva, A., Dermeval, D., Brandão Marques, L., Cezar Ianzer Rodrigues, N., Carolina Silva e Souza, A., Ferreira, R., & Isotani, S. (2023). Towards digital transformation of the validation and triage process of textbooks in the brazilian educational policy. *Sustainability*, *15*(7).

UNESCO. (2016). Every child should have a textbook.

Verma, V., & Aggarwal, R. K. (2020). A comparative analysis of similarity measures akin to the jaccard index in collaborative recommendations: Empirical and theoretical perspective. *Social Network Analysis and Mining*, *10*(1), 43.

Wang, J., & Dong, Y. (2020). Measurement of text similarity: A survey. *Information*, *11*(9).

Development and Deployment of Sentiment Analysis AI on Citizens' Feedback in Goiás

Rafaela M. Rosa [a], *Jessé D. de* Souza [b], *Camila do N.* Freitas [c], etc.

[a] State Government of Goiás, Secretariat of Administration, Goiás, Brazil, rafaela.rosa@goias.gov.br, ORCID number: 0009-0007-9040-4189.

[b] State Government of Goiás, Secretariat of Administration, Goiás, Brazil, jesse.souza@goias.gov.br, ORCID number: 0009-0007-3802-6117.

[c] State Government of Goiás, Secretariat of Administration, Goiás, Brazil, camila.freitas@goias.gov.br, ORCID number: 0009-0004-2208-7167.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. This study presents the development and deployment of a sentiment analysis model based on Natural Language Processing (NLP) techniques in the context of public service evaluation. The model was implemented to automate the classification of citizens' feedback on services provided by the EXPRESSO program in the State of Goiás, Brazil. Before implementation, the classification process was manual, which was time-consuming, and prone to inconsistencies. The dataset used included a wide range of citizen experiences, ensuring that the model captured a comprehensive and representative sample of comments. Preprocessing techniques such as noise removal, tokenization, stemming, and customized stopword adjustments were applied to refine the data for analysis. Among the algorithms tested, Multinomial Naïve Bayes (MNB) stood out for its slightly superior performance in identifying negative feedback — a critical class for monitoring service quality and addressing citizen concerns efficiently. The model was validated with managers to ensure its practical application and was subsequently integrated into the State's Data Warehouse (DW) to feed a real-time monitoring dashboard. Additionally, a visual interface was developed to allow managers to analyze feedback on demand. This interface includes features such as word clouds for positive and negative feedback, facilitating the quick identification of key themes, trends, and recurring issues. The integration of artificial intelligence into the EXPRESSO Program establishes a scalable and replicable framework to improve decision-making processes, enhance operational efficiency, and promote inclusivity. This methodology can be extended to other public service centers, emphasizing the vital role of AI in fostering responsive governance, improving service quality, and enhancing citizens' satisfaction.

Keywords. Sentiment analysis, Natural Language Processing, public service evaluation, machine learning, Naive Bayes.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.944

1. Introduction

The use of advanced technologies has redesigned the way governments deal with challenges in the delivery of public services. In this scenario, Artificial Intelligence (AI) has proven to be fundamental for processing large volumes of data and identifying relevant patterns, becoming a strategic tool in decision-making. The application of AI in public administration has contributed to critical areas, such as health, urban mobility and with the analysis of sentiments, citizens' feedback and real demands can now be monitored, promoting greater accessibility and inclusion, as well as better services to the public.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This paper presents the development and deployment of a sentiment analysis model based on Natural Language Processing (NLP) in the EXPRESSO Program, of the Government of the State of Goiás. The initiative used a representative sample of feedback from service channels spread throughout the State, reflecting the diversity of citizens' demands. The implemented solution automates the classification of comments into three categories — positive, neutral, and negative — allowing managers to quickly identify critical points in the services offered and proactively meet the main demands.

The approach adopted sought to optimize processes and also promote more inclusive public management, by giving voice to citizens and ensuring that their experiences and opinions are taken into account in the improvement of services. Before the implementation of the model, the classification of these comments was carried out manually, being time-consuming and being subject to inconsistencies. Now, with AI, it is possible to process large volumes of data in seconds, increasing the accuracy and efficiency of the analysis. The methodology developed proved to be scalable and replicable, with the potential of expansion to other call centers, which is the most widely adopted public service model throughout Brazil.

This work reinforces the role of AI in promoting a more efficient public administration that is guided by the real demands of the population. It also evidences how technology can be a powerful tool to give visibility to citizens' voices, making public services more transparent, accessible, and inclusive.

2. Related Work

2.1 Artificial Intelligence

Artificial Intelligence (AI) is a field of computer science focused on developing systems capable of performing tasks that typically require human intelligence. These tasks include learning, pattern recognition, decision-making, and problem-solving. AI leverages advanced algorithms and large volumes of data to train models that simulate aspects of human reasoning (Russell & Norvig, 2021).

The integration of artificial intelligence (AI) into public services is increasingly recognized as a solution to enhance interactions between citizens and the government. O'Neill (2021) highlights that AI adoption in public administrations can optimize processes while improving the government's ability to meet the population's needs more effectively. AI-driven systems, such as chatbots and predictive data analysis, can streamline public service operations, enhancing the quality of services provided.

Chien and Chen (2020) demonstrate that digital transformation in the public sector, driven by AI, is not limited just to task automation, but it involves the creation of new governance models. AI-based approaches have emerged as crucial monitoring tools, enabling public managers to identify patterns and societal needs with greater precision. This transformation fosters greater transparency in public administration and enhances communication efficiency alongside the society.

These innovative approaches allow public managers to better understand societal perception, identify priority areas for improvement, and develop targeted strategies to enhance public service delivery. Such initiatives reinforce the importance of leveraging technological tools to create a public administration that is more responsive to citizens' needs and fosters a better government-society engagement.

Models that Inspired the Use of AI in Public Services:

- **United Kingdom – National Health Service (NHS):** The UK's National Health Service employs AI to improve medical diagnosis accuracy and forecast future hospital demands. The "Streams" system, developed in collaboration with DeepMind, analyzes patient data in real-time to identify signs of acute kidney failure, enabling quicker interventions. (Royal Free London NHS Foundation Trust & DeepMind. "Our work on Streams." 2021. Available at: https://www.nhs.uk)
- **United States – Internal Revenue Service (IRS):** In the United States, the IRS has adopted AI systems to detect tax fraud and enhance customer service. By employing advanced algorithms, the IRS identifies irregularities in tax returns more efficiently, saving millions of dollars in manual audits. (Internal Revenue Service. "IRS Artificial Intelligence in Tax Compliance." 2022. Available at: https://www.irs.gov)
- **Estonia – X-Road System:** Estonia, a leader in digital transformation, utilizes AI in its X-Road system to integrate public services. Through this platform, citizens can access a wide range of government services online, from business registration to medical consultations. AI analyses service usage to optimize access and identify areas for expansion. (E-Estonia. "X-Road: The Backbone of Digital Estonia." 2022. Available at: https://e-estonia.com)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **India – Ayushman Bharat Health System:** In India, the Ayushman Bharat program, focused on healthcare, uses AI to monitor and predict disease outbreaks and optimize medical resource planning in underserved regions. This initiative has saved lives by anticipating public health crises. (National Health Authority of India. "Leveraging AI in Ayushman Bharat." 2022. Available at: https://www.pmjay.gov.in)
- **China – Urban Monitoring and Intelligent Mobility:** Several cities in China, such as Hangzhou, employ AI systems for intelligent mobility, including Alibaba's "City Brain" platform. This system analyses real-time traffic data to reduce congestion and improve emergency response. As a result, travel times in urban areas have significantly decreased. (Alibaba Cloud. "City Brain: Smart Cities Powered by AI." 2021. Available at: https://www.alibabacloud.com)

2.2 Machine Learning

Machine Learning is a subfield of artificial intelligence that enables computational systems to learn and improve their performance when exposed to data and past experiences (Alpaydin, E. (2020). Introduction to Machine Learning. MIT Press). This technology is widely used to solve complex problems, automate processes, and perform tasks involving the transformation or classification of large volumes of data.

Machine learning provides the foundation for systems to learn from data and enhance their performance as they process new information. When applied to the field of **Natural Language Processing (NLP)**, this capability is expanded, allowing computers to understand and analyze human text automatically. One of the possible applications of NLP in public administration is **Sentiment Analysis**, which can interpret emotions and sentiments expressed in the citizens' comments. This becomes a valuable tool for assisting public managers in understanding citizens' demands for improved public services.

2.3 Sentiment Analysis

Sentiment Analysis, according to Verma (2022), plays an important role in promoting innovation, transparency, greater citizen participation, and efficiency in public administration. This technology not only enhances communication between the government and society but also provides practical solutions to complex problems, such as traffic congestion, crime prediction, and disaster management. Applications in areas such as **smart governance, smart mobility, smart infrastructure, and smart living** serve as the foundation for the development of more connected cities.

Verma (2022) also highlights that by combining **supervised learning** techniques, sentiment analysis enables the transformation of large volumes of data into actionable insights. Additionally, it can assist in developing strategies to create smarter and more inclusive environments and services.

2.4 Multinomial Naïve Bayes Classifier

The Multinomial Naïve Bayes (MNB) model is based on Bayes' Theorem for classification tasks. Known for its simplicity and efficiency, it is referred to as "Naïve" due to its assumption of independence between features. The algorithm estimates the probability of assigning a given item to a specific class, particularly excelling in text classification based on the words contained in documents.

The multinomial approach stands out by considering the frequency of word occurrences in a document rather than treating words merely as present or absent. This characteristic makes it particularly effective in contexts where term repetition conveys meaningful information for categorization (ABBAS et al., 2019). In addition to this feature, MNB is easy to interpret and demonstrates good processing performance, making it a widely used tool in text classification applications (ARAR & AYAN, 2017). Notably, MNB achieved the highest accuracy in categorizing "negative" feedback, which was the target class for monitoring public services provided by the government of Goiás.

Tab. 1 - Comments and Occurrences by Polarity.

Polarity	Comments	Total Occurrences
Positive	"O atendente foi muito educado." (Attendant was very polite) / "O serviço foi rapido." (The service was fast)	2
Negative	"O sistema é lento e continua travando." (System is slow and keeps getting stuck) / "Terrível." (Terrible)	3
Neutral	"Queda de energia afetou computadores." (Power outage affected computers)	1

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Probabilities:

- Positive: P (pos) = 2/6 = 0,33P
- Negative: P(neg) = 3/6 = 0,50
- Neutral: P(neu) = 1/6 ≈0,17

MNB utilizes message frequencies to calculate the probabilities of each polarity. This method serves as the foundation for estimating conditional probabilities in text classification.

3. EXPRESSO: Citizen Service Program and Its Evaluation Methodology

In October 1999, the first **Vapt Vupt** unit was inaugurated at Buriti Shopping, located in Aparecida de Goiânia, Goiás, with the primary objective of consolidating and simplifying access to public services at different levels—federal, state, and municipal—while also including private companies that serve public interests. Since then, the integrated citizen service model developed in the State of Goiás has become a benchmark in the public services delivery. (https://vaptvupt.go.gov.br/sobre-vaptvupt)

In Brazil, integrated service center models have become a reference in public service delivery, with the State of Goiás being one of the pioneers in adopting this approach through **Vapt Vupt**. According to Lara and Gosling (2016), the management of the relationship between citizens and public administration should be structured based on strategies that promote greater citizen participation and satisfaction, aligning services with their expectations. The integrated service system created in Goiás has counterparts in other brazilian states, such as **Poupatempo** in São Paulo, the **Serviço de Atendimento ao Cidadão** (SAC) in Bahia, the **Organização de Centrais de Atendimento** (OCA) in Acre, the **Unidades de Atendimento Integrado** (UAI) in Minas Gerais, **Ganha Tempo** in Mato Grosso, **Ceará Cidadão** in Ceará, and **Na Hora** in the Federal District.

Goiás State Law No. 20.846, enacted on September 2, 2020 (Goiás, 2020), established the citizen service policy in the State of Goiás and created the **EXPRESSO Program**. This program introduced a new model of service delivery to citizens, integrating civil servants, services, and users in a fast, practical, and decentralized manner. Currently, six service channels are available: **Vapt Vupt, Balcão (Service Desks), Correios (Post Office), Web, APP**, and **Self-Service Totens**.

Each of these channels offers a different service approach, with some being in-person (**Vapt Vupt, Balcão, and Correios**) while others provide digital services (**Web, App, and Self-Service Totens**). Each channel serves a specific audience: in-person channels cater to citizens in the cities where they are located as well as in nearby regions, whereas digital channels are accessible to all residents of the State of Goiás.

At the end of the service, citizens are given the option to evaluate their experience and provide feedback. The requirements and evaluation criteria for EXPRESSO services were established by the **Secretariat of Administration (SEAD)**, in compliance with State Law's Article 59, which considers the following aspects:

- **User satisfaction**
- **Service quality**
- **Compliance with commitments and deadlines established for execution**
- **Number of user interactions**
- **Measures adopted by the public administration for service improvement and enhancement**

The evaluation methodology employs the **NPS (Net Promoter Score) scale**, developed by Reichheld (2003), a well-established tool for measuring user satisfaction. First, the user assigns a rating, followed by additional questions to understand the reasons behind the given score. The results classify users into three distinct groups:

- **Promoters (score of 9 or 10):** Users who positively evaluate the service and often provide constructive suggestions.
- **Neutrals (score of 7 or 8):** Users who evaluate the service but typically do not make recommendations or do so with reservations.
- **Detractors (score of 0 to 6):** Users who are dissatisfied with the service

According to **SEAD – State Secretariat of Administration (2024),** the evaluation form presented to citizens is structured as follows:

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **NPS question (0 to 10) to assess the premises physical infrastructure.** After selecting a score, follow-up questions are provided to justify the rating.
- **NPS question (0 to 10) to assess service delivery.** Additional questions follow to justify the given score.
- At this point, the citizen is invited to evaluate the service and/or leave a comment, both optional.
- If the citizen chooses to evaluate the service, an **NPS question (0 to 10)** is presented, followed by justification questions.
- At the end of the form, the citizen is once again invited to leave a comment, which is optional

Since most of the questions are quantitative, they are analyzed using statistical methods. Comments were manually reviewed by the technical team, which applied manual filters to remove noise, blank comments, or those containing irrelevant words. After filtering, the team individually analyzed each comment, classifying them into the following categories: **Praise, Inquiry, Complaint, Suggestion**, or a combination such as **Praise/Complaint** and **Suggestion/Complaint**. These last two classifications were used when a citizen addressed two issues simultaneously within the same comment.

From May 2022 to December 2023, a total of **71,785,073 services** were provided through the EXPRESSO channels. Since feedback is optional, **437,627 feedback responses** were received during this period, representing **0.61% of the total services provided**. Within this timeframe, **95,000 comments** were submitted, accounting for **0.13% of services and 21.70% of the total feedback responses**.

Although proportionally small, the sample is statistically significant. When considering only the feedback data **(437,627 out of 71,785,073 services)**, this citizen survey demonstrates a **95% confidence level** with a **margin of error of just 0.15%**. When analyzing only the data collected through comments, the margin of error increases to **0.32 percentage points**, but the confidence level remains at **95%**. Given that the feedback originates from both digital and in-person service channels across multiple locations in the State, it is reasonable to assert that the collected feedback is representative.

Monthly reports on user feedback regarding EXPRESSO services are published via https://www.go.gov.br/ and https://goias.gov.br/administracao/transformacao-da-gestao-publicos, from which the numbers used in this research were obtained.

Based on these findings, the **Subsecretariat for Innovation in Management and Public Services** (In portuguese Subsecretaria de Inovação da Gestão e dos Serviço Público) of SEAD identified an opportunity to automate the classification of citizen comments on EXPRESSO services, optimizing the manual process. Before implementing the new methodology, this process took an average of **two working days per week for each monthly batch of comments**. The manual approach was time-consuming and prone to inconsistencies due to human subjectivity, especially in ambiguous classifications such as sentiment combinations.

Given this scenario, the primary objective was to **apply AI techniques to automate comment classification**, reducing processing time and increasing result consistency. A project was then proposed to develop a sentiment **analysis model**, named **ANE – Análise Expresso** (EXPRESSO Analysis), leveraging **NLP** concepts. This approach enabled the reclassification of comments into three **more objective** categories: **Positive, Neutral, and Negative**.

4. Research Methodology

The actions carried out in this research can be summarized in the following processes: data selection, data preprocessing and cleaning, data transformation, training and evaluation of classification algorithms, classification validation with managers, and finally, script adaptation for production.

Understanding the problem and the dataset is essential for applying NLP techniques. An initial exploratory analysis was conducted to identify and address data inconsistencies, textual noise, and critical issues such as class imbalance.

The development of the sentiment analysis model was completed in approximately eight months and employed supervised learning, as it is widely used in sentiment classification problems and is highly efficient when working with labeled data (LIU, 2012). With supervised learning, manually classified examples are provided during training, allowing parameter adjustments to refine the mapping of textual features to the target classes. This approach also ensures scalability, enabling the application of the model to large volumes of future data.

4.1 Data selection

The analyzed comments were collected directly from the EXPRESSO feedback systems in .csv format, with our main

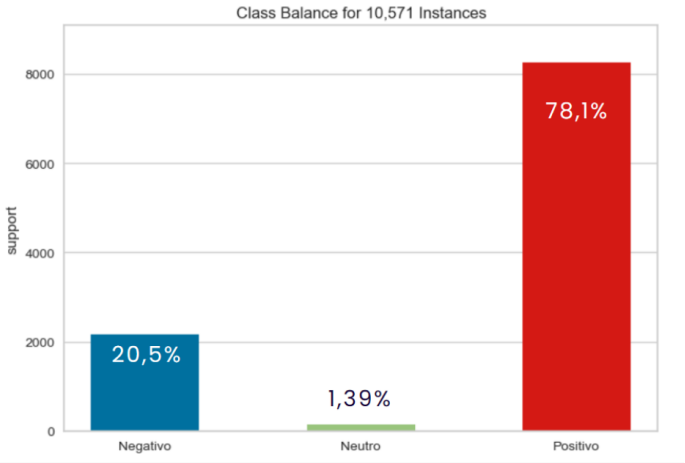
Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

focus on two columns: "Service Channel" and "Leave your comment here", the latter being our primary column containing citizen's feedback. For the initial study, a two-month sample of comments—June and July 2023—was used, totaling 10,571 comments.

Initially, a task force was organized to adjust the targets of the previous manual classification, which included six initial categories (PRAISE, QUESTION, COMPLAINT, SUGGESTION, or combinations such as PRAISE/COMPLAINT and SUGGESTION/COMPLAINT). This step was crucial for methodological approaches in Supervised Learning, allowing the model to be trained with greater accuracy. The comments were then reviewed and reclassified into three categories: POSITIVE, NEUTRAL, and NEGATIVE. This new classification became the updated target, defined as **Previsão_de_Sentimentos**, now containing only three classes.

During the initial analysis, we identified a significant imbalance in the dataset, as shown in Fig. 1. Most of the received comments had a positive tone, while the examples classified as negative—our primary focus for identifying opportunities to improve public services—were underrepresented.

Fig. 1 - Distribution of comments (June/July 2023).



This imbalance interfered with the model's training, leading to overfitting issues. In other words, the model performed well on training data but showed lower performance on new data, indicating poor generalization. This behavior often occurs in imbalanced or insufficiently representative datasets (GOODFELLOW et al., 2016).

To address this issue, we opted to strategically expand and refine the dataset. We requested additional feedback from the EXPRESSO system, incorporating comments from 03/2022 to 12/2023—totaling approximately 95,000 comments—with the goal of obtaining a higher number of negative examples. This strategy resulted in a more representative and balanced dataset.

4.2 Preprocessing

Textual databases often present challenges related to the quality and structure of texts. Issues such as grammatical errors, duplications, and the presence of irrelevant terms are common, especially in citizen comments that use informal language.

To address these issues, we applied a sequence of specific treatments in the preprocessing phase, which involved the following activities:

a) **Noise removal:** Irrelevant elements for analysis were removed, such as special characters, isolated numbers, excessive repetitions of letters or words (e.g. "sooo good!"), URLs, and other symbols that could introduce noise into the data. This step was essential to clean up the text and ensure greater consistency in the data (AGGARWAL & ZHAI, 2012).

b) **Text normalization:** The texts were converted to lowercase, unnecessary punctuation was removed, and linguistic standardizations were applied. This step helped to standardize the data format, reducing variability generated by different writing styles and typographical errors.

c) **Tokenization:** The texts were then divided into smaller units, called "tokens," which can represent words, phrases, or even characters, depending on the level of detail required. For this process, we used the Natural Language Toolkit library (NLTK), a specific module for tokenization, called tokenize. The NLTK library is widely used due to its broad application in NLP. Below is a demonstration of the tokenization process:

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Original text: Ótimo atendimento, foi tudo rápido e prático! (Great service, everything was fast and practical!)
Punctuation removal: Ótimo atendimento foi tudo rápido e prático
Tokenization into individual words: [Ótimo, atendimento, foi, tudo, rápido, e, prático]
Resulting tokens: ["Ótimo", "atendimento", "foi", "tudo", "rápido", "e", "prático"]

d) **Stopwords:** Stopwords are common words, such as articles, prepositions, and conjunctions, that generally have little informational value (Pang & Lee, 2008). When processing large volumes of text, removing stopwords helps with the analysis and also saves computational resources. However, this step needs to be carefully considered based on the objective, as some words, like "não" (not), can completely alter the meaning of a sentence in sentiment analysis. By removing the word 'não', phrases like 'não é bom' (it's not good) or 'não gostei do atendimento' (I did not like the service) would lose their negative context, hindering the model's ability to correctly identify the sentiment polarity. To solve this problem, we adjusted the default stopwords list. This approach improves the effectiveness of sentiment analysis, particularly in scenarios where nuances, such as negative statements, are relatively important for understanding the text (Aggarwal & Zhai, 2012).

e) **Stemming:** Stemming is an essential technique for NLP that reduces words to their roots or stems by removing suffixes and other endings. The goal is to standardize words that share the same semantic core, such as:

Original words: "atendido" (served), "atendimento" (service), "atender" (to serve)
Stemming to root form: "atend" (serve)
This standardization simplifies text analysis by reducing the dimensionality of the data and grouping similar terms together to improve the efficiency of analytical models (Manning, Raghavan & Schütze, 2008).

4.3 Data transformation

After preprocessing the data, we began the data transformation phase, which aims to adapt textual data into a more structured and suitable format for analysis. According to Manning, Raghavan, and Schütze (2008), machine learning and artificial intelligence models cannot directly process text in its original format, as they operate primarily with numbers and mathematical matrices. Therefore, it is necessary to transform texts into numerical representations so they can be used as input for classification and analysis algorithms. This process is known as vectorization.

Vectorization converts words, phrases, or documents into numerical formats that represent their features. Text-based machine learning models, such as sentiment classifiers, are better able to recognize mathematical patterns within vectors. As such, transforming textual data into vectors is essential to enable models to identify relationships, similarities, and semantic differences between words.

For the **ANE project**, we used the following approaches:

a) **Bag of Words (BoW):** Implemented using the CountVectorizer function from the scikit-learn library. This technique transforms texts into a word frequency matrix, where each row represents a sentence or document, and each column represents a unique word in the vocabulary. BoW is effective in identifying the presence or absence of specific words and works well in tasks that do not require complex semantic interpretation.

b) **Custom Tokenization:** This was performed using the TweetTokenizer from the nltk library, which was configured as a custom tokenizer in the CountVectorizer. This technique is especially useful for handling informal language found in comments or tweet-like texts, correctly processing hashtags, emojis, and abbreviations.

Simplified Example of Vectorization Used:

Corpus = ["Atendimento muito ruim" (Very bad service), "Atendimento excelente e rápido" (Excellent and fast service), "Péssimo atendimento" (Terrible service), "Atendimento muito bom" (Very good service)]

Expected Output – Generated Vocabulary:
{ 'atendimento': 0, 'muito': 4, 'ruim': 6, 'excelente': 2, 'rápido': 7, 'péssimo': 5, 'bom': 1}}

Each unique word in the corpus is assigned an index (its position in the vectorized form).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

For example:

atendimento → 0
muito → 4
ruim → 6

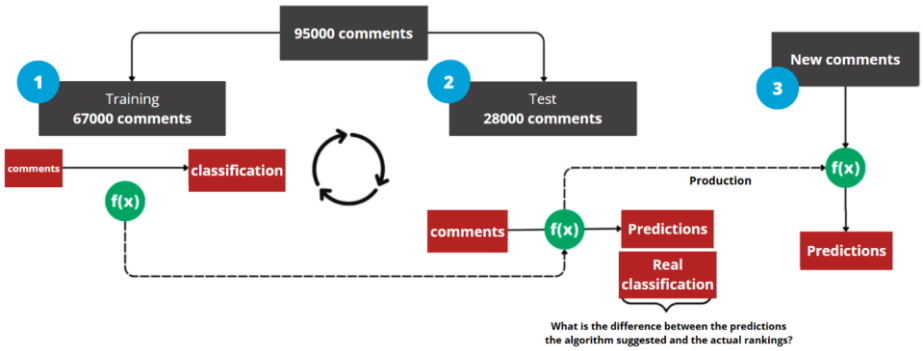
Vectorization of the sentence: "Atendimento muito ruim" (Service very bad)
[1, 0, 0, 0, 1, 0, 1, 0] #Atendimento muito ruim
The word atendimento (index 0) appears once.
The word muito (index 4) appears once.
The word ruim (index 6) appears once.
All other words have a frequency of 0 in this sentence.

The chosen approaches aim to address the characteristics of the analyzed comments, seeking to balance simplicity and effectiveness in pattern extraction. The combination of Bag of Words with custom tokenization proved to be efficient in handling the informal and unstructured nature of the texts.

4.4 Training and evaluation of classification algorithms

We used the traditional split to train and test the model, dividing the data into two subsets as shown in Fig. 2: training set (70%) – used to adjust the model parameters, and test set (30%) – reserved for evaluating the model's performance on unseen data.

Fig. 2 - Training and Test Split.



For the ANE project, we tested four algorithms to select the one with the best performance in the negative class. The tested algorithms were Logistic Regression, Support Vector Machines, Multinomial Naïve Bayes, and Random Forest. These algorithms are traditionally recognized for their efficiency in classification tasks, especially in multi-class categorization problems (McCallum & Nigam, 1998).

The models were evaluated using widely recognized classification metrics, such as precision, recall, F1-score, and accuracy. These metrics were applied to analyze the performance of the different algorithms in identifying patterns and correctly classifying comments within the dataset.

Table 2 presents the accuracy of the models tested for the comment classification task.

Tab. 2 - Overall accuracy of tested algorithms.

Algorithms	Accuracy
Logistic Regression	0.955577
Support Vector Machines	0.951323
MNB	0.950378
Random Forest	0.858223

Although the Multinomial Naïve Bayes (MNB) model did not achieve the highest overall accuracy, it stood out in a crucial aspect of our problem. The MNB model exhibited the highest precision and recall for the negative class, whereas the other models achieved approximately 90% accuracy in this class, which is the primary focus of this project. Accurately classifying negative comments—often characterized by informal language, abbreviations, or more subtle sentiments—was essential for choosing MNB.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

We initially experimented with the Gaussian Naïve Bayes (GaussianNB) variant, which assumes continuous feature distributions. However, since our input features were derived from vectorized textual data using TF-IDF (Term Frequency-Inverse Document Frequency)—a more suitable representation for discrete data—we also evaluated the Multinomial Naïve Bayes (MultinomialNB) algorithm. The MultinomialNB model performed better, particularly in handling the frequency distribution of words commonly found in natural language data. Consequently, we selected MultinomialNB as the Naïve Bayes proxy in the final comparison. The model was trained using its default hyperparameters: alpha = 1.0 for Laplace smoothing, fit_prior = True, and class_prior = None.

As observed in Fig. 3, the recall evaluation shows that the performance of the Multinomial Naïve Bayes model is slightly superior to the other tested algorithms.

Fig. 3 - General evaluation of the Multinomial Naïve Bayes model.

	What proportion of identifications were actually correct? PRECISÃO	How good is the model at predicting the class? RECALL	Balance between precision and recall F1-SCORE	Sample quantity SUPPORT
NEGATIVE	0.91	0.92	0.91	4385
NEUTRAL	0.84	0.12	0.20	643
POSITIVE	0.96	0.99	0.97	23937
accuracy			0.96	28965
macro avg	0.91	0.67	0.70	28965
weighted avg	0.95	0.96	0.95	28965

This result highlights the strength of MNB in handling text data with class imbalances or sparse distributions. Its probabilistic approach and sensitivity to word frequencies made it slightly more effective in identifying and recognizing patterns associated with negative sentiment. On the other hand, models like Logistic Regression and Support Vector Machines, despite achieving higher overall accuracy, were not as efficient in classifying this target class.

These findings reinforce the importance of aligning the model selection with the specific objectives of the analysis. For the ANE project, prioritizing the classification of negative feedback was essential, justifying the choice of Multinomial Naïve Bayes.

4.5 Algorithm Validation

The algorithm validation phase aimed to ensure that the developed model met the project objectives and the practical needs of monitoring Expresso services. This process was carried out in collaboration with the managers responsible for these operations to ensure that the chosen model provided acceptable metrics and produced coherent and useful classifications for decision-making.

For the managers' validation, an executable visual interface was developed that allowed analysis from the .csv file. The application enabled data to be locally loaded for classification and validation by the managers, based on the extracted file with evaluations from any unit and period. The local ANE - Análise EXPRESSO model allowed the comment classification in just a few seconds, highlighting those ones that required immediate attention.

The interface also included a feature for visualizing word clouds separated by class ('positive' and 'negative'), providing an overview of the most frequent terms and helping managers identifying patterns in the comments. In the negative comments (Fig. 4), the word cloud highlights recurring issues such as 'delay' or 'line', which may indicate critical areas that need to be prioritized. In the positive comments (Fig. 5), signs of efficiency or good service are quickly identified. This macro-level visualization of comments facilitates the identification of critical points to be analyzed.

Fig. 4 - Word Cloud with the Negative Class.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



Fig. 5 - Word Cloud with the Positive Class.



After the validation by managers and the approval of the model's efficiency in categorizing feedback, especially negative comments, fine-tuning adjustments were made to enhance alignment with the operational context. This included incorporating words and expressions commonly used by the team for service testing.

From that point, the script was adapted for integration with the Data Warehouse (DW) of the State of Goiás, enabling the classification of stored comments. To save and load the model, Python's **Pickle** module was used. However, since the model includes lambda functions, the additional **Dill** package was required (Izadi, 2019). Following these adaptations, the Pickle file was incorporated into a data processing routine, which now feeds a service monitoring dashboard. This dashboard, available exclusively to managers, utilizes the AI model developed to analyze citizen feedback, classifying their experiences with public services into predefined categories: positive, neutral, and negative. On average, 120 to 200 comments are processed and analyzed daily.

5. Discussion

This study highlighted the significance of applying NLP techniques to analyze comments related to the EXPRESSO services in the State of Goiás. The automated classification facilitated a deeper understanding of citizen feedback and enabled more efficient real-time monitoring, becoming an essential tool in overseeing the quality of public services.

A key point was the analysis of the neutral class. Although this class showed low accuracy due to the limited number of examples available in the training dataset, the model proved promising by effectively capturing neutral comments in new samples. This shows that, despite initial limitations, the model can recognize nuances in texts, indicating that the adopted approach is robust and has potential for refinement. A future improvement would involve expanding the dataset, especially by adding more examples of neutral comments, to reduce bias and improve performance in this class.

Another relevant aspect of the study was the geographical coverage of the database. The used data sample significantly represented the different regions of Goiás, which lends validity to the model in identifying the diverse contexts experienced by public service users. This representativeness is essential to ensure that the model's classifications take into consideration the needs of the entire population.

A graphical interface was developed to support the analysis of Excel and CSV files for local use by the management responsible for evaluations. However, it was also automated on the Goiás state server, being directly fed from the data warehouse, it is replicable. This opens up opportunities for the approach to be applied in other customer service models across Brazil, enabling a national expansion of the developed solution. The standardization of data

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

input processes and the automation of classification make the model to be a scalable tool, which can be adapted to different regional contexts and the specific demands of each locality.

To successfully implement an artificial intelligence program focused on sentiment analysis of comments, it is essential to start the process with clear and transparent communication with managers, ensuring their support and alignment with the initiative's goals. It is also crucial to inform the team that AI is not here to replace them, but rather to eliminate repetitive and monotonous tasks, allowing them to focus on more relevant and strategic activities. The goal is to significantly enhance management by transforming large volumes of data into clear and actionable insights. With tools like sentiment analysis and word cloud visualizations, it becomes possible to quickly identify patterns, emotions, and recurring themes in customer or employee feedback. This enables managers to understand, objectively and in real time, how people perceive products, services, or even the organizational climate. With this information in hand, decisions are no longer based on assumptions but grounded in concrete data, increasing assertiveness, anticipating problems, and creating space for continuous improvement.

Finally, the results obtained reinforce the impact of using sentiment classification algorithms in public management. By prioritizing negative comments as the model's main focus, it allowed for more precise identification of critical points in the services provided, serving as an important monitoring tool for managers to understand citizens' improvements demands in public services. In this way, the work contributed to the improvement of sentiment analysis techniques in the public services context and to the enhancement of the quality of services offered to the population.

Acknowledgement

- **Funding or Grant:** this work is the result of a project developed by the Secretariat of Administration of the State of Goiás - SEAD. No specific monetary funding or grant number is associated with this project.
- **Data/Software Access Statement**: the data analyzed in this study are protected under Brazil's General Data Protection Law (*Lei Geral de Proteção de Dados - LGPD*, Law No. 13.709/2018) due to the presence of personal information from citizens. For further inquiries about the data, contact SEAD. The following software tools were used for data processing and analysis: Jupyter, Visual Studio Code, Python, and Microsoft Excel.
- **Contributor Statement**: Author 1: Conceptualization, Formal Analysis, Investigation, Methodology, Writing – Original Draft, Writing – Review & Editing; Author 2: Data Curation, Software, Validation, Visualization, Writing – Original Draft, Writing – Review & Editing; Author 3: Conceptualization, Project Administration, Supervision, Visualization, Writing – Original Draft, Implementation Manager, Writing – Review & Editing.
- **Use of AI**: During the preparation of this work, the authors used ChatGPT and Copilot to assist with translation between English and Portuguese. ChatGPT and Claude were also employed to support code generation and debugging. After using these tools, the authors reviewed, edited, and validated the content thoroughly, ensuring its quality and accuracy. The authors take full responsibility for the final content of this publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

1. Aggarwal, C. C., & Zhai, C. (2012). Mining Text Data. Springer Science & Business Media.

2. Alpaydin, E. (2020). Introduction to Machine Learning. MIT Press.

3. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.

4. Liu, B. (2012). Sentiment Analysis and Opinion Mining. Morgan & Claypool Publishers.

5. Manning, C. D., Raghavan, P., & Schütze, H. (2008). Introduction to Information Retrieval. Cambridge University Press.

6. Pang, B., & Lee, L. (2008). Opinion Mining and Sentiment Analysis. Foundations and Trends in Information Retrieval, 2(1–2), 1–135.

7. Verma, S. (2022). Sentiment analysis of public services for smart society: Literature review and future research directions. Government Information Quarterly, 39(3), 101708. https://doi.org/10.1016/j.giq.2022.101708

8. Governo do Estado de Goiás. Lei nº 20.846/2020. Recuperado de

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://legisla.casacivil.go.gov.br/pesquisa_legislacao/103353/lei-20846.

9. Royal Free London NHS Foundation Trust & DeepMind. "Our work on Streams." Recuperado de https://www.nhs.uk.

10. Internal Revenue Service. "IRS Artificial Intelligence in Tax Compliance." Recuperado de https://www.irs.gov.

11. E-Estonia. "X-Road: The Backbone of Digital Estonia." Recuperado de https://e-estonia.com.

12. National Health Authority of India. "Leveraging AI in Ayushman Bharat." Recuperado de https://www.pmjay.gov.in.

13. Chien, S., & Chen, W. (2020). AI in public administration: A framework for policy development and service innovation. Journal of Public Administration Research and Theory, 30(4), 567-583. https://doi.org/10.1093/jopart/muz048

14. Izadi, M. (2019, March 11). Pickle your model in Python. Medium. https://medium.com/@maziarizadi/pickle-your-model-in-python-2bbe7dba2bbb

15. SEAD - Secretaria de Estado da Administração. (2024, abril). Metodologia de avaliação dos serviços públicos: Gerência de avaliação da gestão e dos serviços públicos. SEAD.

16. Lara, R. D., & Gosling, M. S. (2016). Um modelo de gestão do relacionamento entre os cidadãos e a administração pública. Revista Eletrônica de Administração, 22(2), 352-376. https://doi.org/10.1590/1413-2311.0522015.59196

17. Goiás. (2020). Lei Estadual nº 20.846, de 2 de setembro de 2020. Institui a política de atendimento ao cidadão no Estado de Goiás e cria o Programa EXPRESSO. Diário Oficial do Estado de Goiás, Goiás.

18. Reichheld, F. F. (2003). The one number you need to grow. Harvard Business Review, 81(12), 46–54.

19. Russell, S., & Norvig, P. (2021). Artificial intelligence: A modern approach (4th ed.). Pearson.

20. O'Neill, R. (2021). AI in public administration: Current practices and future prospects. Public Administration Review, 81(3), 434-448. https://doi.org/10.1111/puar.13208

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Enhancing Open Data Findability: Fine-Tuning LLMs(T5) for Metadata Generation.

*Umair*Ahmed[a*], *Andrea*Polini[a]

[a]Dipartimento di Informatica, Universita di Camerino, Camerino, Italy, Emails: umair.ahmed@unicam.it, an-drea.polini@unicam.it, ORCIDs: 0000-0003-2260-2777, 0000-0002-2840-7561.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025:

Abstract. Metadata is essential for improving the discoverability and findability of datasets. According to the European Data Portal (EDP), Europe's largest open data portal, keywords and categories alone contribute to 60 percent of a dataset's visibility. Given that datasets can have highly variable and complex contexts, we propose leveraging the power of Large Language Models (LLMs), specifically T5-small and T5-large, to generate these metadata. In our study, we used EDP as our case study. We obtained 60,000 datasets from EDP and undertook thorough data cleaning and transformation. This process yielded 3,131 datasets for keyword extraction and 2,790 datasets for category extraction, ready for model fine-tuning.

The base versions of T5-small and T5-large initially struggled to produce keywords that were representative of those generated by humans, resulting in F1 scores of only 0.0455 and 0.1051, respectively. However, fine-tuning significantly improved their performance, achieving an F1 score of 0.4538 for T5-small and 0.6085 for T5-large. A similar pattern was observed in category extraction. The base T5-small and T5-large models had F1 scores of only 0.1222 and 0.3326, respectively. In contrast, the fine-tuned models produced F1 scores of 0.6284 and 0.8322, respectively. Notably, T5-large produced keywords similar to those generated by humans in over 60% of cases, and its category predictions matched human-generated ones in over 80% of cases. This highlights the potential of using large language models (LLMs) for generating human-like metadata, thereby significantly enhancing data findability and usability across various applications.

Keywords. FAIR Metadata, European Data Portal, Open Data, Large Language Models, LLM, T5, Artificial Intelligence, Annotation, Tagging, Keyword Extraction
Research paper, DOI: https://doi.org/10.59490/dgo.2025.941

1. Introduction

In the current data-driven world, there has been a significant increase in the volume and circulation of data. It has alerted stakeholders of its potential to be the new oil. Europe's data economy was estimated to be around €739 billion in 2020 (Van Loenen et al., 2021). Making this data open could lead to a more transparent and inclusive ecosystem. While its potential has already turned heads and a significant amount of data is open, its findability and discoverability across different portals still remain a challenge.

In this study we focus on the lack of quality metadata, that is one of the major causes of poor findability. Indeed, metadata definition is often overlooked by publishers when uploading a dataset. They are usually either unaware of the importance of metadata or more focused on the task of making the data open while ignoring the potential impact of having good metadata. It necessitates an alternate mechanism to fill in the metadata or recommend it to publishers, forming this study's basis. As the European Data Portal (EDP) (EU,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2025) is one of the largest open data portals, we use it as the case study for this research. There are several metadata attributes that enhance a dataset's visibility, including title, description, categories/themes, and keywords. However, according to the EDP, as shown in Table 1, keywords and categories/themes account for 60% of the overall findability score for datasets (EU, 2025). Apart from EDP, keywords and categories are considered to be the most essential elements in general findability. It motivates us to focus on the automated extraction of keywords and categories. By generating good-quality and relevant metadata, we can significantly improve the discoverability of these datasets.

Tab. 1 – European Data Portal Findability Score (EU, 2025)

Indicator	**Description**	**Metrics**	**Weight**
Keyword usage	Keywords directly support the search and thus increase the findability of the data dataset.	The system checks whether keywords are defined. The number of keywords has no impact on the score.	30
Categories	Categories help users to explore datasets thematically.	It is checked whether one or more categories are assigned to the dataset. The number of assigned categories has no impact on the score.	30
Geo search	Usage of spatial information would enable users in order to find the dataset with a geo-facetted search.	It is checked whether the property is set or not.	20
Time-based search	Usage of temporal information would enable users for a timely based facetted search.	It is checked whether the property is set or not.	20

Numerous AI methodologies exist to perform classification and concept extraction. However, this study focuses on leveraging Large Language Models (LLMs) to address the problem of missing/complete metadata, given their deep understanding of the context of texts. It mainly investigates the performance of T5-small and T5-large in generating keywords and categories for datasets within the EDP.

For this study, we extracted 60,000 datasets from EDP, each comprising metadata fields such as titles, descriptions, keywords, and categories. We filtered the data after a rigorous cleaning and transformation process to ensure consistency and relevance. The final dataset included 3,131 instances for keyword extraction and 2,790 instances for category extraction. We fine-tuned both T5 models on these datasets to generate high-quality, human-like metadata. For keywords, we evaluated model-generated outputs using ROUGE-1 and cosine similarity with a threshold of 0.5 to measure the semantic overlap with human-generated keywords. For categories, we performed a one-to-one matching between model-predicted and actual categories. We calculated precision, recall, and F1 scores to assess overall accuracy for both tasks.

The results of this study reflect the effectiveness of fine-tuning large language models (LLMs) for metadata generation. The fine-tuned Flan-T5-large model consistently outperformed T5-small and the base models in both keyword and category extraction tasks, achieving F1 scores of 0.6085 and 0.8322, respectively. These results highlight the significant potential of LLMs to improve metadata quality, address critical gaps in open data platforms, and enhance dataset findability and discoverability. While significant research is underway in the field of semantic search mechanisms due to the advent of large language models (LLMs), our proposal aims explicitly to enhance the searchability and discoverability of datasets that already exist in open data portals. The search mechanisms mostly rely on basic one-to-one matches.

In the subsequent sections, we present a detailed discussion of our study's related work, methodology, results, and implications of our study.

2. Related Works

The significance of metadata, particularly keywords and categories (tagging), in improving a resource's findability, discoverability, and accessibility is well documented. Although several studies have focused on meta-

data generation, minimal research specifically addresses AI's use for generating metadata of open datasets. Following studies have explored the problem of findability and metadata extraction in various domains and from different perspectives. Most of the explored studies employed traditional machine learning models for keyword extraction, while more recent studies also employed LLMs. One such study, RAKE, performs keyword extraction by identifying co-occurrence relationships between words in a document. Even if it is quite fast, it struggles with more semantic relations between texts (Rose et al., 2010). A more advanced method like YAKE!, an improvement on RAKE, employs additional local statistical features for unsupervised keyword extraction. It considers multiple features, including word frequency, co-occurrence, and position, to extract keywords more efficiently (Campos et al., 2020). Moreover, this particular method improves upon frequency-based methods by assigning a higher weight to words occurring often (Würsch et al., 2023). This study explores both machine learning (decision tree and kea) and deep learning (ANN and LSTM) models (Deng, 2024). Despite their effectiveness, traditional methods remain limited in extracting high-quality metadata, especially in cases where semantic understanding is essential.

While traditional methods have been quite robust, contemporary LLMs have paved the way for more semantically aware keyword extraction. For instance, LLM-TAKE utilizes theme-aware keyword extraction, leveraging LLMs to generate keywords that are contextually aware and capture contextual relations (Maragheh et al., 2023). Similarly, Lee et al. (2023) explored and employed a trained LLM, Galactica by Meta, to generate keywords for scientific literature. It showed significant improvements over traditional methods like RAKE and YAKE! (Lee et al., 2023). Purwar and Sundar (2023) use KeyBERT for keyword generation and GPT 3.5 for question answering about the context of the text (Purwar & Sundar, 2023). Ahmed et al. employed a hybrid of BERT, RAKE, TAKE, and TextRank (BRYT) to generate semantically aware keywords from dataset descriptions, which considered the best keywords from each model and reranked them to give the most optimal output (Ahmed et al., 2024)(Ahmed, 2023).

Beyond keyword extraction, category/theme tagging has also benefited from LLMs' ability to understand context, be semantically aware, and generalize across domains. Models like T5 (Raffel et al., 2020) and GPT-3 (Brown et al., 2020) have been fine-tuned for domain-specific metadata generation, including multi-label classification tasks for thematic tagging. For instance, li et al. explored hierarchical transformer models for multi-label text classification. It demonstrated their capability to understand semantic knowledge at different levels to classify the text into given categories (Li et al., 2022). Recent developments also emphasize the integration of multimodal data with LLMs for combined keyword extraction and annotation. Kathiriya et al. explored multimodal LLMs to enhance metadata tagging across datasets that include diverse information (Kathiriya et al., n.d.). Dai et al. also explored the potential of LLMs, particularly GPT-3.5, to replicate human-like behavior in various tasks (Dai et al., 2023). The integration of LLMs with multimodal data, as explored by Kathiriya et al. (2023), further demonstrates the potential of AI-driven approaches to enhance the discoverability of information across diverse platforms, such as e-commerce and data portals (Kathiriya et al., n.d.). Moreover, prompt-tuning and zero-shot capabilities of LLMs, such as OpenAI's GPT models, have made it possible to extract both keywords and thematic categories as multimodal efficiently. By combining supervised fine-tuning and techniques like few-shot learning, these models can address the dual challenge of keyword extraction and thematic tagging at the same time, making them invaluable for dataset-level metadata generation. However, they are significantly more expensive and might hallucinate answers (Ouyang et al., 2022).

3. Methodology

In today's information-driven world, open datasets can potentially solve real-world problems, whether they concern the economy, climate, governance, or health. However, for this to be realized, those datasets have to be findable, accessible, and usable. This notion shaped the basis of our research question: "How can we make vast amounts of data findable and discoverable?". Unfortunately, this vast amount of data, more often than not, hide in plain sight due to poor metadata, such as missing/misrepresentative keywords or missing/misclassified categories. Our goal in this study was to select a semantically capable AI agent, train it to thoroughly understand dataset descriptions, and generate accurate, representative metadata, much like an expert human curator might do.

To achieve this, we curated a methodology (reflected in Fig. 1 and Fig. 2) that involved gathering data, cleaning and refining it, selecting the AI model, designing clear instructions for AI (prompts), fine-tuning the model to

mimic an expert human curator, and evaluating it using the collected data. In the following sections, we provide insights into each step of the methodology.

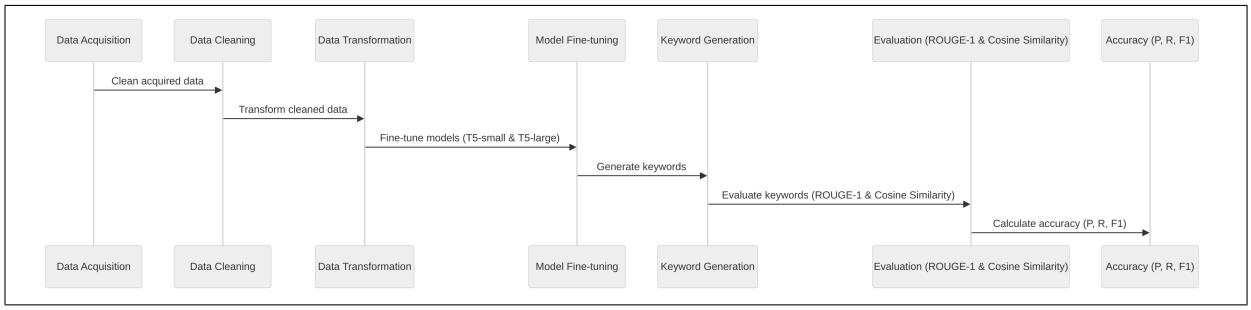


Fig. 1 – Diagram illustrating the key components of the keyword extraction

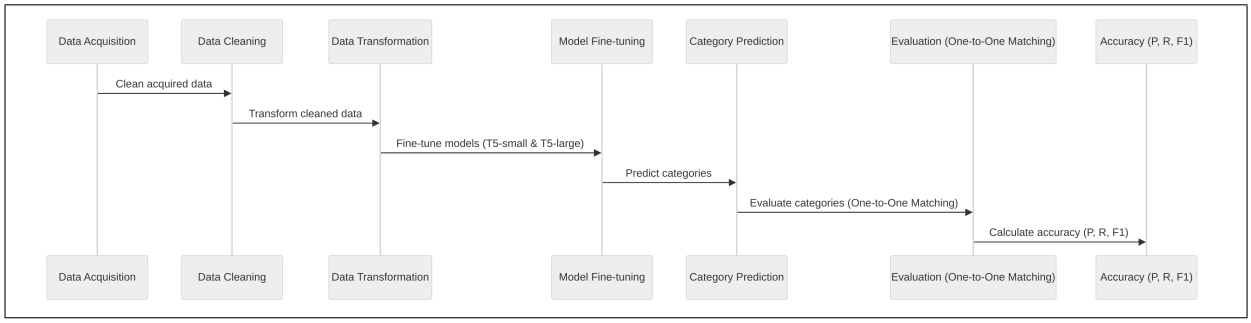


Fig. 2 – Diagram illustrating the key components of the category extraction

3.1. Data Collection and Preprocessing

The European Data Portal is one of the most significant open data initiatives, aggregating open data from EU states. We selected it as our use case and extracted 60000 datasets from it. These datasets were related to various sectors, such as environment, economy, health, and governance. Although there were significant amounts of extracted datasets, their quality was variable, which prompted the need for extensive data cleaning.

We aimed to curate two clean datasets for each task, necessitating task-specific data cleaning and transformation to ensure appropriate model fine-tuning.

3.1.1. Data Exploration and Initial Observations

Prior to data cleaning, we performed an exploratory analysis to understand it. The following observations were recorded and shaped our strategy towards data cleaning:

- **Inconsistent Metadata:** A significant amount of datasets had minimal or missing keywords and categories. Moreover, many of the keywords and categories present were not representative.
  - **keywords:** Many instances had repetitive or nonrepresentative long keywords. For instance, one of the datasets had 41 keywords and one of the keywords was 'From 25 to 34 years (current quarter)' which definitely hurts the chances of a dataset being findable
  - **Categories/Themes:** Several datasets had either missing categories or too many categories assigned to them. For instance, one of the datasets had the following six categories assigned to it: 'Economy and finance | Education, culture and sport | Government and public sector | Health | Population and society | Regions and cities'.
- **Noise in Descriptions:** Some descriptions contained garbage characters, HTML tags, just names of columns, or were too short to be considered for the AI model to extract metadata from. For instance, the following dataset description was too small to consider: 'Traffic signals in Copenhagen Municipality'

- **Multilingual Records:** Various descriptions were in different languages and had to be cleaned to keep the dataset consistent. For instance, the following description: 'Navly, ligne de navette autonome, électrique et sans conducteur au sud du quartier de la Confluence, le long de la Saône.'

These highlighted observations necessitated a more detailed cleaning of the data for efficient training and evaluation of the model.

3.1.2. Preparing the Keyword Extraction Dataset

In the keyword extraction task, we aimed to extract keywords that were relevant and concise. With that in mind, we performed the following data cleaning for it:

- **Language Filtering:** We filtered out non-English descriptions to maintain consistency in training the language models, as different languages in the prompt could confuse the model while training. For instance, a description in French could make it extract multilingual keywords.
- **Title Deduplication:** Using fuzzy matching, we eliminated datasets with titles that had more than 80% similarity to avoid redundancy. This ensured that the model was fine-tuned on a diverse range of examples.
- **HTML Tag Removal:** Some descriptions contained HTML tags, which we eliminated for better text preprocessing. It was essential because non-textual elements in the description could disrupt the model's capability.
- **Number of keywords:** We selected descriptions with 3 to 12 keywords (to cover variability), as the recommended range for optimal keyword searchability is between 5 and 10 (Pottier et al., 2023).
- **Keyword Length:** We excluded keywords with more than three words to eliminate overly complex or irrelevant terms.

After this cleaning and transformation process, we were left with **3,131 records**. These were split into training (80%), evaluation (10%), and testing (10%) sets.

3.1.3. Preparing the Category Extraction Dataset

This task required further data cleaning and transformation to make the categories consistent and meaningful for the model to learn from. These categories are essential for navigating through datasets in any data portal which made us prioritize uniformity and clarity in associations.

- **Redundant Categories:** Some datasets had the same categories with different links or texts assigned to them. We merged those categories into one. For instance: 'http://publications.europa.eu/resource/authority/data-theme/GOVE, https://data.gov.ie/Government'
- **Standard Category URL:** We removed the categories not pointing to the standard Category URL or corresponding to category list names. For instance: 'ncb3a7ce63a654bed8f47f82f30cedd96b7, ncb3a7ce63a654bed8f47f82f30cedd96b9'
- **URL to Names:** We converted URLs of categories into their category names to make the category extraction more meaningful for the user. For instance: 'http://publications.europa.eu/resource/authority/data-theme/ECON' was converted to 'Economy and finance'

This process yielded in a dataset of **2,790 records** for category extraction, similarly split into training (80%), evaluation (10%), and testing (10%) sets.

3.2. Model Selection: Why we chose T5

Choosing a model was a critical task, as it would affect all aspects of the study, be it accuracy, time, space, or finances. We chose T5 (Text-to-Text Transfer Transformer), designed by Google, because of its capability to understand semantic relations in the text while being a small model trainable with a modest amount of resources (Raffel et al., 2020). It puts the model in a unique position where it is not so large that it consumes

significant resources like GPT or LLaMA. Yet, it is also not too small to be unable to understand semantic relationships in the text. Moreover, it was designed to handle a wide array of tasks using a text-to-text approach. In our study, both inputs (descriptions) and outputs (keywords/categories) are in a textual format, making it ideal for these tasks given our compute resources. We employed two variants of T5, namely T5-small and T5-large. Following is a brief overview of the models' architecture.

- **T5-small:** It has 60 million parameters, with 6 encoder/decoder layers, a hidden size of 512, and 8 attention heads. This model is lightweight, resource-efficient, and suitable for low-resource environments, but it may underperform on complex tasks (Raffel et al., 2020).
- **T5-large:** It has 770 million parameters, with 24 encoder and decoder layers, a hidden size of 1024, and 16 attention heads. This model captures intricate patterns and generalizes well for complex tasks; however, it requires significant computational resources (Raffel et al., 2020).

Given various model sizes and limited resources, we wanted to explore the possibility of performing this task with the smallest model to consume minimal resources. This is indeed also needed to permit fast suggestions to the operator uploading the dataset. While T5-small provided faster training and inference, T5-large demonstrated superior performance, making it more suitable for capturing nuanced relationships in complex texts.

3.3. Fine-Tuning T5: Unlocking Task-Specific Precision

Similar to how students and researchers begin by exploring a wide array of subjects before narrowing their focus to specialize in one specific area, fine-tuning helps a language model become highly skilled at a specific task (Ohm, 2024). T5 also had been trained on a vast corpus of data, acquiring general language capabilities. However, the base versions of T5, without fine-tuning, performed inadequately on specific tasks. In our case, to generate human-like metadata, task-specific training was necessary. This led to our decision to fine-tune the model for improved performance.

We used our cleaned-out datasets to fine-tune T5 for our respective tasks. While fine-tuning, we carefully monitored the performance of models to avoid overfitting — a condition where the model starts memorizing data instead of understanding the underlying patterns, much like a student who memorizes the answers to a number of questions instead of understanding the concepts. We let it train for n epochs (iterations) until it showed any signs of overfitting, and then we stopped it. Early stoppage allowed us to determine the optimal number of epochs (training cycles). Following are the details for each task-specific fine-tuning:

3.3.1. Keywords

Flan-T5-small: As reflected in Table 2, we stopped fine-tuning at 17 epochs as the model showed signs of overfitting beyond this point. A learning rate of 4e-5 allowed the model to converge efficiently. Moreover, given the hardware resources and model, we kept the batch size at 8.

Flan-T5-large: This was the larger model, which was trained for 12 epochs before it also started overfitting. The slightly lower learning rate of 3e-5 ensured optimal convergence. It took more time due to its larger size compared to T5-small.

Model	Learning Rate	Batch Size (Train)	Batch Size (Eval)	Epochs	Weight Decay
Flan-T5-small	4e-5	8	8	17	0.02
Flan-T5-large	3e-5	8	8	12	0.02

Tab. 2 – Keyword Extraction: Finetuning configurations for T5-small and Flan-T5-large models

3.3.2. Categories

Flan-T5-small: As reflected in Table 3, we stopped fine-tuning at 8 epochs as the model showed signs of overfitting beyond this point. A learning rate of 4e-5 helped the model to converge efficiently. It took less time than the keyword extraction task because it ran for fewer epochs and had less complex task

Flan-T5-large: The larger model also stopped at 7 epochs, reducing from 12 epochs in keyword extraction because it started to reflect overfitting after that. Although it took significantly more time than T5-small to finetune but it was still less than T5-large for keyword extraction. It is reflected in Table 3.

Model	Learning Rate	Batch Size (Train)	Batch Size (Eval)	Epochs	Weight Decay
Flan-T5-small	4e-5	8	8	8	0.02
Flan-T5-large	3e-5	8	8	7	0.02

Tab. 3 – Catergory Extraction: Training configurations for T5-small and Flan-T5-large models

To perform the fine-tuning, we converted our datasets into T5-specific input prompts, as explained in the subsequent section.

3.3.3. Prompt Design

The efficiency of any LLM depends on well-curated prompts designed for a specific task (Alharbi et al., 2023; Maratsi et al., 2024) and a specific model. Conventionally, you provide an input textual prompt and labels as answers to those prompts. Following are prompts we crafted for each task:

Keyword Extraction

- **Input:** ["Generate 3 to 12 keywords for the following dataset description to improve its findability in a portal. Description: " + datasetDescription]
- **Labels:** Original Dataset Keywords

Category Extraction

- **Input:** ["From the following themes: 'Transport', 'Health', 'Government and public sector', 'Regions and cities', 'Environment', 'International issues', 'Justice, legal system and public safety', 'Energy', 'Education', 'culture and sport', 'Economy and finance', 'Population and society', 'Science and technology', predict the most relevant themes for this dataset description. Description: " + datasetDescription]
- **Labels:** Original Dataset Categories

These prompts were used to finetune T5 small and T5 large for both problems: keyword extraction and category extraction, respectively. The prompts were more concrete and simplistic yet gave enough context for T5 to be able to generate the the required output.

3.4. Model Evaluation

3.4.1. Keywords

We compared the generated keywords from the models with the original keywords using the following similarity metrics:

- **ROUGE-1 (Grusky, 2023):** ROUGE-1 assesses the similarity between the generated keywords and reference keywords by measuring the overlap of unigrams, which are single words.

$$ROUGE-1 = \frac{Numberofoverlappingunigrams}{Totalreferenceunigrams}$$

This metric offers a clear method to evaluate how much of the original content is represented by the generated keywords. We chose ROUGE-1 because it effectively measures direct word matches and is commonly used in tasks like text summarization and text generation.

- **Cosine Similarity (Gunawan et al., 2018):** It calculates the cosine of the angle between two vectors representing the generated and original keywords.

$$CosineSimilarity = \frac{\sum_{i=1}^{n} A_i \cdot B_i}{\sqrt{\sum_{i=1}^{n} A_i^2} \cdot \sqrt{\sum_{i=1}^{n} B_i^2}}$$

Cosine similarity is useful for estimating semantic similarity between words/sentences. This metric is commonly applied in information retrieval and semantic similarity tasks.

We calculated how many original (human-like) keywords were accurately predicted by the model. If 50% or more of the original keywords matched using either of the two metrics, we conventionally considered it a match for that row. We considered using both metrics to capture two-fold matching between keywords: unigram and semantic.

3.4.2. Categories

We compared the generated categories from the models with the original categories using one-to-one matching. The categories were predefined, and the predicted category was only one of those 13 categories, which made the matching simpler.

We calculated the models' accuracy after matching the predicted and original labels in both tasks. We used precision, recall, and F1 scores to estimate the model's accuracy, as reflected below:

- **Precision:** Precision measures the proportion of correctly predicted keywords/categories (matches) out of all the keywords/categories predicted by the model (Kumar & Gupta, 2015). It reflects how many generated keywords mirror keywords a human curator might choose. It is calculated as:

$$Precision = \frac{Number of Matches}{Total Predicted Keywords/Categories} (Kumar \& Gupta, 2015)$$

- **Recall:** Recall measures the proportion of correctly predicted keywords/categories (matches) out of all the original keywords/categories in the dataset (Kumar & Gupta, 2015). It is calculated as:

$$Recall = \frac{Number of Matches}{Total Original Keywords/Categories} (Kumar \& Gupta, 2015)$$

- **F1 Score:** The F1 score is the harmonic mean of precision and recall, balancing their contributions (Kumar & Gupta, 2015). It is calculated as:

$$F1Score = 2 \cdot \frac{Precision \cdot Recall}{Precision + Recall} (Kumar \& Gupta, 2015)$$

These metrics were calculated for all test datasets, comprehensively evaluating the model's ability to predict relevant and accurate metadata.

3.5. Machine Resources and Fine-Tuning Runtime

The fine-tuning process for both keyword and category extraction tasks was conducted on a machine with the following specifications:

- **CPU:** 8 Cores
- **RAM:** 64 GB
- **GPU:** NVIDIA A100

The fine-tuning runtimes for each model and task are summarized in Table 4.

These runtimes highlight the computational efficiency differences between Flan-T5-large and Flan-T5-small, with the latter requiring significantly less time due to its smaller size and fewer parameters.

Task	Model	Fine-Tuning Time (hh:mm:ss)
Keyword Extraction	Flan-T5-large	1:07:43
Keyword Extraction	Flan-T5-small	00:08:31
Category Extraction	Flan-T5-large	00:31:58
Category Extraction	Flan-T5-small	00:04:01

Tab. 4 – Fine-tuning runtimes for each model and task.

Results Overview

In this section, we aimed to evaluate how effectively fine-tuned LLMs can generate metadata—particularly keywords and categories—to improve the findability of the datasets. We focused on two models, namely T5-small and T5-large, and compared their performance before and after fine-tuning. This comparison reflected an apparent transformation. Fine-tuning the base models enabled them to shift from generating non-representative and unreliable metadata to generating effective metadata that closely resembled what a human curator might create. This section views these observations from the lens of metrics like precision, recall, F1 scores, and match rates.

Keyword Extraction

Keywords define the essence of any resource and allow users to understand the summary of the resource without navigating it. In this study, we employed T5-small and T5-large to generate the keywords for EDP datasets. Initially, T5-small and T5-large struggled with extracting keywords. Their base (non-finetuned) models generated keywords that were either inconsistent or irrelevant when compared to human-curated ones. They fell short in both matching algorithms, Rouge-1 and cosine similarity, with a minimum threshold of 50 percent. As reflected in (Table 5) and Fig 3, T5-small only generated keywords for 2 datasets that matched at least 50 percent with the human-labeled metadata, while T5-large only managed just three datasets at a similar threshold.

Match Percentage	T5-small (Base)	T5-small (Finetuned)	T5-large (Base)	T5-large (Finetuned)
$\geq 10\%$	36	220	82	271
$\geq 20\%$	15	206	51	258
$\geq 30\%$	9	189	25	245
$\geq 40\%$	7	148	14	220
$\geq 50\%$	2	139	3	207
$\geq 60\%$	2	126	1	195
$\geq 70\%$	0	89	0	133
$\geq 80\%$	0	62	0	115
$\geq 90\%$	0	45	0	89
$= 100\%$	0	45	0	88

Tab. 5 – Keyword Extraction: Match Percentages Across Models.

As demonstrated in (Table 6) and Fig 4, their performance was significantly weak across all key metrics. Precision, which reflects how many generated keywords were actually correct, was just 0.1093 for T5-small and 0.1919 for T5-large. Recall, which represents how well the model captured the full range of relevant keywords, was similarly low at 0.0287 for t5-small and 0.0724 for t5-large. Consequently, F1 scores, which balance precision and recall, were abysmal: 0.0455 for T5-small and 0.1051 for T5-large. These scores reflected the models' inability to understand the semantic nuances in dataset descriptions.

However, fine-tuning transformed their performance drastically, given it enhanced the model's understanding of the particular task of keyword extraction. Once fine-tuned, the T5-small model improved its match rate to 139 rows at the 50% threshold, while T5-large matched in 207 rows. It is reflected in (Table 5) and Fig 3.

As observed in (Table 6) and Fig 4, the precision of the fine-tuned T5-large model improved to 0.6423, and its recall increased to 0.5781, resulting in an F1 score of 0.6085. This meant that the model generated keywords relevant to the dataset descriptions over 60% of the time—comparable to human experts. This improvement

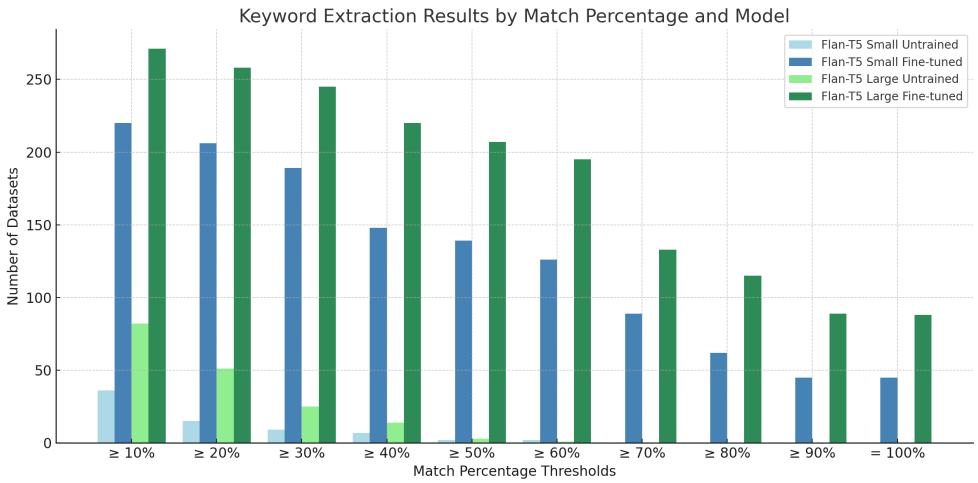


Fig. 3 – Match Percentages Across Models for Keyword Extraction.

Model	Precision	Recall	F1 Score
T5-large (Finetuned)	0.6423	0.5781	0.6085
T5-large (base)	0.1919	0.0724	0.1051
T5-small (Finetuned)	0.5227	0.4010	0.4538
T5-small (base)	0.1093	0.0287	0.0455

Tab. 6 – Keyword Extraction: Precision, Recall, and F1 Scores.

highlights how fine-tuned language models can significantly enhance metadata quality, ensuring that users can find the information they need even through basic keyword-driven searches.

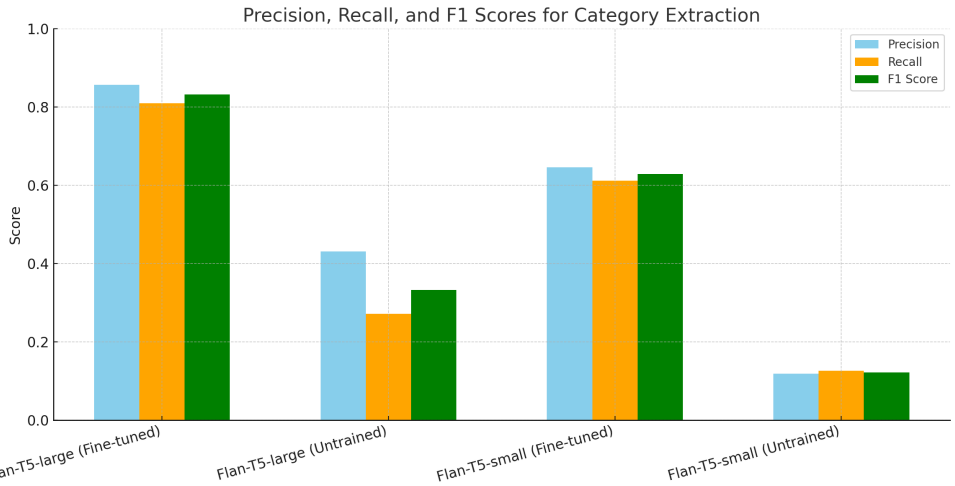


Fig. 4 – Precision, Recall, and F1 Scores for Keyword Extraction Models.

Category Extraction

Dataset themes/categories are essential for organizing datasets thematically, allowing users to navigate large data repositories more effectively. For category extraction as well, we employed T5-small and T5-large. Similar to keyword extraction, both base models performed poorly. As reflected in (Table 7) and Fig 5, T5-small had 223 rows where no category matches were found, while T5-large had 138 such rows. The number of rows with match percentages in the 75–100% range was also minimal, with only 30 matches for T5-small and 50 for T5-large. These results indicated that the models struggled to associate dataset descriptions with relevant categories due to a lack of understanding of semantic context.

Match Percentage	T5-small (Base)	T5-small (Finetuned)	T5-large (Base)	T5-large (Finetuned)
0%	223	100	138	44
1 – 25%	5	4	11	2
25 – 50%	20	22	79	14
50 – 75%	1	1	1	3
75 – 100%	30	152	50	216

Tab. 7 – Category Extraction: Match Percentages Across Models.

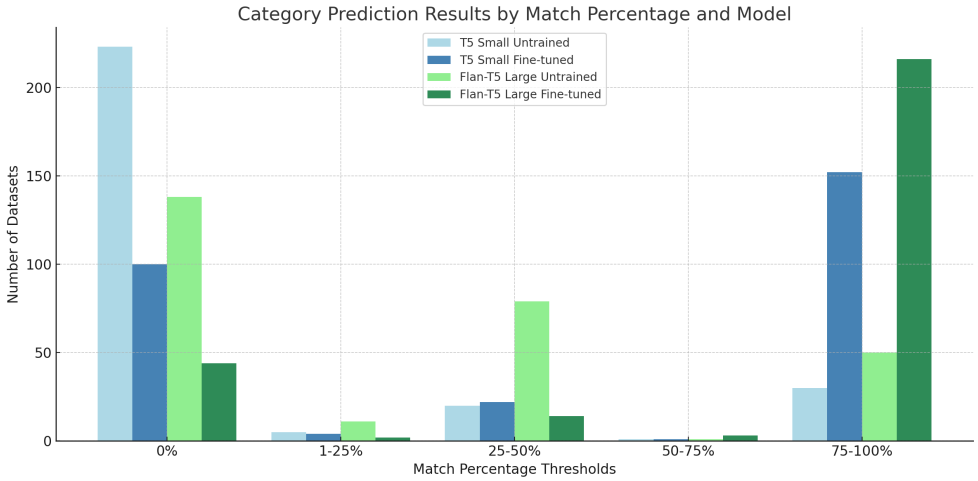


Fig. 5 – Match Percentages Across Models for Category Extraction.

Fine-tuning again led to significant improvements in match percentages. The number of rows with no matches was reduced to 100 for T5-small and 44 for T5-large. Meanwhile, rows with matches in the 75–100% range increased to 152 for T5-small and 216 for T5-large. This demonstrated a notable enhancement in the models' ability to align their predictions with human-curated categories.

Model	Precision	Recall	F1 Score
T5-large (Finetuned)	0.8566	0.8092	0.8322
T5-large (base)	0.4303	0.2710	0.3326
T5-small (Finetuned)	0.6459	0.6118	0.6284
T5-small (base)	0.1188	0.1258	0.1222

Tab. 8 – Category Extraction: Precision, Recall, and F1 Scores.

The improvement in match rates was further reflected in accuracy metrics. As observed in (Table 8) and Fig 6, the fine-tuned T5-small model achieved a precision of 0.6459, a recall of 0.6118, and an F1 score of 0.6284. The fine-tuned T5-large model demonstrated even better performance, with a precision of 0.8566, a recall of 0.8092, and an F1 score of 0.8322. These results highlight the effectiveness of fine-tuning in enabling models to interpret dataset descriptions better and predict relevant categories to enable more efficient thematic searches.

Fine-tuning consistently enhanced the performance of both models, with Flan-T5-large outperforming Flan-T5-small in both tasks. Figures 3 and 5 visually highlight the improvements in match percentages for each task, while Figures 4 and 6 emphasize the precision, recall, and F1 score advancements.

4. CONCLUSION AND FUTURE WORKS

This study explored the potential of fine-tuning Large Language Models (LLMs), specifically T5-small and Flan-T5-large, for generating keywords and categories for open datasets. While the base models struggled in both tasks, fine-tuning significantly improved their performance. Although both models demonstrated considerable improvements, T5-large consistently outperformed T5-small across all metrics.

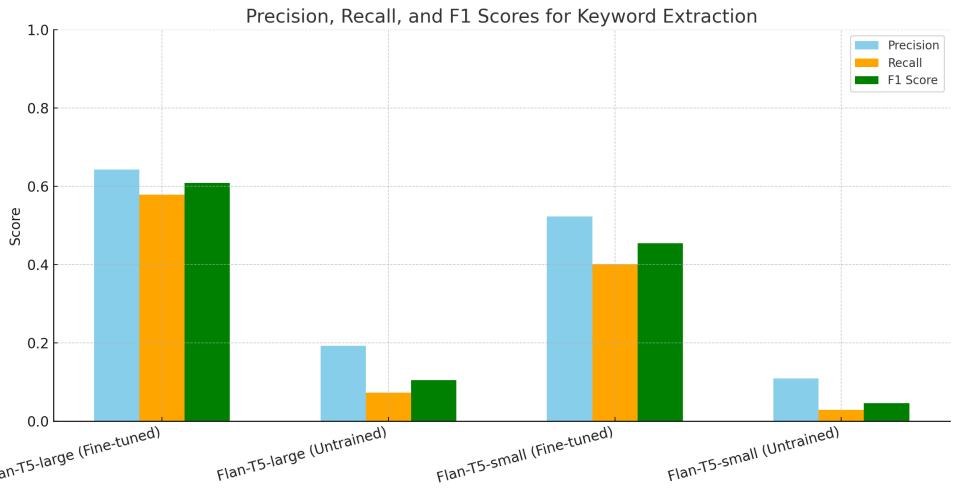


Fig. 6 – Precision, Recall, and F1 Scores for Category Extraction Models.

For keyword extraction, the base T5-small model achieved an F1 score of 0.0455, while T5-large had 0.1051. After fine-tuning, T5-small improved significantly with an F1 score of 0.4538, and T5-large achieved 0.6085, demonstrating its ability to generate human-like keywords that will improve dataset discoverability. Similarly, for category extraction, the base T5-small model had an F1 score of 0.1222, and T5-large scored 0.3326. With fine-tuning, T5-small improved its F1 score to 0.6284, while T5-large excelled with 0.8322, showcasing its capability to capture complex semantic relationships. These results highlight the potential of LLMs to generate metadata for missing or incomplete entries in open data portals, thereby improving dataset findability and discoverability.

Future work could further explore several avenues to enhance the scope and accuracy of metadata generation. Expanding the dataset to include more extensive and diverse examples could improve model generalizability and enable it to handle a wider range of contexts. Employing other large language models, such as GPT, LLaMA, and DeepSeek-R1, could significantly impact the study's accuracy and performance outcomes. Multilingual support would allow the models to generate metadata in multiple languages, catering to a broader audience. Additionally, integrating actual dataset samples or other metadata elements, such as titles, publishers, catalogs, or geographic information, as input features could improve prediction quality. Following keyword and category extraction, we want to generate the description using the dataset's contents. Another promising direction involves incorporating user feedback from data portal users and publishers, enabling iterative refinement of generated metadata to better align with user needs.

By addressing these areas, future studies can significantly contribute to a more accessible, interoperable, and user-friendly open data ecosystem.

Acknowledgement

Funding or Grant

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 955569. The opinions expressed in this document reflect only the author's view and in no way reflect the European Commission's opinions. The European Commission is not responsible for any use that may be made of the information it contains.

Data/Software Access Statement

The data for this is placed at the following repository: https://github.com/umairahmedq/MDEusingLLM.

Contributor Statement

Umair Ahmed contributed in Conceptualization, Data Curation, Formal analysis, Investigation, Methodology, Software, Resources, Validation, Visualization, Writing – Original Draft, Writing - Review & Editing. Andrea Polini contributed in Conceptualization, Supervision, Project administration, Funding acquisition, Resources, Writing - Review & Editing.

Use of AI

During the preparation of this work, the author(s) used [Grammarly and OpenAI] in order to [refine the language and enhance clarity in communication]. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict Of Interest (COI)

Conflict Of Interest (COI)*: There is no conflict of interest

References

Ahmed, U. (2023). Reimagining open data ecosystems: A practical approach using ai, ci, and knowledge graphs. *BIR Workshops*, 235–249.

Ahmed, U., Alexopoulos, C., Piangerelli, M., & Polini, A. (2024). Bryt: Automated keyword extraction for open datasets. *Intelligent Systems with Applications*, *23*, 200421.

Alharbi, R., Ahmed, U., Dobriy, D., Łajewska, W., Menotti, L., Saeedizade, M. J., & Dumontier, M. (2023). Exploring the role of generative ai in constructing knowledge graphs for drug indications with medical context. *Proceedings http://ceur-ws. org ISSN*, *1613*, 0073.

Brown, T., Mann, B., Ryder, N., Subbiah, M., Kaplan, J. D., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell, A., et al. (2020). Language models are few-shot learners. *Advances in neural information processing systems*, *33*, 1877–1901.

Campos, R., Mangaravite, V., Pasquali, A., Jorge, A., Nunes, C., & Jatowt, A. (2020). Yake! keyword extraction from single documents using multiple local features. *Information Sciences*, *509*, 257–289.

Dai, S.-C., Xiong, A., & Ku, L.-W. (2023). Llm-in-the-loop: Leveraging large language model for thematic analysis. *arXiv preprint arXiv:2310.15100*.

Deng, H. (2024). The advancements and progresses of artificial intelligence-based keyword extraction methods. *2024 International Conference on Artificial Intelligence and Communication (ICAIC 2024)*, 580–585.

EU. (2025). European data portal [Accessed: 2025-01-21].

Grusky, M. (2023). Rogue scores. *Proceedings of the 61st Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers)*, 1914–1934.

Gunawan, D., Sembiring, C., & Budiman, M. A. (2018). The implementation of cosine similarity to calculate text relevance between two documents. *Journal of physics: conference series*, *978*, 012120.

Kathiriya, S., Mullapudi, M., & Karangara, R. (n.d.). Optimizing ecommerce listing: Llm based description and keyword generation from multimodal data.

Kumar, S., & Gupta, P. (2015). Comparative analysis of intersection algorithms on queries using precision, recall and f-score. *International Journal of Computer Applications*, *130*(7), 28–36.

Lee, W., Chun, M., Jeong, H., & Jung, H. (2023). Toward keyword generation through large language models. *Companion Proceedings of the 28th International Conference on Intelligent User Interfaces*, 37–40.

Li, J., Wang, C., Fang, X., Yu, K., Zhao, J., Wu, X., & Gong, J. (2022). Multi-label text classification via hierarchical transformer-cnn. *Proceedings of the 2022 14th International Conference on Machine Learning and Computing*, 120–125.

Maragheh, R. Y., Fang, C., Irugu, C. C., Parikh, P., Cho, J., Xu, J., Sukumar, S., Patel, M., Korpeoglu, E., Kumar, S., et al. (2023). Llm-take: Theme-aware keyword extraction using large language models. *2023 IEEE International Conference on Big Data (BigData)*, 4318–4324.

Maratsi, M. I., Ahmed, U., Alexopoulos, C., Charalabidis, Y., & Polini, A. (2024). Towards cross-domain linking of data: A semantic mapping of cultural heritage ontologies. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 165–176.

Ohm, P. (2024). Focusing on fine-tuning: Understanding the four pathways for shaping generative ai. *Columbia Science and Technology Law Review, Forthcoming*.

Ouyang, L., Wu, J., Jiang, X., Almeida, D., Wainwright, C., Mishkin, P., Zhang, C., Agarwal, S., Slama, K., Ray, A., et al. (2022). Training language models to follow instructions with human feedback. *Advances in neural information processing systems*, *35*, 27730–27744.

Pottier, P., Lagisz, M., Burke, S., Drobniak, S. M., Downing, P. A., Macartney, E. L., Martinig, A. R., Mizuno, A., Morrison, K., Pollo, P., et al. (2023). Keywords to success: A practical guide to maximise the visibility and impact of academic papers. *bioRxiv*, 2023–10.

Purwar, A., & Sundar, R. (2023). Keyword augmented retrieval: Novel framework for information retrieval integrated with speech interface. *Proceedings of the Third International Conference on AI-ML Systems*, 1–5.

Raffel, C., Shazeer, N., Roberts, A., Lee, K., Narang, S., Matena, M., Zhou, Y., Li, W., & Liu, P. J. (2020). Exploring the limits of transfer learning with a unified text-to-text transformer. *Journal of machine learning research*, *21*(140), 1–67.

Rose, S., Engel, D., Cramer, N., & Cowley, W. (2010). Automatic keyword extraction from individual documents. *Text mining: applications and theory*, 1–20.

Van Loenen, B., Zuiderwijk, A., Vancau-Wenberghe, G., Lopez-Pellicer, F. J., Mulder, I., Alexopoulos, C., Magnussen, R., Saddiqa, M., De Rosnay, M. D., Crompvoets, J., et al. (2021). Towards value-creating and sustainable open data ecosystems: A comparative case study and a research agenda. *JeDEM-eJournal of eDemocracy and Open Government*, *13*(2), 1–27.

Würsch, M., Kucharavy, A., David, D. P., & Mermoud, A. (2023). Llms perform poorly at concept extraction in cyber-security research literature. *arXiv preprint arXiv:2312.07110*.

Ensuring Data Quality in National Educational Databases: Insights from Brazil's Centralized Database of High School Students' Data

Abílio Nogueira Barros[a,b], Emanuel Marques Queiroga[c,b], Markson Rebelo Marcolino[d,b], Débora Barbosa Leite Silva[b], Diego Dermeval[b], André Lima[b], Leonardo Brandão Marques[b], Cristian Cechinel[d,b] and Thales Vieira[b*]

[a]Departamento de Computação, Universidade Federal Rural de Pernambuco (UFRPE), Recife 52171, Brazil, abilionbarros@gmail.com

[b]Center of Excellence for Social Technologies (NEES), Universidade Federal de Alagoas, Maceió 57072, Brazil, {debora.silva, diego.matos, andre.lima, leonardo.marques, thales.vieira}@nees.ufal.br

[c]Instituto Federal de Educação, Ciência e Tecnologia Sul-Rio-Grandense (IFSul), Pelotas 96.015-360, Brazil, emanuel.marques@nees.ufal.br

[d]Centro de Ciências, Tecnologias e Saúde, Universidade Federal de Santa Catarina, Araranguá 88040, Brazil, cristian.cechinel@ufsc.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. This study investigates challenges in ensuring data quality within Brazil's national educational database, the Sistema Gestão Presente (SGP), and proposes solutions. Reliable and integrated data systems are critical for evidence-based policymaking, particularly in education. The SGP, designed to centralize student attendance and enrollment data, faces issues such as inconsistent data entry, logical errors, and systemic reporting anomalies. To address these challenges, a data-driven methodology inspired by the DMAIC framework was implemented, focusing on defining problems, measuring and analyzing data inconsistencies, improving processes through tailored solutions, and monitoring outcomes for continuous quality assurance. Seven case studies illustrate the results of this approach. These include resolving inconsistent enrollment dates, limiting multiple active enrollments per student, and ensuring consistency between disenrollment justifications and active statuses. Further, systemic anomalies, such as inflated attendance rates and implausibly high class hours reported at state levels, were identified and corrected through validation rules, training initiatives, and auditing mechanisms. These interventions reduced data inconsistencies, enhanced reliability, and improved system usability. The findings demonstrate how integrating validation mechanisms, improving data entry workflows, and fostering stakeholder collaboration can address large-scale data challenges. By ensuring the quality and integrity of educational data, the SGP enables more accurate insights into attendance patterns, dropout rates, and program effectiveness. These improvements lay the foundation for robust evidence-based policies and equitable educational outcomes across Brazil, highlighting the transformative potential of data quality assurance for public sector decision-making.

Keywords. Data quality, interoperability, data integrity, public policies, education.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.943

1. Introduction

The quality and integrity of educational data are foundational to developing evidence-based policies that drive meaningful improvements in education. This study explores the need for reliable educational data, focusing

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

on attendance records, and investigates common anomalies that can arise in large-scale datasets. Among the many data points collected in education systems, attendance data is a critical indicator of student engagement, resource allocation, and overall system performance. Accurate attendance records are more than just statistics. They tell how students interact with their learning environments and provide essential insights for shaping their futures. Without reliable data, policymakers risk basing decisions on flawed insights, leading to inefficiencies and missed opportunities for improving educational outcomes. Data reliability is paramount for fostering accountability and enabling informed decision-making (Jenkins & Duri, 2020).

This study draws on data from the *Sistema Gestão Presente* (SGP), a comprehensive database that tracks student attendance across Brazil, designed to integrate data from thousands of sub-national educational departments. The SGP is a critical tool for monitoring student engagement at a national level, providing detailed records of student attendance in classrooms across diverse educational settings. However, the scale and complexity of the SGP dataset bring unique challenges, such as data inconsistencies, varying collection methodologies, and discrepancies in reporting.

Data collection for large-scale educational systems often involves multiple stakeholders, including schools, districts, and state-level administrators. This decentralized approach creates unique challenges for interoperability, as data from various sources must be harmonized within a unified system. Differences in data formats, collection methods, and validation protocols can result in inconsistencies and errors that undermine the credibility of the entire dataset (Rocha et al., 2024).

Maintaining data quality goes beyond initial collection; it requires continuous verification throughout the data lifecycle. While validations at the point of entry are essential, they are insufficient to address the complexities of large and evolving datasets. A practical quality assurance framework must have ongoing monitoring, anomaly detection, and feedback mechanisms to identify and correct errors as they arise. These processes are crucial not only for maintaining the integrity of the data but also for building trust among the stakeholders who depend on it for informed decision-making (Redyuk et al., 2021; Taleb et al., 2021).

Reliable educational data, especially attendance records, is the backbone of effective policymaking. However, collecting accurate data on a nationwide scale is no simple task(Queiroga et al., 2024). Schools, districts, and state systems often use varied methods, making consolidating information into a single, coherent dataset challenging. By addressing these challenges and building systems that ensure data consistency, trustworthiness, and ease of integration, we can empower educators and policymakers with the insights needed to create impactful, student-focused policies and initiatives.

The present paper describes how data inconsistencies inside SGP were dealt with by adopting a data-driven approach to redesign the system based on post-implementation analysis and enhancements. The remainder of the paper is structured as follows. Section 2 describes the work focusing on data interoperability problems, while section 3 presents the educational context of SGP. Section 4 illustrates the methodology followed during the development of SGP to ensure data quality and integrity while describing the most important actors and stakeholders involved. Section 5 describes seven study cases to illustrate the data inconsistencies in the SGP and how they were resolved by adopting the presented methodology. Section 6 discusses the findings from the work, and section 7 concludes the paper.

2. Related Work

Data interoperability is a fundamental need in the public sector, encompassing different areas of governmental activity. As highlighted by Restrepo-Carmona et al., 2024, interoperability and the systematization of public databases can enhance transparency, accountability, and efficiency in the management of public funds. These examples demonstrate how interoperability transcends sectors, acting as a crucial pillar for the modernization and effectiveness of public administration.

Another relevant work on the importance of interoperability in the governmental context is Tavares and Bitencourt, 2022, which explores the relationship between interoperability and public policy evaluation within the scope of digital governance. Despite its significance, the implementation of interoperability faces significant barriers, such as the need for investments in technological infrastructure, personnel training, and cultural shifts within public institutions. These last two points, in particular, are directly tied to the success of data

usage, as public agents play a central role throughout the data lifecycle—from initial entry to final interpretation for decision-making. However, as noted by various studies in this field, the challenges faced are global and structural. The survey by Restrepo-Carmona et al., 2024, when analyzing the feasibility of interoperability in Latin American governments, identified recurring difficulties such as limited access to public data, lack of standardization, and the need for greater interinstitutional collaboration to integrate data efficiently. Additionally, infrastructure, governance, and organizational culture issues exacerbate these challenges.

Moving into the health sector, interoperability is also recognized as a critical factor for the reliability and quality of data. As noted by D'Amore et al., 2018, processes and tools aimed at cataloging and enhancing clinical data quality underscore the importance of well-defined standards. Similarly, Valdés and Lecaros, 2024 proposes necessary actions for creating biobanks in the Latin American context, aiming to strengthen research and produce high-quality scientific evidence on a global scale.

Interoperability plays a crucial role in Brazil's healthcare system, particularly for data quality and system integration. According to the systematic review by (Barbalho et al., 2022), 78.58% of analyzed studies highlight interoperability between systems as essential for improving patient care. Their research identified 31 national health information systems operating in primary care between 2013-2018, with significant fragmentation challenges. This fragmentation became more evident in the implementation of e-SUS Primary Care Strategy, as shown by (Coelho Neto et al., 2021), where only 12 of 31 systems achieved complete integration with e-SUS interfaces. In comparison, 15 systems showed no integration at all. The study revealed a stark disparity between systems managed by different government departments - notably between the Health Care Secretariat (SAS) and Health Surveillance Secretariat (SVS), where SVS systems showed minimal integration despite having similar numbers of systems in use. Similarly, (Vasques et al., 2024) propose a maturity framework for evaluating interoperability in Brazilian healthcare institutions, noting that despite SUS protocols established in 2011 to coordinate information from over 6,000 healthcare providers, private institutions often develop independent systems that minimize contribution to the broader Brazilian health network. This fragmentation persists despite initiatives like the National Health Data Network (RNDS), which impact data quality and limit the potential for integrated healthcare delivery.

Entering the educational domain, several studies explore interoperability and data adequacy for implementing and improving educational systems. For instance, Macedo de Andrade et al., 2022 evaluates a program's impact on encouraging educational data use by school actors. This study employed a quasi-experimental Differences-in-Differences (DiD) model to analyze the effects of the *Escolas em Foco* program. The methodology combines advanced statistical techniques to measure the program's impact while addressing the importance of data interoperability to enhance student learning. The analysis was conducted using various datasets, highlighting how the effective use of such information can support improvements in school performance.

The work of BOZ and SIMSEK, 2022, the interoperability of information systems within Turkey's Ministry of National Education (MoNE) is explored in detail. The article emphasizes that MoNE is the country's largest public institution, serving 18 million students and employing over one million teachers. To manage this robust structure, the ministry operates several information systems. During the study, metrics were identified to evaluate interoperability and strategies to improve intra-system communication. The work stresses that a stronger correlation between data is essential for more in-depth analyses, promoting advancements in the use of educational information.

In the Brazilian context, Queiroga et al., 2024 addresses the integration of the SAEB (National System of Basic Education Evaluation) and School Census databases. This study connects information about student performance and school conditions, enabling comprehensive analyses and identifying factors that impact educational equity in Brazil. The integration of these databases allowed researchers to go beyond isolated analyses, generating deeper *insights* into the relationships between school infrastructure and educational outcomes. The study reinforces the importance of reliable and interconnected data to provide a current overview and support public policies to improve Brazilian education.

Once the importance of data interoperability has been analyzed, data quality is another crucial factor for using these data. The study by Wijayanti et al., 2018 evaluates data quality in higher education, focusing on the Statistics Institute of Indonesia. This study used a quantitative approach to measure data quality, followed by a qualitative analysis of the results. Direct queries in SQL (Structured Query Language) were conducted in the integrated information system database. The evaluation revealed that the data quality at the Statistics Insti-

tute does not meet governmental requirements. Observing the completeness pillar, only 21.15% of business rules were met, and regarding validity, 57.90% of business rules were fulfilled, with issues found related to inconsistent data formats and types.

To solve the same problem of ensuring data quality in integrating university data, the study at Universitas Amikom Purwokerto Wahid et al., 2024 implemented a data warehouse. This data warehouse meets reporting requirements and promotes a culture of high-quality data management, where data is accessible, accurate, and useful for decision-making and strategic planning. Additionally, Du, 2021 described a model that seeks to define a theoretical and methodological framework for classifying, collecting, analyzing, and evaluating educational data quality, aiming to improve the management and utilization of these data. The study addresses the importance of a data quality management system in universities, encompassing quality assurance, process management, and data quality evaluation. The proposed model also emphasizes the need for a data quality evaluation system to ensure that collected data is accurate and complete. Although more focused on academic systems, these examples highlight the importance of data quality in connected contexts, demonstrating that efforts must be systematic and continuous to ensure the accurate and correct use of these data.

3. Educational context - The Sistema Gestão Presente (SGP)

The *Sistema Gestão Presente* (SGP)[1] is a new tool developed by Brazil's Ministry of Education (MEC) to enable comprehensive monitoring of students in basic education. This system is designed to centralize student enrollment and attendance tracking information, providing a sustainable and integrated platform for educational networks to submit data. Its implementation aims to streamline data management processes while enhancing accessibility and reliability across the education sector.

To accommodate the diverse realities of educational networks, the SGP allows for two formats of information submission: through APIs for educational networks with integrated systems and via data spreadsheets for those lacking advanced technological infrastructure. Figure 1 illustrates the data flow and integration within the SGP, highlighting its role in managing student data for Brazil's educational networks.

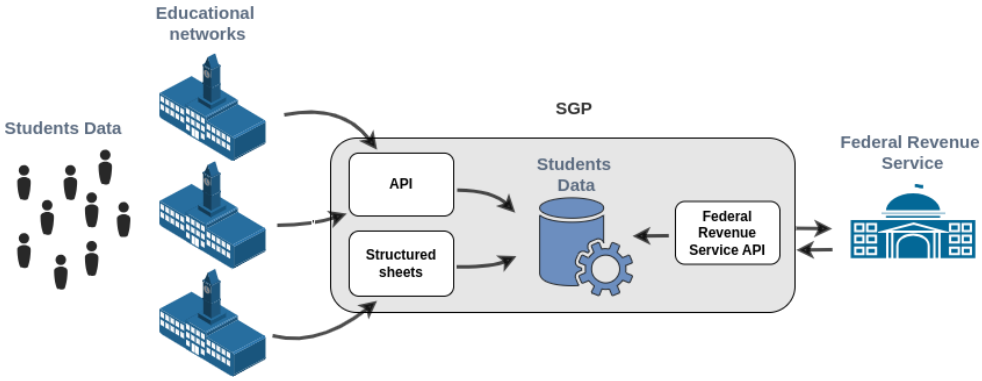


Fig. 1 – Sistema Gestão Presente.

The figure shows that the process begins with student data collected from schools across various educational networks. This data is transmitted to the SGP via structured spreadsheets or an API, depending on the technological capabilities of the institutions. Once in the SGP, the student data is stored in a centralized database, which can be processed and utilized. The system also integrates with the Federal Revenue Service through an API, enabling a two-way data exchange to support compliance, verification, and analysis needs.

This flexibility aims to enhance the system's reach and efficiency, ensuring that schools with robust systems and those with more limited resources can participate inclusively. With the consolidated database, studies can be conducted, and techniques can be applied to identify patterns and generate alerts about critical issues such as school dropout rates, student attendance patterns, or abrupt changes in attendance behavior. For instance, students with historically high attendance rates who suddenly show significant declines may indicate situations requiring closer monitoring by the school. This oversight allows for proactive interventions to address

[1] https://gestaopresente.mec.gov.br/

problems and promote student retention in the school environment (Macarini et al., 2020; Queiroga et al., 2022).

Implementing a system to support educational management in a country with continental dimensions, such as Brazil, is a significant challenge. In 2023, the National Institute for Educational Studies and Research Anísio Teixeira. (INEP) reported 47.3 million enrollments distributed across 178,500 educational entities in BrazilBrasil. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep), 2024, covering the entire national territory. Given the magnitude of this challenge, obstacles related to integrating various education networks are expected, considering their specific educational characteristics, such as differences in the number of school days, workloads, and regional particularities. These challenges were reflected in the data entered during the system's initial months of use. Errors or inconsistencies were identified, highlighting initial difficulties in adaptation by educational institutions.

The following section will address the anomalies detected and reported during this period, aiming to highlight the actions taken to improve the quality and accuracy of the data entered into the system.

4. Methodology for data quality assurance

This section describes the methodology currently followed by the SGP team to ensure the quality and integrity of data inside the system. Subsection 4.1 describes the main actors involved in this process, and 4.2 depicts the different steps followed during the process.

4.1. Working teams and stakeholders

Leading a project of great significance, such as the development and maintenance of the SGP, requires the integrated effort of multidisciplinary teams performing different roles within the organizational structure. This collaboration is essential for the system to meet the complex demands of the Brazilian educational context. At the project's core is project management, tasked with planning, coordinating, and ensuring the completion of each stage within the established deadlines and objectives while adapting to demands arising from interactions with external stakeholders. Developers, in turn, are responsible for implementing technical features, ensuring system robustness, user interface efficiency, database integrity, and the continuous refinement of business rules. Simultaneously, the data quality team monitors and validates the consistency and integrity of the data, ensuring its reliability for internal and external applications, such as future studies and analyses.

Additionally, the team focuses on the public policy perspective and strategically aligns project activities with societal priorities. This team works to maximize the system's impact, manage external demands, prepare manuals, organize training sessions, and mediate potential conflicts. Collaboration with external stakeholders is equally indispensable. The Ministry of Education, as the central coordinator, sets strategic guidelines and ensures alignment with national public policies. Meanwhile, state and municipal education departments are critical in implementing the system locally. They act as a bridge between the SGP and educational institutions, providing data, offering initial support, and serving as schools' first point of contact. Figure 2 depicts the most important actors involved in the process of ensure data quality inside SGP.

This integration between internal and external teams ensures that the SGP operates efficiently and is aligned with its users' real needs. As a result, the system directly contributes to quality educational management that is equitable and responsive to regional and national challenges.

4.2. Workflow

The methodology for data quality assurance follows a data-driven approach to problem-solving and optimization with a similar structure and purpose of lean DMAIC (Define, Measure, Analyze, Improve, Control) Six Sigma framework (Srinivasan et al., 2016). The process begins with problem definition ("Define" phase in DMAIC), focusing on clarifying hypotheses and research questions to set the foundation for analysis. In the design and prototyping phase ("Measure" and "Analyze" stages from DMAIC), data is systematically examined using statistical methods, machine learning, and visualization to identify and understand anomalies. The implementation phase ("Improve" phase from DMAIC) translates analytical findings into actionable solutions such as new business rules, training, and auditing to resolve identified issues. Lastly, the evaluation



Fig. 2 – Actors involved on SGP's data quality assurance.

and learning phase mirrors the "Control" phase, emphasizing monitoring implemented solutions, ensuring their effectiveness, and capturing insights for continuous improvement. Figure 3 gives an overall view of the methodology cycle and its actors.

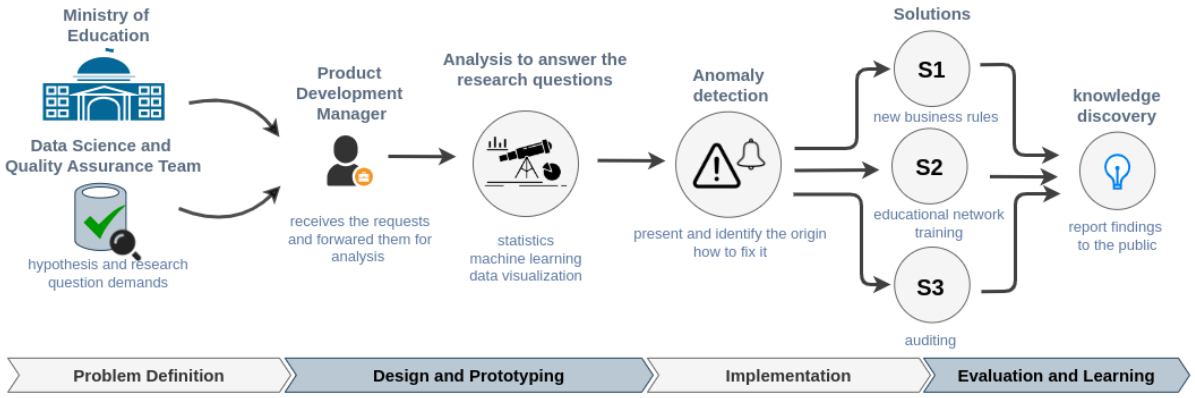


Fig. 3 – Overview of the data quality assurance process.

The figure shows that the process starts with the Ministry of Education or other stakeholders submitting hypotheses and research questions to the Data Science and Quality Assurance Team. The **problem definition** phase identifies and categorizes any inconsistencies in the data. This includes raising concerns and forming hypotheses to address incorrect data inputs or calculation errors. It's also a collaborative process involving stakeholders in understanding the scope and root causes of the problems entirely. The Product Development Manager plays a key role here, providing a bridge to ensure these issues are forwarded for deeper analysis. At this stage, the data is reviewed in detail to uncover patterns, outliers, and areas that need further investigation. This analysis lays the groundwork for the next steps and relies on technical expertise and a strong understanding of the educational context. From this work, two main types of hypotheses typically emerge:

- Team-Driven Hypotheses: These are based on patterns, anomalies, or inconsistencies uncovered through internal analysis.
- Externally Requested Hypotheses: These come from higher-level teams or the Ministry of Education (MEC) and address specific institutional priorities.

Once the hypotheses are formed, they are critically analyzed to ensure relevance and impact. This involves combining technical knowledge with an understanding of educational data and business rules, ensuring the investigations are well-targeted and aligned with the broader goals.

Data is then analyzed in the **design and prototyping** phase to address the research questions. Here, some techniques are used, such as statistical methods (quantitatively measuring and evaluating data), machine

learning (to detect more complex patterns or anomalies that are challenging to identify manually), and data visualization techniques (that assist in clearly and comprehensively communicating findings). Next, anomalies are identified, their causes traced, and potential solutions proposed. Tailored solutions are developed for each specific case. For example, new business rules are prototyped and tested on subsets of data, while training programs and audit strategies are designed iteratively to incorporate feedback from stakeholders.

The **implementation phase** focuses on implementing and deploying these solutions incrementally to minimize disruptions. Business rules were implemented in the system with automated validation, training sessions were delivered to users, and auditing processes were institutionalized to ensure ongoing data integrity. Three main types of outcomes have already been implemented according to the nature of each issue. These solutions included:

1. (S1) creation of new business rules within SGP - addressing scenarios where inconsistencies required new rules to be implemented at the system level to prevent similar issues in the future;
2. (S2) Training within the educational network - Cases involving manual input or network-related errors were mitigated through user training programs aimed at reducing future occurrences and
3. (S3) Data Auditing - Recommendations to the managers and government stakeholders to audit inconsistencies that were not resolved to ensure data reliability and integrity

Finally, the process concludes with **evaluation and learning**, where the outcomes of the implemented solutions are evaluated. Metrics such as the inconsistencies of anomalies, user feedback, and system performance are analyzed to measure the effectiveness of the interventions. Lessons learned are documented to refine future processes and ensure continuous improvement and shared publicly to foster knowledge discovery.

5. Case studies

To illustrate the methodology presented in the previous section, we present seven cases developed for eight months related to the data quality assurance process inside SGP. Each case has particularities that help to understand the nuances and complexities of data quality assurance inside a national educational system that receives information from all nationwide educational networks. As this process is cycled and is still under development, some solutions for specific cases are presented as suggestions for implementation and still need further evaluation.

5.1. Case 1: Inconsistent Enrollment Dates

Problem Definition: Inconsistent start dates were observed in the student's enrollment data. These inconsistencies suggest incorrect data entry, which can skew analysis when dates are used as filters or reference points for decision-making. To identify the scope of the problem, we executed a query that excluded the *starting date* condition, capturing all enrollment records regardless of their start dates. The analysis revealed a range of anomalous start years, from as early as 1900 (implying a 125-year-old high school student) to as late as 2029 (suggesting enrollment 4 years into the future). The most frequent inconsistencies were found in the years immediately preceding 2024. For example, 382,221 enrollments were recorded in 2022 and 153,407 in 2023. Outlier years, such as 1900, 1985, and 2029, also appeared in the dataset but with minimal occurrences (one enrollment each). Other years, such as 2016 (222 enrollments), 2018 (563 enrollments), and 2021 (3,659 enrollments), suggested a gradual increase in data reporting errors over time. These inconsistencies likely resulted from manual data entry errors or the lack of validation rules to ensure accurate recording of start dates. It is important to highlight that SGP is dealing with information from students enrolled in high school education, so dates such as 2016 or 1018 are considered not coherent with the expected date ranges.

Design and Prototyping: To address this issue, we proposed implementing validation rules to restrict start dates to a predefined range, with the current year as the last valid year for enrollment records. A prototype validation mechanism was designed to flag and reject entries with start dates outside the acceptable range during data input. This prototype was tested on a subset of historical data to evaluate its effectiveness and to identify potential edge cases, such as valid future or historical enrollments. In addition to technical solutions, systemic measures were proposed to minimize recurring errors. Training sessions are suggested to be developed for data entry staff to emphasize the importance of accurate data recording and to reduce manual errors.

Furthermore, a reporting dashboard was designed to highlight anomalous dates, enabling administrators to review and correct outliers in real-time.

Implementation: The validation mechanism was implemented in the application layer, and the date entry interface was updated with a date picker that restricted inputs to valid years, such as 2024. The team suggested guidelines explaining the validation rules for stakeholders to ensure a smooth transition. Additionally, historical data containing invalid start dates was retrospectively cleaned, with corrections prioritized for the most critical discrepancies. This combination of preventive measures and corrective actions ensured a robust implementation.

Evaluation and Learning: The solution's success is evaluated using several metrics. These include monitoring the reduction of invalid start dates in new records and assessing the efficiency of the reporting dashboard in flagging and correcting errors. User feedback is also being collected to evaluate the usability of the updated date entry interface and the clarity of the validation rules. The findings from this case underscore the importance of integrating validation mechanisms into data entry processes to improve overall data quality. The lessons learned are applied to other system areas with similar data validation challenges. These iterative improvements demonstrate a commitment to maintaining accurate and reliable data for analysis and decision-making.

5.2. Case 2: Multiple Active Enrollments for a Student

Problem Definition: After defining the criteria for an active enrollment, we identified cases where individuals had multiple active enrollments associated with their ID. While some instances of dual active enrollments are expected and valid, such as students simultaneously attending regular and technical schools, other cases raised concerns. Specifically, we focused on individuals with more than two active enrollments, which deviates from the expected norm. Our analysis revealed 138,747 individuals with more than two active enrollments at the time of the query. The presence of such anomalies indicates potential issues within the system, including errors in the registration process that allow duplicate or conflicting records, the absence of validation mechanisms to limit the number of active enrollments per individual, or possible misuse of the system—whether intentional or unintentional—resulting in inflated enrollment counts.

Design and Prototyping: To address this issue, we proposed implementing system-level validations to restrict the number of active enrollments associated with a single student ID to a maximum of two, accounting for valid scenarios such as simultaneous enrollment in regular and technical schools. A prototype validation rule was designed and tested on historical data to identify and flag records exceeding the defined threshold. In addition to this technical solution, we developed guidelines to clarify the conditions under which dual enrollments are permissible, ensuring alignment with institutional policies. These guidelines were shared with stakeholders to understand legitimate enrollment scenarios better and standardize data entry practices.

Implementation: The validation mechanism was integrated into the enrollment system to prevent the creation of new records that exceed the maximum allowable number of active enrollments—this involved frontend restrictions during the registration process and backend validations at the database level. A cleanup process was initiated for existing records to address individuals flagged with more than two active enrollments. This included engaging with educational institutions to verify and resolve duplicate or conflicting records. Training sessions were conducted for registration staff to support these efforts, emphasizing the importance of adhering to the validation rules and accurately categorizing dual enrollments. A reporting mechanism was also introduced to monitor new instances of multiple active enrollments, allowing for continuous oversight and prompt resolution of anomalies.

Evaluation and Learning: The success of the implemented solution is being evaluated through a reduction in the number of individuals with more than two active enrollments in subsequent data analyses. Additionally, the reporting mechanism tracks compliance with the validation rules and detects any remaining anomalies in real time. Feedback from registration staff and institutional stakeholders is being collected to assess the guidelines' clarity and the usability of the system improvements. This case highlights the importance of establishing precise validation mechanisms and robust monitoring processes to maintain data integrity. The insights gained from addressing this issue are applied to other system areas to prevent similar anomalies and ensure that the data accurately reflects real-world conditions.

5.3. Case 3: Enrollments with Justification for Disenrollment and Active Status

Problem Definition: In the enrollments table, the column `co_tipo_justificativa_desmatricula` records the reason for disenrollment. This field only contains a value if the enrollment is deactivated. However, our analysis identified cases where enrollments were simultaneously marked as active (`st_matricula_ativa = true`) and had a justification for disenrollment recorded. At the time of analysis, 26,106 enrollments exhibited this inconsistency. This issue suggests potential data entry or synchronization errors within the system. The inconsistencies likely result from incorrect updates to the enrollment status, where records remain active despite a justification for disenrollment being provided. Other possible causes include miscommunication between system modules responsible for managing enrollment statuses and disenrollment reasons and the lack of validation checks to prevent conflicting information in these fields during data entry. This inconsistency affects data reliability, particularly in metrics that accurately report active versus inactive enrollments and analyze disenrollment trends, which rely on precisely categorizing enrollment statuses.

Design and Prototyping: To address this issue, we proposed implementing validation rules to ensure that a justification for disenrollment can only be recorded if the enrollment status is marked as inactive. These rules were designed to operate at both the application and database levels to prevent conflicting information from being entered. A prototype validation mechanism was developed and tested on historical data to identify the extent of the issue and ensure that the rules functioned correctly. In addition to the validation rules, we proposed reviewing and redesigning the data entry workflows to reduce the likelihood of errors during status updates. This included automating clearing disenrollment justifications when enrollment is reactivated and enhancing system logs to capture changes to the enrollment status and associated justification fields.

Implementation: The validation mechanism was implemented to enforce consistency between the enrollment status and the justification for disenrollment fields. In the application layer, updates to the status field were synchronized with the justification field, ensuring that conflicting values could not be saved. At the database level, constraints were added to restrict the recording of a justification for disenrollment to inactive enrollments only. A system-wide data cleanup was performed to resolve existing inconsistencies. This involved reviewing the 26,106 flagged records and correcting them either by deactivating the enrollment or clearing the justification field, depending on the circumstances. Registration staff is also advised to be provided with guidelines detailing the correct process for handling enrollment status updates to ensure compliance with the new rules.

Evaluation and Learning: The solution's effectiveness is evaluated by continuously monitoring new enrollment records to ensure no further inconsistencies occur. Metrics include the number of new flagged records, the accuracy of active versus inactive enrollment reports, and the consistency of disenrollment trend analyses. Feedback from system users and administrators is suggested to be collected to assess the updated workflows' usability and the clarity of the validation rules. This case highlights the importance of validation mechanisms and system automation in maintaining data integrity.

5.4. Case 4: Analysis on the Application of 100% Attendances at the State Level

Problem Definition: Building upon the resolution of fundamental data inconsistencies, we expanded our analysis to investigate more complex anomalies, focusing specifically on the accuracy of attendance reporting at the state level. The aim was to assess whether all states correctly reported student attendance data and identify potential patterns or inconsistencies in applying 100% attendance rates. To achieve this, we calculated the percentage of full attendances relative to the total informed attendances for each State and month. This analysis enabled us to identify the State with the highest rate of full attendance across the analyzed period. The results revealed that State A reported the highest rate of full attendance in July 2024, with 104,937 enrollments (out of 140,859 informed enrollments) marked as having 100% attendance. This corresponded to a rate of 74.5%, the highest among all states during this timeframe. Such high rates of attendance of 100% could indicate genuine trends of high attendance, potentially reflecting efficient educational policies or practices. However, they could also result from overreporting or inaccuracies in data submission by institutions, raising questions about the reliability of attendance reporting.

Design and Prototyping: To investigate the validity of these findings, we designed an analysis framework to detect potential overreporting patterns and validate attendance data at the state level. This involved cross-referencing attendance data with other indicators, such as dropout rates and institutional capacity, to evaluate

whether the reported rates of 100% attendance were consistent with different metrics. Prototypes of visual dashboards were developed to present the attendance data in an accessible format, highlighting states and months with unusually high rates of full attendance. These dashboards allowed stakeholders to identify and investigate potential anomalies quickly.

Evaluation and Learning: The evaluation phase focused on monitoring flagged cases of potential overreporting and assessing the impact of the new reporting guidelines on attendance data quality. Metrics such as the number of flagged anomalies, feedback from state administrators, and improvements in attendance consistency were used to evaluate the effectiveness of the implemented measures. This case underscores the importance of cross-referencing attendance data with other indicators to ensure reliability. The findings have provided valuable insights into attendance reporting practices at the state level and have informed the development of additional validation mechanisms to maintain data integrity in future analyses.

5.5. Case 5: Hours Studied Greater than Hours Offered

Problem Definition: During an exploratory data analysis of the database, an inconsistency was identified where the reported hours studied exceeded the number of hours offered. This issue undermines the data's reliability, which could affect decision-making processes and policy outcomes. Queries were executed to identify the scope of the problem, and inconsistencies were flagged across three months. It is important to highlight that both information (hours studied and hours offered) are reported from the same source (educational network).

- In February 2024, there were 7,119 enrollments in State A, primarily in State schools, where the hours studied were greater than those offered.
- In March 2024, a similar issue was detected in State B, with 15 enrollments, all in State schools.
- By April 2024, 106 enrollments in State C were identified with the same inconsistency, predominantly in Federal schools.

The root causes of this issue likely include manual data entry errors leading to overreported hours studied, miscommunication between system modules responsible for calculating hours, and potential discrepancies in data aggregation processes at the institutional or regional level. The inconsistencies were reported to the product owner to address this issue, who prioritized a solution to mitigate its impact and ensure data consistency.

Design and Prototyping: The proposed solution involved implementing a business rule to prevent hours studied from exceeding hours offered. This rule was designed to operate at the database level, integrating validation mechanisms to stop invalid entries during data input and flagging existing anomalies for manual review. In addition to the technical solution, measures were proposed to address systemic issues, such as improved training for staff responsible for data entry and introducing auditing processes to monitor data integrity, particularly in regions with a high incidence of anomalies.

Implementation: The business rule deployment was planned carefully to minimize disruption. The rule was integrated into the application layer (via form validation) and the database (using triggers or constraints). Users and stakeholders were informed about the change, and guidelines were provided to ensure smooth adoption. A correction strategy was devised to address existing anomalies, prioritizing regions and school types most affected by the issue.

Evaluation and Learning: The success of the implementation is being measured through the reduction of inconsistencies over subsequent months and the Frequency and distribution of rule triggers. It is also suggested that feedback be collected from users and administrators regarding the rule's usability and effectiveness.

5.6. Case 6: Enrollments by State with More than 300 Studied Class Hours

Problem Definition: In our analysis, we identified cases where students were reported to study more than 300 class hours within a month. This threshold was selected as an inconsistency, representing an average of over 10 hours of study per day — an unlikely scenario given standard academic schedules and considering a maximum of 22 days per month (220 class hours monthly plus 80 extra hours). Such cases raise questions

about the accuracy of the reported data and the underlying processes involved in calculating hours studied. This threshold can be considered quite conservative, and similar analyses could also consider lesser and more conservative thresholds.

Our investigation revealed significant findings across several states. State D reported the highest number of such enrollments in February 2024, with 2,891 enrollments exceeding the 300-hour threshold. Similarly, State E showed consistently high numbers, with 2,221 enrollments in February 2024 and 2,087 enrollments in March 2024. Other notable occurrences included State F, which reported 2,466 enrollments in November 2024, and State G, with 1,503 enrollments in February 2024. These patterns highlight potential systemic issues in the reporting of studied class hours. These inconsistencies suggest possible causes such as data entry errors, where hours studied were inaccurately recorded, miscommunication or discrepancies in how hours are calculated or aggregated at the institutional level, and the absence of validation mechanisms to flag and correct unfeasible data entries during the reporting process.

Design and Prototyping: To address these anomalies, we suggested implementing validation rules to flag cases where reported class hours exceed a predefined threshold. The prototype for these rules included automated checks to identify and mark entries exceeding the 300-hour limit for review. Historical data was used to simulate the behavior of these checks, allowing us to evaluate their effectiveness in identifying potential errors without hindering legitimate data. In addition to validation mechanisms, we designed a feedback loop involving institutional administrators. This process allowed flagged data to be reviewed collaboratively, ensuring that the identified anomalies were corrected or justified. Training materials and guidelines were developed to clarify how class hours should be calculated and reported, reducing the likelihood of recurring errors.

Implementation: The validation rules were integrated into the reporting system, ensuring entries exceeding the 300-hour threshold were flagged automatically for manual review. This integration occurred at both the data entry and aggregation stages, providing multiple validation layers to prevent unfeasible data from being finalized in reports. A retrospective cleanup was also conducted to address the anomalies identified in historical data. States with the highest occurrences of anomalies, such as State D and State E, were prioritized in this process. Communication channels were established with educational institutions in these states to resolve discrepancies and implement corrective measures.

Evaluation and Learning: The evaluation phase focuses on assessing the impact of the implemented measures. Metrics include a reduction in the number of enrollments reported with more than 300 class hours and improvements in the overall accuracy of reported class hours. Feedback from institutional administrators is suggested to be collected to refine the validation rules and ensure their practicality in day-to-day reporting. This case underscores the importance of robust validation mechanisms and collaborative review processes in maintaining data accuracy. By addressing the root causes of these anomalies, the system is better equipped to handle similar issues in the future, ensuring the reliability of data used for analysis and decision-making. Lessons learned from this case are being applied to other areas of data reporting to promote consistency and prevent the propagation of errors.

5.7. Case 7: Monthly Class Offered Hours Higher than 300

Problem Definition: An additional anomaly was identified in the data, involving cases where schools reported offering more than 300 class hours per month for enrollment. This threshold is considered unfeasible, as it implies an average of over 10 hours per day, which is highly unlikely under regular academic schedules. Such cases raise questions about the accuracy of the reported data and the processes involved in calculating the number of hours offered. Our analysis revealed several notable findings. State H reported the highest occurrence of such cases in February 2024, with 3,831 enrollments exceeding the 300-hour threshold. State I also exhibited consistently high numbers, including 2,221 enrollments in February 2024 and 2,087 enrollments in March 2024. Other states with significant occurrences included State J, which reported 1,503 enrollments in February 2024, and State K, with 2,898 enrollments in November 2024. These patterns suggest systemic issues that may lead to overreporting or inaccuracies in the reported hours offered. The anomalies could stem from data entry errors, such as inaccurately recording the number of hours offered, discrepancies in how hours are calculated or aggregated at the institutional level, or the absence of validation checks to flag and correct unfeasible data entries during reporting.

Design and Prototyping: To address these anomalies, we proposed developing validation rules to flag in-

stances where the reported hours offered exceed the 300-hour threshold. The validation process included automated checks to identify and mark records exceeding this limit for manual review. Prototyping used historical data to simulate these rules' behavior and ensure they effectively captured anomalies without hindering legitimate data entries. In addition to the validation rules, we suggested developing guidelines to standardize the reporting hours offered. These guidelines should emphasize the importance of accurate data entry and provide clear instructions on how hours should be calculated and aggregated. Training sessions were also suggested to educate institutional staff about these standards and the role of validation mechanisms in ensuring data integrity.

Implementation: The validation rules were integrated into the reporting system, with automated checks applied during data entry and aggregation. These checks flagged entries exceeding the 300-hour limit, ensuring they were reviewed, corrected, or justified. A retrospective cleanup process was also carried out to address historical anomalies, prioritizing states with the highest occurrences, such as State H and State I. Communication channels were suggested to be established with institutional administrators to facilitate the resolution of flagged inconsistencies and to ensure that corrective measures were effectively implemented. The reporting system was also enhanced to provide real-time feedback to users entering data, reducing the likelihood of future errors.

Evaluation and Learning: The effectiveness of the implemented solutions is being evaluated by monitoring the reduction in the number of enrollments exceeding the 300-hour threshold in subsequent reporting periods. Metrics such as the frequency of flagged anomalies, the resolution time for flagged cases, and feedback from institutional administrators are being used to assess the impact of these measures. This case highlights the importance of establishing robust validation mechanisms and fostering collaboration with institutional stakeholders to ensure accurate data reporting. The insights gained from addressing these anomalies are being used to refine the validation processes further and to apply similar approaches to other areas of data reporting. Through iterative learning, the system continues to evolve, ensuring the reliability and accuracy of reported data for analysis and decision-making.

6. Discussion

The seven cases of data inconsistencies previously presented can be broadly categorized into three main groups according to the types of errors found: Input Data Errors, Logical Inconsistencies, and Systemic or Aggregated Inconsistencies. Input Data Errors arise from manual data entry mistakes or the absence of proper validation mechanisms, as seen in cases like inconsistent enrollment dates and study hours exceeding offered hours. These errors rely primarily on validation and automated solutions to prevent mistakes at entry, together with training and educating users. Logical Inconsistencies occur when conflicting or unrealistic data is reported, such as students having multiple active enrollments or simultaneous active statuses with disenrollment justifications. Logical inconsistencies are mainly resolved through validation to enforce consistent logic and monitoring to detect real-time conflicts. Lastly, Systemic or Aggregated Anomalies reflect broader reporting or systemic issues, including implausible state-wide 100% attendance rates or unrealistic monthly study and offered hours that exceed feasible academic schedules. These errors require monitoring to flag irregular patterns and training to ensure adherence to reporting standards.

To foster data-driven public policies in education in Brazil, data infrastructure must be improved on the three fronts described by (Sellar, 2015), which are: *scales* across which the infrastructure is being integrated, the *scope* of the data being created, and the *explanatory power* enabled by the data infrastructure. SGP can be considered the first nationwide initiative focused on developing a unified database in the educational context that reaches the granularity of the data at a personal level (student level). In Brazil, public educational institutions are managed by different state entities according to their educational level. For instance, the Federal Government typically manages public federal universities, while State Governments manage high school education and, in some cases, Upper middle schools, and Municipalities manage Lower and Upper Middle schools and Early Childhood Education. Considering this administrative division, each public organization is also responsible for maintaining, securing, and managing its data (Filgueiras & Lui, 2023). This makes it very difficult to have an integrated student attendance centralized database, which is key for advancing evidence-based and data-driven policy capabilities in the country(Queiroga et al., 2024; Williamson, 2019).

Once that interoperability issues are overcome and data quality integrity is improved inside SGP, it becomes feasible to foster knowledge discovery inside the system to promote assertive public policies. For instance,

soon, it will become possible to evaluate student retention rates and compare the outcomes of beneficiaries and non-beneficiaries of social programs, enabling targeted interventions to address challenges in academic progression. Data integration also allows for analyzing school attendance patterns before and after specific events or seasons, such as natural disasters or agricultural cycles, helping policymakers design strategies to mitigate disruptions. Moreover, precise definitions for identifying dropouts, supported by accurate and comprehensive data, ensure precise tracking of students' educational trajectories and facilitate the development of effective measures to reduce dropout rates. Advanced techniques, such as explainable AI (xAI) and clustering, can help to provide a deeper understanding of attendance behaviors, highlighting high and low-risk groups for intervention. Integrated and high-quality data also support the development of tools to monitor the impact of educational programs, enabling continuous evaluation, refinement, and improved policy outcomes. At the regional level, data integration facilitates global and state-level clustering, allowing for the creation of tailored policies that address regional disparities and promote equity. Specific public educational program analyses become actionable through comprehensive datasets, offering insights into program effectiveness and identifying areas for improvement. Furthermore, SGP data may enable comparisons of economic indicators, such as resource allocation relative to population demographics, optimizing public investments in education, and enhancing outcomes across various contexts.

7. Final Remarks

The results from this study demonstrate the transformative impact of addressing data inconsistencies within Brazil's Sistema Gestão Presente (SGP). The application of a structured, data-driven methodology effectively helped to resolve critical challenges such as inconsistent enrollment dates, redundant active enrollments, and systemic reporting anomalies. Notably, introducing tailored validation mechanisms, automated error detection, and the proposal of enhanced training initiatives can significantly improve data integrity and usability. By systematically identifying and correcting anomalies, the SGP interactively enhances its reliability as a national educational database and establishes itself as a model for continuous quality assurance in large-scale public systems.

These findings provide valuable insights for other organizations aiming to improve the data quality of their systems. By adopting a similar approach that combines robust validation protocols, stakeholder engagement, and ongoing monitoring, other systems can achieve greater consistency and accuracy in their datasets. Additionally, the lessons from SGP's case studies highlight the importance of integrating technical solutions with user training and feedback loops. These practices help to ensure data quality and foster stakeholder confidence, enabling better-informed decisions and more effective public policies.

Acknowledgments

This work was supported by the Ministry of Education (MEC), Brazil, under Grant TED13914. The funders had no role in the study design, data collection and analysis, the decision to publish, or the preparation of the manuscript. Additionally, the funders had no influence on the interpretation of data and the final conclusions drawn.

References

Barbalho, I. M., Fernandes, F., Barros, D. M., Paiva, J. C., Henriques, J., Morais, A. H., Coutinho, K. D., Coelho Neto, G. C., Chioro, A., & Valentim, R. A. (2022). Electronic health records in brazil: Prospects and technological challenges. *Frontiers in Public Health*, *10*, 963841.

BOZ, M., & SIMSEK, I. (2022). Analysis of education management information systems of the ministry of national education in terms of interoperability. *Journal of Qualitative Research in Education*, (32). DOI: https://doi.org/10.14689/enad.32.1702.

Brasil. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (Inep). (2024). *Censo da educação básica 2023: Notas estatísticas*. Inep.

Coelho Neto, G. C., Andreazza, R., & Chioro, A. (2021). Integration among national health information systems in brazil: The case of e-sus primary care. *Revista de saude publica*, *55*, 93.

D'Amore, J., et al. (2018). Interoperability progress and remaining data quality barriers of certified health information technologies. *AMIA ... Annual Symposium proceedings. AMIA Symposium*, *2018*, 358–367.

Du, J. (2021). Research on the construction of educational data quality model based on multiple constraints model. *2021 IEEE 4th International Conference on Information Systems and Computer Aided Education (ICISCAE)*, 363–367.

Filgueiras, F., & Lui, L. (2023). Designing data governance in brazil: An institutional analysis. *Policy Design and Practice*, *6*(1), 41–56.

Jenkins, M., & Duri, J. (2020). *The role of evidence, data and research findings in promoting integrity in education* (tech. rep.) (This document is part of the Transparency International Anti-Corruption Helpdesk series.). Transparency International. Berlin, Germany. https://knowledgehub.transparency.org/assets/uploads/kproducts/The-role-of-evidence-data-and-research-findings-in-promoting-integrity-in-education.pdf

Macarini, L. A. M., dos Santos, H. L., Cechinel, C., Ochoa, X. O., Rodés, V., Casas, A. P., Lucas, P. P., Maya, R., Alonso, G. E. A., & Díaz, P. (2020). Towards the implementation of a countrywide k-12 learning analytics initiative in uruguay. *Interactive Learning Environments*, *28*(2), 166–190. DOI: https://doi.org/10.1080/10494820.2019.1636082.

Macedo de Andrade, F., Ceneviva, R., & Koslisnki, M. C. (2022). Escolas em foco: A avaliação de impacto do programa de'políticas públicas baseadas em evidências' da rede municipal de ensino do rio de janeiro. *Education Policy Analysis Archives/Archivos Analíticos de Políticas Educativas/Arquivos Analíticos de Políticas Educativas*, *30*.

Queiroga, E. M., Batista Machado, M. F., Paragarino, V. R., Primo, T. T., & Cechinel, C. (2022). Early prediction of at-risk students in secondary education: A countrywide k-12 learning analytics initiative in uruguay. *Information*, *13*(9). DOI: https://doi.org/10.3390/info13090401.

Queiroga, E. M., Siqueira, E. S., dos Santos Portela, C., Cordeiro, T. D., Bittencourt, I. I., Isotani, S., Melo, R. F., Muñoz, R., & Cechinel, C. (2024). Data-driven strategies for achieving school equity: Insights from brazil and policy recommendations. *IEEE Access*.

Redyuk, S., Kaoudi, Z., Markl, V., & Schelter, S. (2021). Automating data quality validation for dynamic data ingestion [Published under the terms of the Creative Commons license CC-by-nc-nd 4.0]. *Proceedings of the 24th International Conference on Extending Database Technology (EDBT)*, March 23–26, 2021. https://openproceedings.org/2021/...

Restrepo-Carmona, J. A., Zuluaga, J. C., Velásquez, M., Zuluaga, C., Villamil, R. M., Morales, O., Hurtado, Á. M., Escobar, C. A., Sierra-Pérez, J., & Vásquez, R. E. (2024). Smart supervision of public expenditure: A review on data capture, storage, processing, and interoperability with a case study from colombia. *Information*, *15*(10), 616.

Rocha, J. C., Ramos, V., Cechinel, C., Hernández-Leal, E. J., Munoz, R., & Primo, T. T. (2024). Data interoperability in learning analytics - review of literature. *2024 L Latin American Computer Conference (CLEI)*, 1–8. DOI: https://doi.org/10.1109/CLEI64178.2024.10700464.

Sellar, S. (2015). Data infrastructure: A review of expanding accountability systems and large-scale assessments in education. *Discourse: Studies in the Cultural Politics of Education*, *36*(5), 765–777. DOI: https://doi.org/10.1080/01596306.2014.931117.

Srinivasan, K., Muthu, S., Devadasan, S., & Sugumaran, C. (2016). Six sigma through dmaic phases: A literature review. *International Journal of Productivity and Quality Management*, *17*(2), 236–257. DOI: https://doi.org/10.1504/IJPQM.2016.074462.

Taleb, I., Serhani, M. A., Bouhaddioui, C., & Dssouli, R. (2021). Big data quality framework: A holistic approach to continuous quality management. *Journal of Big Data*, *8*(1), 76. DOI: https://doi.org/10.1186/s40537-021-00468-0.

Tavares, A. R., & Bitencourt, C. M. (2022). Avaliação de políticas públicas e interoperabilidade na perspectiva da governança pública digital. *Revista de Direito Econômico e Socioambiental*, *13*(3), 687–723.

Valdés, E., & Lecaros, J. A. (2024). Biobanks and data interoperability in latin america: Engendering high-quality evidence for the global research ecosystem. *Frontiers in Medicine*, *11*, 1481891.

Vasques, L., Rijo, R., & Alves, D. (2024). Interoperability at healthcare institutions in brazil: Framework for identify maturity stages. *Procedia Computer Science*, *239*, 2316–2321.

Wahid, A. M., Afuan, L., & Utomo, F. S. (2024). Enhancing collaboration data management through data warehouse design: Meeting ban-pt accreditation and kerma reporting requirements in higher education. *J. Tek. Inform. Jutif*, *5*(6).

Wijayanti, W., Hidayanto, A. N., Wilantika, N., Adawati, I. R., & Yudhoatmojo, S. B. (2018). Data quality assessment on higher education: A case study of institute of statistics. *2018 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI)*, 231–236.

Williamson, B. (2019). Policy networks, performance metrics and platform markets: Charting the expanding data infrastructure of higher education. *British Journal of Educational Technology*, *50*(6), 2794–2809.

Forecasting Student Enrollments in Brazilian Schools for Equitable and Efficient Education Resource Allocation

Lenardo Chaves e Silva[a,c*], *Luciano* de Souza Cabral[e,c], *Jário* José dos Santos Júnior[b,c], *Luam* Leiverton Pereira dos Santos[f,c], *Thyago* Tenório Martins de Oliveira[b,c], *Breno* Jacinto Duarte da Costa[g,c], *Joana* Fusco Lobo[d], *Dalgoberto* Miguilino Pinho Júnior[b,c], *Nicholas* Joseph Tavares da Cruz[b,c], *Rafael* de Amorim Silva[b,c], *Bruno* Almeida Pimentel[b,c]

[a]Federal Rural University of the Semi-Arid, Av. Francisco Mota, 572, Mossoró, 59625-900, Rio Grande do Norte, Brazil, e-mail: lenardo@ufersa.edu.br

[b]Federal University of Alagoas, Av. Lourival Melo Mota, S/N, Maceió, 57072-970, Alagoas, Brazil

[c]Center for Excellence in Social Technologies, Av. Lourival Melo Mota, S/N, Maceió, 57072-970, Alagoas, Brazil, e-mail: {luciano.cabral, jario.junior, luam.leiverton, thyago.tenorio, breno.duarte, dalgoberto.pinho, nicholas.cruz, rafael.amorim, bruno.pimentel}@nees.ufal.br

[d]National Education Development Fund, Setor Bancário Sul, Quadra 2, Bloco F, Brasília, 70070-929, Distrito Federal, Brazil, e-mail: joana.fusco@fnde.gov.br,

[e]Pernambuco Federal Institute of Education, Science, and Technology, Av. Barão de Lucena, 251, Jaboatão dos Guararapes, 55014120, Pernambuco, Brazil

[f]Federal University of the San Francisco Valley, Av. José de Sá Maniçoba, S/N, Petrolina, 56304-917, Pernambuco, Brazil

[g]Alagoas Federal Institute of Education, Science, and Technology, Av. do Ferroviário, 530, Maceió, 57020-600, Alagoas, Brazil

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. In recent years, there has been growing scientific interest in developing effective techniques for forecasting student enrollment across the school spectrum (i.e., primary, secondary, and higher education). Enrollment forecasting is crucial in shaping public education policies by guiding resource allocation and ensuring equitable access to educational opportunities. In this sense, Machine Learning (ML) models emerge as a promising approach to forecasting the number of students that should be enrolled in a given school term by considering the high complexity of grouping and identifying useful patterns in the prediction process. In this work, we develop a predictive model based on the Random Forest (RF) algorithm to forecast the enrollment of students across the entire spectrum of Brazilian education. We use a database provided by the National Education Development Fund (FNDE), a Brazilian government body responsible for purchasing and distributing textbooks to all public schools. We generate 1,531,185 time series to serve as an input to RF processing. Our training dataset utilized data between 2010 and 2020, and our testing dataset utilizes data from 2021. As a result, RF obtains a higher performance in all the investigated scenarios concerning the Exponential Smoothing (ES) baseline algorithm. Since RF demonstrated acceptable performance, the Brazilian government could benefit from this forecasting technique for student enrollment in school environments and to ensure equitable access to essential resources, such as didactic materials, for the students.

Keywords. Machine Learning, Random Forest, forecasting, enrollment, Brazilian education
Research paper, DOI: https://doi.org/10.59490/dgo.2025.939

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1. Introduction

Brazilian education is extensive and consists of several levels and institutions. As an instance, this system encompasses Early Childhood, Basic, Secondary, Professional, and Higher Education. Some facts highlight the width of our education system: (i) Brazil has around 178.3 thousand basic education schools in operation, serving students in the initial years (1st to 5th), with a total of 105.4 thousand schools, and in the final years (6th to 9th), totaling 61.8 thousand schools; (ii) The municipal network is mainly responsible for offering the initial years, registering approximately 10.1 million students in 2022 (69.3%), equivalent to 85.5% of the public network; (iii) In the final years of primary education, the municipal network serves 5.3 million students (44.4%), while the state network serves 4.8 million (39.9%) (Andrade, 2023).

In this sense, millions of students are enrolled yearly in public or private schools to ensure access to quality education. Government bodies must have as an essential part of their public policies the ensurence of the availability of educational resources (e.g., textbooks and other didactic materials) for schools and students. In Brazil, the National Education Development Fund (FNDE) is responsible for delivering textbooks for these schools and ensuring that the content of these textbooks is used exclusively for educational purposes.

However, it is challenging to precisely forecast the number of students being enrolled each year. Currently, FNDE distributes textbooks according to projections from the school census for the two years prior to the program year, as this is the information available at the time of processing the choice made by the schools. Such forecasts are carried out using the Exponential Smoothing method (Billah et al., 2006). Therefore, there may be small fluctuations between the number of books and the number of students. The greater this fluctuation, the greater the financial cost in the process, due to the excess of books that will be purchased and distributed. Furthermore, the lack of a precise number implies that many students do not receive textbooks during the school period, causing great harm to their education and hindering fair and equal educational development.

In recent literature, the context of the problem of predicting job enrollments is mainly in university environments (Ayasi et al., 2023; Khademi and Nakhkob, 2016; Shao et al., 2022) and has a significant number of related studies. In the school context, there is a minimal number of studies (e.g., Abideen et al., 2023) and the scope of the experiments is not representative, due to the small sample size. Our work has a much more comprehensive and representative scope, in addition to being applied to a complex and challenging scenario.

As highlighted (Scholl, 2024), the Digital Government Research (DGR) field has evolved significantly in recent years, especially in developing solutions for public administration. These solutions aim to bring government closer to society through technologies, such as the services offered to the population, social media as a means of communication, and Artificial Intelligence as a tool to support decision-making. In this sense, this paper investigates using Machibe Learning (ML) models to forecast the number of enrolled students (Sarker, 2021). We develop a predictive model based on the Random Forest (RF) algorithm (Pichler and Hartig, 2023) able to forecast the enrollment of students across the entire spectrum of Brazilian education.

The research methodology adopted for this work is based on the Design Science Research (DSR) paradigm (Gregor and Hevner, 2013; Hevner et al., 2004). To apply the DSR methodology, we followed the guidelines of (Peffers et al., 2007), which specify the process in a sequence of six activities: 1. Identify the problem and motivation; 2. Define the objectives for the solution; 3. Design and develop; 4. Demonstrate; 5. Evaluate; 6. Communicate. Figure 1 presents the DSR methodology process defined for this work.

Therefore, considering the complexity (Sobrinho et al., 2023) and the high cost (FNDE, 2022) of the Brazilian government to the processes involving the acquisition and distribution of books to students in public schools (Activity 1), our motivation is to improve decision-making by FNDE, proposing predictive models based on machine learning to more assertively and automatically infer the number of students at each stage of education in each school (Activity 2), minimizing the financial losses of the government (e.g., excessive purchases) and social losses (e.g., students without access to teaching materials).

We used a database provided by the FNDE to develop the proposed predictive model (Activity 3). We generate 1,531,185 times series to serve as an input to the RF processing. We also use a data mining process with an interpolate imputation method that mitigates null values in the dataset and a hold-out method that splits the dataset into training and testing sets. Our training dataset utilizes data proceeding from 2010 to 2020.

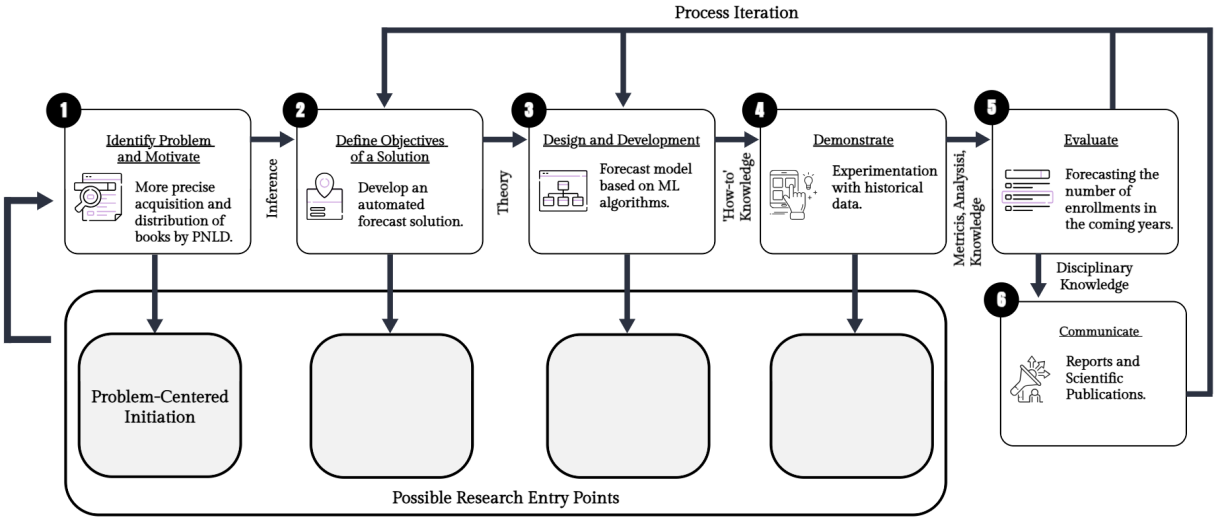


Fig. 1 – DSR Process. Adapted from Peffers et al., 2007.

For demonstration purposes (Activity 4), we used historical data from 2021 as our testing dataset and considered in the experiments the aspects of school grade, geographic location, Brazilian regions, federative unit, population size, dependence type, and school size. As a result, RF obtains higher performance in all the investigated scenarios in relation to the Exponential Smoothing (ES) baseline algorithm. The ES algorithm was chosen as a comparative baseline with the RF because in the related literature (Chen, 2022) it achieved better accuracy and stability in forecasting the number of high school enrollments and vocational education enrollment.

Since the RF demonstrated acceptable performance in forecasting student enrollments in school environments, the next step is to integrate the model into the system used by FNDE to forecast the enrollments in the coming years (Activity 5). Finally, for communication purposes (Activity 6), we wrote technical reports about the entire research and development process of the proposed predictive model and provided them to FNDE. Additionally, we carry out the process of scientific writing and publishing articles based on the results achieved with the experiments performed.

The main contributions of this study are two-fold:

1. the proposition of an ML model for automatic prediction of enrollment in public schools in Brazil aims to increase efficiency and reduce the time needed to perform this challenging task of forecasting the number of student enrollments in each class of each public school in a country of continental geographic dimension;
2. the provision of a solution to support FNDE's decision-making in effective planning for the distribution of textbooks in the country, with the possibility of reducing financial costs and social impacts on Education.

The justification for using ML algorithms as an alternative solution to the Exponential Smoothing method used by FNDE to forecast student enrollment is based on the ability of such algorithms to make predictions without the need for explicit programming, learning automatically from historical data (Sarker, 2021). This flexible and dynamic nature of learning makes ML algorithms the ideal solution for complex prediction problems, such as predicting student enrollment.

Studies such as those by (Fischer-Abaigar et al., 2024) and (Amarasinghe et al., 2023) emphasize the alignment of ML models with real-world complexities, ensuring that their outputs are actionable, explainable, and equitable. These works argue for a shift from purely predictive goals to decision-making frameworks that prioritize policy impact.

The work structure is presented as follows. Section 2 highlights some literature works that investigate the usage of ML techniques for enrollment forecasting-related issues. Section 3 describes the RF model that it

utilized as a baseline for running our experiments. Section 4 presents scenarios and methodology utilized in our experiments. Section 5 presents the results extracted from our experiments and discussion. In Section 6 we present our concluding remarks.

2. Related Work

Machine Learning (ML) is a subset of Artificial Intelligence (AI) that focuses on the development of algorithms and models that enable computers to learn and make predictions or decisions without being explicitly programmed, hence the term learning (Sarker, 2021). ML deals with the design and construction of systems that can automatically learn and improve from experience, typically by analyzing and extracting patterns from large amounts of data. The RF algorithm belongs to the ensemble learning category of ML algorithms using bagging and boosting techniques (Pichler and Hartig, 2023). They are renowned for their robustness and versatility in both classification and regression tasks. Within the ensemble framework, RF operates by constructing multiple decision trees during training and then aggregating their predictions to make a final prediction. With their ability to deliver accurate predictions and interpretability, RF has become a popular choice for various predictive modeling tasks across different domains, including Education (Sarker, 2021).

The task of accurately forecasting school enrollment rates is critical for school management. It allows to minimize unnecessary administrative costs as well as burdens to both students and faculty. In addition, it is possible to adequately plan for the number of classes, teachers, and resources needed to meet students' demands. The use of ML models to forecast student enrollment in schools has shown to be a promising approach to dealing with this problem, as observed in the literature (Abideen et al., 2023; Masini et al., 2023; Shao et al., 2022).

Several related works have emerged in the literature in recent years. (Feng et al., 2011) analyzed enrollment data from 25 randomly selected Chinese provinces as training data to predict enrollment rates in another six provinces using an Artificial Neural Network (ANN) model combined with association rules. The authors stated that the proposed model is viable and effective in supporting decision-making in university admissions.

(Khademi and Nakhkob, 2016) used classical ML models (Logistic Regression - LR, Naive Bayes - NB and Decision Tree - DT) and Artificial Neural Networks - ANN (MultiLayer Perceptron - MLPs) combined (*bagging* and *boosting*) to predict the increase in enrollment in universities in Iran. The results showed that the model was able to accurately predict the increase in enrollments based on historical data, student demographic information, and socioeconomic data from the region, reaching almost 96% accuracy with the best model.

A study designed by (Soltys et al., 2021) used an AI services framework from Amazon Web Services (AWS), SageMaker, along with standard Python tools for data analysis, including Pandas, NumPy, Matplotlib, and Scikit-Learn [1]. Based on three years of enrollment history, a model was built to calculate, individually or in batch mode, enrollment probabilities for certain candidates. The idea was to use these probabilities during admissions periods to target undecided students.

More recent research by (Ayasi et al., 2023) delves into the application of ML and neural network algorithms in forecasting future student enrollments in higher education courses. Utilizing real data from the Arab American University in Palestine (AAUP), the study employed eight ML algorithms alongside the Multilayer Perceptron (MLP) neural network model to anticipate the enrollment likelihood of students in specific courses. Findings indicate that ensemble-based and bagging algorithms outshine other classifiers, including neural network models, in forecasting individual-level student enrollments. Notably, the RF achieves a remarkable accuracy of 94% and an F1 score of 79% following the application of undersampling techniques to address dataset imbalance. The study suggests future research endeavors to develop a universal model for forecasting enrollment across all courses at AAUP, underscoring the efficacy of these techniques in enhancing resource allocation and student support.

(Shao et al., 2022) developed a study to replicate course enrollment forecasts through a conditional probability analysis utilizing student data from San Diego State University. Subsequently, the study sought to enhance these predictions by employing classification and regression trees (CART) and the RF algorithm. By integrating student demographic and academic information into the algorithms, the authors aimed to evaluate their

[1] https://scikit-learn.org/

impact on refining the accuracy of course enrollment predictions. Furthermore, the authors conducted an analysis to determine the most influential factors affecting General Chemistry enrollment numbers, utilizing a variable importance metric derived from tree-based algorithms.

Finally, (Abideen et al., 2023) analyzed five years of enrollment data from 100 schools within Punjab, Pakistan. Essential features have been extracted and analyzed using various ML algorithms, including Multiple Linear Regression, RF, and Decision Tree. These algorithms play a crucial role in forecasting future school enrollments and classifying target levels for each school. The findings enable a brief analysis of forthcoming registrations and target levels. Moreover, the proposed model aids in identifying solutions to address low enrollment rates in schools, thereby contributing to the enhancement of literacy rates within the region.

Therefore, the main differences between our work and the aforementioned related works are the following: 1. our scope is broader and is related to public schools in Brazil and their respective educational stages, while the cited literature has a more specific scope with a primary focus on universities around the world (e.g., USA, China, Iran, and Palestine); 2. our work involves a complex, challenging and socially impactful context, while the contexts of the aforementioned works do not present these characteristics; 3. we propose a solution using Random Forest, a traditional Machine Learning algorithm, simple to implement and that does not require as many computational resources to execute, while most of the solutions identified in the literature, despite making use of modern and robust algorithms, such as Artificial Neural Networks, require a better computational infrastructure.

3. Forecasting Student Enrollments

This section presents the methodological step-by-step for conceiving the predictive model based on Random Forest algorithm as a potential solution for projecting enrollment in classes in elementary education schools in Brazil.

3.1. Dataset

In this work, we designed a predictive model using a dataset provided by FNDE. The dataset comprised 10,980,537 enrollment records of Brazilian Basic Education schools. To filter the dataset, we used the year and school grade code criteria, which resulted in 33 teaching stages and 12 years of school census data, spanning from 2010 to 2021. In addition, the dataset contains a total of 221.771 schools distributed in 5.570 Brazilian cities. The school records has six variables, as illustrated in Table 1: (a) Census Collection Year (YEAR); (b) Municipal Code (MUN_CO); (c) School Code (CD_SCH); (d) School Grade Code (GRADE_CD); and (e) Number of Students (STD_N).

Tab. 1 – A random sample with five records from the investigated dataset.

YEAR	MUN_CO	CD_SCH	GRADE_CD	STD_N
2010	43016413	4301107	15	1
2013	21097690	2105500	19	78
2012	23165820	2307304	20	11
2014	22134484	2210938	21	16
2019	21001219	2101301	16	2

In the predictive analysis proposed in this study, we only used the variables YEAR and STD_N. The other variables were used only to compare the performance results of the models according to the scenarios defined for the experiments.

Table 2 presents the descriptive statistics of the main variables present in the dataset, providing an idea of the data profile.

As seen in Table 2, the variable STD_N (target) presents an average of 49.29 students enrolled, with a median of 26 and standard deviation of 75.36. The minimum number of registered enrollments is equal to 1, while the maximum number is 31,542. These numbers characterize a discrepant variation in enrollments among Brazilian schools.

Tab. 2 – Descriptive Statistics of the dataset provided by the FNDE.

Variable	Mean	Median	Std. Dev.	Min.	Max.
YEAR	-	-	-	2010	2021
STD_N	49.29	26	75.36	1	31,542

3.2. Model

The biggest challenge in time series forecasting with traditional ML methods is setting up the problem correctly. There are basically three different possibilities by which we can classify a time series forecasting problem as a Supervised ML problem, namely:

1. Predict the next time step using previous observations;
2. Predict the next time interval using a sequence of past observations;
3. Predict a sequence of future time steps using a sequence of past observations.

In this work, we will frame the problem as non-prediction of school enrollment for the coming year using historical data from previous years. In this configuration, the model will generate a prediction for the next time step, considering only the previous observation.

For our analysis, it was necessary to organize the dataset in such a way that previous observations (historical time series) become a resource to predict the next observation (forecasting of enrollments in subsequent years). Therefore, we added a second column (y) that shifts the STD_N column so that the value in one year (red line, e.g., 2019) becomes a predictor of the value for the next year (blue line, e.g., 2020), allowing the comparison shown in Figure 2.

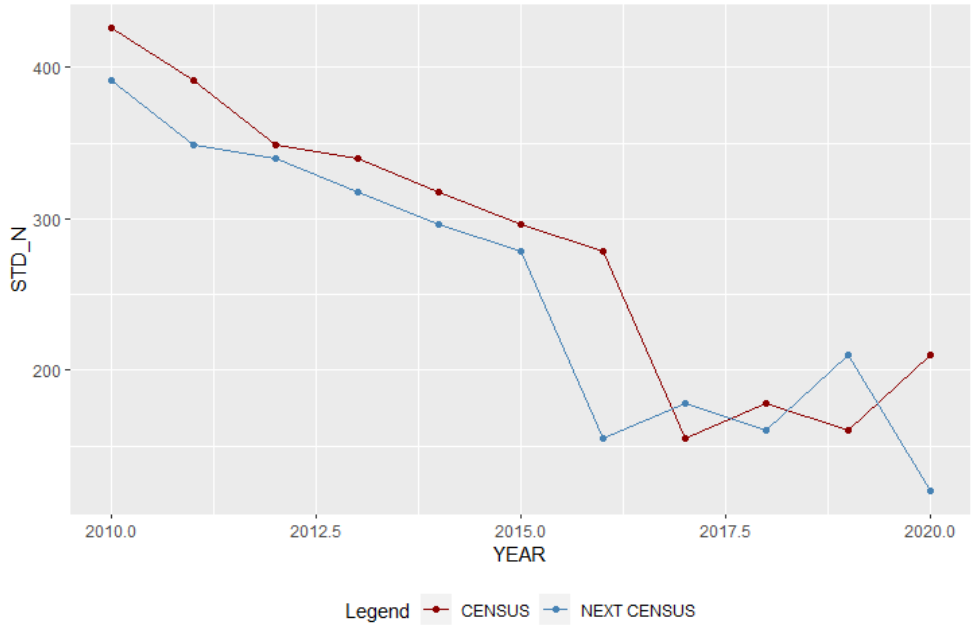


Fig. 2 – Example of viewing the series 15042537.

After arranging the data for the analysis proposed in the work, we started the experiments, as described in Section 4.

4. Experiment

In this work, we develop an experiment to validate the efficiency of RF into scenarios of forecasting Student Enrollments. The following metrics are utilized to measure this efficiency: (i) R^2 (R-squared) (Hiregoudar,

2020); (ii) MAE (Mean Absolute Error) (Penteado, 2021); (iii) MAPE (Mean Absolute Percentual Error) (Penteado, 2021); (iv) MASE (Mean Absolute Scaled Error) (Hyndman and Koehler, 2006); (v) MSE (Mean Squared Error) (Penteado, 2021); (vi) RMSE (Root Mean Squared Error) (Penteado, 2021); (vii) RAE (Relative Absolute Error) (Hiregoudar, 2020); and (viii) U-Theil (Bliemel, 1973).

4.1. Scenarios

The scenario utilized in this work is described as follows. We adopt Brazilian primary schools as our baseline scenario to perform forecasting techniques. In that sense, we investigate the dataset with the following concerns:

- **Global:** it encompasses the application of metrics along all the considered dataset with no filtering utilization. In this case, we consider previously considered filters, being deleted null data.
- **Teaching Stage:** it encompasses grouped data in according with the teaching stage, thus being defined by 36 categories;
- **Geographic Location:** it encompasses grouped data in according with the location in the urban perimeter of schools, thus being defined by Urban and Rural categories;
- **Brazilian Regions:** it encompasses grouped data in according with the location of schools in Brazilian Regions, thus being defined by the categories: (a) North; (b) Northeast; (c) East Center; (d) Southeast; and (e) South;
- **Federative Unit:** it encompasses grouped data according to the location of 27 Brazilian states;
- **Population Size:** it encompasses grouped data according to the population ranges of cities and municipals that encompass such schools, thus being defined by the following categories: (i) Up to 20 thousand inhabitants; (ii) Between 20 and 50 thousand inhabitants; (iii) Between 50 and 100 thousand inhabitants; (iv) Between 100 and 500 thousand inhabitants; (v) Between 500 and 1 million inhabitants; and (vi) Over 1 million inhabitants;
- **Dependency Type:** it encompasses grouped data by school sector, and its categorization is: (1) Federal, (2) State, (3) Municipal, (4) Private, and (5) All Public.
- **School Size:** categorized into five classes (1 to 5), the first being the smallest (smallest range of total number of students per school) and the last being the largest, the entities/schools according to their statistical distribution in the population (quantiles) for each year analyzed.

To carry out our experiments, we grouped the data according to each scenario mentioned above. In this way, we were able to discuss the performance results of RF and ES algorithms (baseline) according to the context analyzed in each experiment.

4.2. Design Methodology

Figure 3 presents the steps of the design methodology defined for the model development and evaluation.

Starting from a dataset provided by FNDE, we generate 1.531.185 times series in order to serve as an input to RF processing. The composition of these series is performed by grouping the following columns: (a) *CD_SCH*; (b) *MUN_CO*; and (iii) *GRADE_CD*. Likewise, we estimate the regression value for the reference year 2021.

We utilize the *interpolate* imputation method (Robinson and Hamann, 2011) to mitigate absent values in the investigated dataset since it presents acceptable performance to reduce dataset-related prediction errors. Moreover, we also use the *hold-out* method (Sammut and Webb, 2017) to slice the dataset into two subsets: a training one, used to tune the model, and a testing one, used to evaluate the model's performance in forecasting the data not belonging to the training subset. We have partitioned the training dataset with data proceeding from 2010 to 2020 to each entity, and we define the testing dataset with data proceeding from 2021.

Each school and teaching stage is represented by the regression estimated value. Therefore, such value is obtained for each time series and concatenated, thus generating a new dataset. Therefore, the model was evaluated by processing error measurement metrics and model evaluation. We utilize a *random state* in the enrollment forecasting model using the RF in order to ensure scientific-level repeatability. Although the RF model was designed based on the pre-processed dataset, the prediction results were filtered by each scenario to allow for a more in-depth discussion.

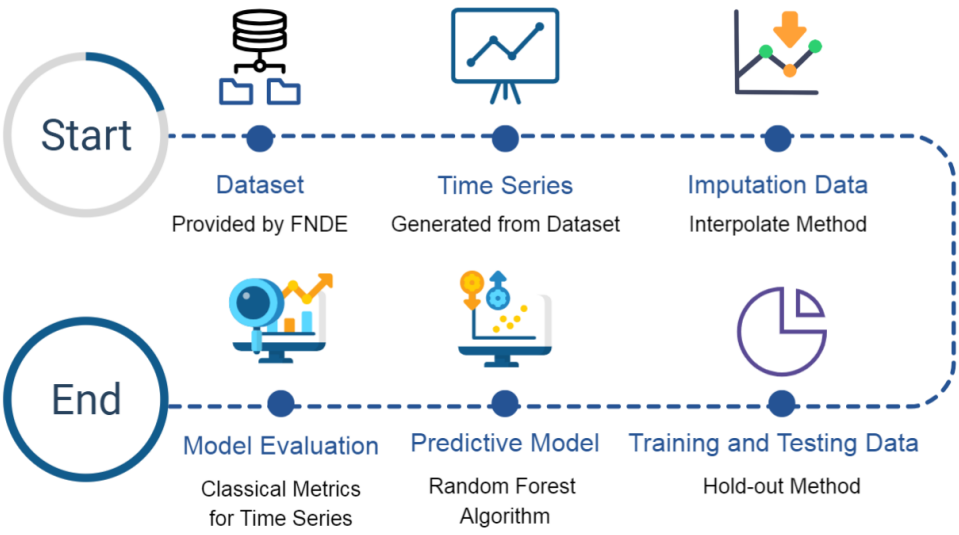


Fig. 3 – Development and Evaluation Process.

Finally, the computing environment used to perform the experiments consists of a computer with an Intel(R) Xeon(R) E-2244G processor, with CPU cores of 3.80GHz, and 32.0 GB of RAM memory. We understand this information is relevant since processing time is an important factor in the practical application.

5. Results

This section presents the results and discussion on predicting enrollment in Brazilian schools using the Random Forest (RF) algorithm and comparing its performance with the baseline model that uses the Exponential Smoothing (ES) technique.

Table 3 presents the *benchmarking* results of the designed model by contrasting the RF algorithm with the ES model in the "Global" scenario with complete dataset. In this scenario, except for U-Theil, we observed a better performance of the RF in all other metrics evaluated.

Tab. 3 – Evaluation of RF *vs.* ES (baseline) models for the "Global" scenario.

Model	R^2	MAE	MAPE	MSE	RMSE	MASE	RAE	U-Theil
ES	0.83	12.52	46.97	941.63	30.69	0.44	0.29	**0.25**
RF	**0.87**	**11.62**	**42.01**	**745.04**	**27.30**	**0.41**	**0.27**	0.26

In other investigated scenarios, we first have calculated the values of each metric in each subcategory and then we have calculated the average. For example, in the "Teaching Stage" scenario, the comparative results between the ES (baseline) model and the RF algorithm are presented in Table 4. As a result, the performance of the models in this scenario is similar to that of the "Global" scenario, but with a reduction in R^2 and an increase in the values of the error metrics, with the exception of MASE.

Tab. 4 – Evaluation of RF *vs.* ES (baseline) models for the "Teaching Stage" scenario.

Model	R^2	MAE	MAPE	MSE	RMSE	MASE	RAE	U-Theil
ES	0.76	21.70	57.45	2952.4	41.49	0.35	0.41	**0.507**
σ ($\pm$)	0.20	14.00	45.70	5975.0	35.60	0.14	0.18	0.230
RF	**0.79**	**20.20**	**52.80**	**2537.18**	**38.43**	**0.332**	**0.38**	0.514
σ ($\pm$)	0.18	12.70	36.20	5313.00	33.10	0.130	0.17	0.230

We applied the paired-samples t-test (Xu et al., 2017), where the null hypothesis (H_0) assumes that the true mean difference (μd) is equal to zero. Table 5 shows the *p-values* calculated for each metric used to evaluate

the model's performance. Considering the statistical significance of $p \leq 0.05$, when analyzing the *p-values* of all metrics, we found that they are lower than 0.05. Therefore, we confirm the hypothesis that there is a statistical difference between the performance results of the RF and ES models.

Tab. 5 – T-test - Paired Two Sample for Means: "Teaching Stage" scenario.

Metric	***p-value***
R^2	0.0005579
MAE	9.865728e-06
MAPE	0.02979593
MSE	0.02354106
RMSE	0.0009053389
MASE	1.362274e-06
RAE	3.476034e-07
U-Theil	0.0012871

In relation to "Geographic Location", the results presented in Table 6 demonstrate a superiority of RF, with emphasis on the R^2 metric.

Tab. 6 – Evaluation of RF *vs.* ES (baseline) models for the "Geographic Location" scenario.

Model	R^2	**MAE**	**MAPE**	**MSE**	**RMSE**	**MASE**	**RAE**	**U-Theil**
ES	0.771	11.57	48.2	841	25.6	0.499	0.389	**0.212**
σ ($\pm$)	0.042	9.31	12.3	989	19.3	0.066	0.014	0.009
RF	**0.81**	**10.75**	**43.3**	**666**	**22.9**	**0.466**	**0.363**	0.222
σ ($\pm$)	0.042	8.58	12.8	774	16.9	0.066	0.016	0.007

We conducted a paired t-test to compare the means of each metric of each model across different scenarios, similar to what we did for the "Teaching Stages" scenario. The results for the "Geographic Location" scenario are presented in Table 7. The obtained *p-values* for the metrics R^2, MAPE, MASE, and RAE were below 0.05, indicating a statistical difference between the means of these metrics for the ES model compared to the RF model. However, there was no statistical difference observed for the MAE, MSE, RMSE, and U-Theil metrics, suggesting similar performance of both models for these metrics.

Tab. 7 – T-test Paired Two Sample for Means: "Geographic Location" scenario.

Metric	***p-value***
R^2	0.003233613
MAE	0.3573881
MAPE	0.04610538
MSE	0.4554039
RMSE	0.3571983
MASE	0.0002570144
RAE	0.04314648
U-Theil	0.1019322

In the "Brazilian Regions" scenario (see Table 8), the RF has achieved a better performance than the ES model (*baseline*). This behavior is repeated in scenarios that encompass data grouped by "Federation Unit", "Population Size" and "Type of Dependency", as shown in Tables 10, 12, 14, and 16, respectively.

We show the results of the paired t-test for the "Brazilian Regions" scenario in Table 9. The *p-values* calculated for all metrics allow us to reject the null hypothesis and conclude that the means are statistically different when comparing the performance of the ES and RF models. A similar result is also observed in the "Federative Unit" scenario, as shown in Table 11.

The results of the paired t-test for the "Population Size", "Dependency Type", and "School Size" scenarios are shown, respectively, in Tables 13, 15, 17. In these scenarios, there were many variations in results. For example, in the "Population Size" scenario (see Table 13), except the *p-value* obtained for the R^2 metric, the other

Tab. 8 – Evaluation of RF *vs.* ES (baseline) models for the "Brazilian Regions" scenario.

Model	R^2	MAE	MAPE	MSE	RMSE	MASE	RAE	U-Theil
ES	0.808	12.85	46.68	935	30.37	0.444	0.314	**0.272**
σ ($\pm$)	0.075	2.75	7.51	227	3.99	0.022	0.039	0.021
RF	**0.841**	**11.90**	**41.63**	**760**	**27.35**	**0.411**	**0.291**	0.281
σ ($\pm$)	0.076	2.60	7.03	199	3.83	0.021	0.038	0.020

Tab. 9 – T-test Paired Two Sample for Means: "Brazilian Regions" scenario.

Metric	*p-value*
R^2	0.00267542
MAE	0.0006234588
MAPE	3.944342e-05
MSE	0.01473016
RMSE	0.01258553
MASE	0.0001404595
RAE	8.05893e-05
U-Theil	0.0002031214

Tab. 10 – Evaluation of RF *vs.* ES (baseline) models for the "Federative Unit" scenario.

Model	R^2	MAE	MAPE	MSE	RMSE	MASE	RAE	U-Theil
ES	0.783	13.02	47.46	988	29.8	0.443	0.319	**0.350**
σ ($\pm$)	0.095	4.18	7.91	860	10.1	0.047	0.049	0.074
RF	**0.824**	**11.99**	**42.21**	**805**	**27.01**	**0.409**	**0.294**	0.357
σ ($\pm$)	0.072	3.79	7.18	683	8.85	0.044	0.046	0.072

Tab. 11 – T-test Paired Two Sample for Means: "Federative Unit" scenario.

Metric	*p-value*
R^2	0.0001219464
MAE	9.750767e-12
MAPE	2.814718e-15
MSE	0.0006719472
RMSE	1.774589e-05
MASE	1.220686e-18
RAE	3.434326e-18
U-Theil	7.375808e-12

p-values had values lower than 0.05, indicating the rejection of the null hypothesis. Therefore, in this scenario, we can conclude that there is a statistical similarity between the means of the ES and RF models only for the R^2 metric.

Tab. 12 – Evaluation of RF *vs.* ES (baseline) models for the "Population Size" scenario.

Model	R^2	MAE	MAPE	MSE	RMSE	MASE	RAE	U-Theil
ES	0.778	14.99	44.66	1232	33.5	0.441	0.335	**0.270**
σ ($\pm$)	0.097	6.26	5.57	880	11.3	0.008	0.041	0.012
RF	**0.84**	**13.95**	**39.74**	**1027**	**30.1**	**0.409**	**0.31**	0.279
σ ($\pm$)	0.03	5.94	5.51	862	12.2	0.009	0.04	0.011

For the "Dependency Type" scenario (see Table 15), the *p-values* for the error metrics MSE, MASE, RAE, and U-Theil exceeded the value of 0.05, which leads us to accept the null hypothesis that the means of these metrics, for both ES and RF models, are statistically equal. For the other error metrics and the R^2 metric, the means

Tab. 13 – T-test Paired Two Sample for Means: "Population Size" scenario.

Metric	***p-value***
R^2	0.1235081
MAE	0.0006663735
MAPE	1.503282e-05
MSE	0.005347984
RMSE	0.0182089
MASE	3.38188e-06
RAE	2.196989e-06
U-Theil	7.119195e-06

Tab. 14 – Evaluation of RF *vs.* ES (baseline) models for the "Dependency Type" scenario.

Model	R^2	**MAE**	**MAPE**	**MSE**	**RMSE**	**MASE**	**RAE**	**U-Theil**
ES	0.791	17.02	45.71	1991	38.88	0.450	0.35	0.453
σ ($\pm$)	0.053	8.81	18.60	2504	24.50	0.060	0.06	0.303
RF	**0.851**	**15.11**	**40.84**	**1512**	**33.75**	**0.390**	**0.30**	**0.446**
σ ($\pm$)	0.025	8.54	17.6	1841	21.60	0.052	0.05	0.270

are statistically different.

Tab. 15 – T-test Paired Two Sample for Means: "Dependency Type" scenario.

Metric	***p-value***
R^2	0.02513679
MAE	0.03603456
MAPE	0.0005633837
MSE	0.1921146
RMSE	0.0353659
MASE	0.09901843
RAE	0.09540237
U-Theil	0.6418034

Tab. 16 – Evaluation of RF *vs.* ES (baseline) models for the "School Size" scenario.

Model	R^2	**MAE**	**MAPE**	**MSE**	**RMSE**	**MASE**	**RAE**	**U-Theil**
ES	0.659	12.53	46.9	943	24.9	0.493	0.46	0.507
σ ($\pm$)	0.204	9.60	14.1	1393	20.2	0.063	0.09	0.203
RF	**0.70**	**11.64**	**41.9**	**746**	**22.3**	**0.461**	**0.43**	**0.453**
σ ($\pm$)	0.21	8.88	14.1	1079	17.6	0.066	0.09	0.247

Finally, for the "School Size" scenario (see Table 17), in addition to the *p-value* of R^2, the *p-values* for the MAPE, MASE and RAE metrics were less than 0.05, allowing us to conclude that the means are statistically different for the ES and RF models. Differently, the averages for the MAE, MSE, RMSE, and U-Theil metrics are statistically similar, as the *p-values* were greater than 0.05.

Our experiments have presented relevant results, thus enabling the comparison of the ES (*baseline*) model in time series with the performance of the RF algorithm. Given the experiment results, we understand that there is a variation in performance of the RF-based model in accordance with the scenario. For example, in the "Teaching Stages" and "School Size" scenarios, both models performed less than 0.8 for the R^2 metric. In the scenarios "Geographic Location", "Federative Unit", "Population Size" and "Dependency Type", only the RF model performed better than 0.8 for the R^2 metric. Only in the Global and "Brazilian Regions" scenarios did both models exceed the value of 0.8 for the R^2 metric.

When it comes to the error metrics MAE, MAPE, MSE, RMSE, MASE, and RAE, the RF model reduced the value of

Tab. 17 – T-test Paired Two Sample for Means: "School Size" scenario.

Metric	***p-value***
R^2	8.62111e-05
MAE	0.05070706
MAPE	5.064793e-05
MSE	0.234543
RMSE	0.09082856
MASE	0.0004177525
RAE	0.0004358726
U-Theil	0.3324351

the prediction error in all scenarios: "Global", "Teaching Stages", "Geographical Location", "Brazilian Regions", "Federative Units", "Population Size", and "Type of Dependency".

For the U-theil metric, specific to evaluating predictive models for time series, the baseline model outperformed RF only in the "Dependency Type" and "School Size" scenarios.

Considering all the variations of the analyzed scenarios, we obtained 86 results in total. Analyzing the frequency of the best performing models (ES *vs.* RF), the supremacy of the RF algorithm was evident in all scenarios, with a processing time of 160934.6 seconds.

As mentioned in Section 2, this work focuses on public schools in Brazil. However, our solution can be adopted in other countries with different realities. While it is most suitable for countries similar to Brazil—particularly developing nations with heterogeneous income distribution and economies influenced by major world powers—our approach can also benefit underdeveloped countries, especially those in the Global South. These countries, despite having low socioeconomic indicators and the Health and Education sectors are mostly the government's responsibility, can utilize our solution due to its simplicity and minimal reliance on computational resources.

As mentioned in Section 2, this work focuses on public schools in Brazil. However, our solution can be adopted in other countries with different realities. While it is most suitable for countries similar to Brazil—particularly developing nations with heterogeneous income distribution and economies influenced by major world powers—our approach can also benefit underdeveloped countries, especially those in the Global South. These countries, despite having low socioeconomic indicators and , can utilize our solution due to its simplicity and minimal reliance on computational resources.

6. Concluding Remarks

The Brazilian National Textbook Program (Programa Nacional do Livro e do Material Didático — PNLD) is one of the largest and most democratic government programs for education in Brazil. It was created in 1938, but was entitled of PNLD in 1985, to distribute textbooks, pedagogical and literary books, and other educational materials to teachers and students in public schools throughout the country (Sobrinho et al., 2023). Given the vast geographic, economic, and cultural diversity of the country, it is not easy to estimate the exact number of students in each class at each school in every Brazilian municipality.

This paper highlights the untapped potential of machine learning in transforming enrollment forecasting into a powerful tool for public policy. The study investigated a RF-based ML Model to forecast student enrollment in Brazilian schools. We used as a scenario the public school, and we created a dataset to carry out this forecasting. RF with ES as baseline to verify the performance of enrollment forecasts in public schools. The results show an improvement in the distribution process, allowing children to have access to books and improving equity. As a consequence, implementing a solution that is less likely to have prediction errors can significantly reduce the issue of having too many books in schools, which leads to financial waste. Additionally, this solution can also solve the problem of students not receiving books due to their unavailability, which results in inestimable losses in terms of their education.

This type of experiment seeks to provide more effective solutions compared to the ES model used by the Brazil-

ian government, as it is not just about forecasting the number of enrollments in classes in basic education schools in Brazil. The use of this information becomes even more important for government bodies responsible for Brazilian Education to plan the acquisition of teaching resources, such as books, to meet the demands of society.

In this context, having an effective solution for predicting the number of students who will enroll in each class in each school the following year allows the government to make more efficient decisions regarding purchasing books and other didactic materials to be distributed in schools. Thus, regarding the state of the practice, we characterize the advancement of our work by proposing a predictive model based on a machine learning algorithm that does not require assumptions (i.e., Random Forest), unlike the Exponential Smoothing method, which requires data to be stationary and predictions to be short-term. Therefore, our solution assists the Brazilian government in optimizing resources for education, ensuring equal access to didactic materials for all students in public schools.

As limitations, we identified the following points: (i) During the descriptive and graphical analysis stage of the data present in the dataset, we observed that there were observations with values that deviated from the standards of the large mass of data. However, we decided not to analyze in this study the influence and impact of these data on the performance of the models, baseline, and RF, therefore characterizing a limitation of this study. (ii) We only use historical data relating to the number of enrollments in previous years as predictors to forecast the number of enrollments in the following year. This decision limited the solution to a reduced set of variables that, perhaps alone, were insufficient to explain the value of the target variable.

In order to work on the limitations, we suggested the following future works: (i) investigate the characteristic observations of outliers and influential points in the dataset that may impact the performance of the models; (ii) enhance the performance of our proposed predictive model, adding more predictor variables. For this purpose, we can use the microdata from the Brazilian basic education census provided by INEP. This dataset contains over 300 attributes, which should provide us with ample options to choose other variables. Once we have added these variables, we need to evaluate the impact of this change on the model's performance; (iii) optimize the model parameters through *tunning* techniques such as *GridSearch* or *RandomSearch*, which have the potential to improve prediction and evaluation results of predictive models; (iv) In addition, other ML models will be tested, aiming to present a fairer comparative analysis and seek even better solutions to the enrollment forecast problem; (v) Finally, we will present the results of this work to the FNDE and propose integrating our solution into the enrollment prediction system used by the Brazilian government.

Acknowledgement

We thank the members of the Center for Excellence in Social Technologies (NEES), who collaborated with this research. We also thank the National Education Development Fund from Brazil for supporting this research through the Decentralized Execution Term (TED) 12244.

Funding

We thank the FNDE for supporting this research through the Decentralized Execution Term (TED) (Grant Number: TED 12244).

Data Access Statement

We also thank FNDE for providing the datasets that supported our research.

Contributor Statement

We thank the members of the Center for Excellence in Social Technologies (NEES) who collaborated with this research.

Conflict Of Interest (COI)

Author Bruno Pimentel has received research grants from the FNDE in Brazil. The remaining authors are members of the NEES.

References

Abideen, Z. u., Mazhar, T., Razzaq, A., Haq, I., Ullah, I., Alasmary, H., & Mohamed, H. G. (2023). Analysis of Enrollment Criteria in Secondary Schools Using Machine Learning and Data Mining Approach [Publisher: MDPI]. *Electronics*, *12*(3), 694. Retrieved February 15, 2024, from https://www.mdpi.com/2079-9292/12/3/694

Amarasinghe, K., Rodolfa, K. T., Lamba, H., & Ghani, R. (2023). Explainable machine learning for public policy: Use cases, gaps, and research directions. *Data & Policy*, *5*, e5. DOI: https://doi.org/10.1017/dap.2023.2.

Andrade, J. (2023, February). Censo escolar: Matrículas na educação básica cresceram em 2022 [Last accessed 19 Feb. 2024].

Ayasi, B., Saleh, M., García-Vico, A., & Carmona, C. J. (2023, December). Predicting course enrollment with machine learning and neural networks: A comparative study of algorithms. ISTES Organization Monument, CO, USA.

Billah, B., King, M. L., Snyder, R. D., & Koehler, A. B. (2006). Exponential smoothing model selection for forecasting. *International Journal of Forecasting*, *22*(2), 239–247. DOI: https://doi.org/https://doi.org/10.1016/j.ijforecast.2005.08.002.

Bliemel, F. (1973). Theil's forecast accuracy coefficient: A clarification. *Journal of Marketing Research*, *10*(4), 444–446. Retrieved January 5, 2024, from http://www.jstor.org/stable/3149394

Chen, Q. (2022). A comparative study on the forecast models of the enrollment proportion of general education and vocational education. *International Education Studies*, *15*(6), 109–126.

Feng, S., Zhou, S., & Liu, Y. (2011). Research on data mining in university admissions decision-making [Last accessed 20 Jun. 2023.]. *International Journal of Advancements in Computing Technology*, *3*(6), 176–186. https://doi.org/10.4156/ijact.vol3.issue6.21

Fischer-Abaigar, U., Kern, C., Barda, N., & Kreuter, F. (2024). Bridging the gap: Towards an expanded toolkit for AI-driven decision-making in the public sector. *Government Information Quarterly*, *41*(4), 101976. DOI: https://doi.org/10.1016/j.giq.2024.101976.

FNDE. (2022, January). Em 2021 foram investidos r$1,9 bilhoem livros e material didtico do PNLD$. https://www.gov.br/fnde/pt-br/assuntos/noticias/em-2021-foram-investidos-1-9-bilhao-em-livros-e-material-didatico-do-pnld

Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. *MIS Q.*, *37*(2), 337–356. DOI: https://doi.org/10.25300/MISQ/2013/37.2.01.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. *MIS Q.*, *28*(1), 75–105.

Hiregoudar, S. (2020, August). Ways to evaluate regression models [Accessed 23 Feb. 2023]. https://towardsdatascience.com/ways-to-evaluate-regression-models%20-77a3ff45ba70

Hyndman, R. J., & Koehler, A. B. (2006). Another look at measures of forecast accuracy. *International Journal of Forecasting*, *22*(4), 679–688. DOI: https://doi.org/https://doi.org/10.1016/j.ijforecast.2006.03.001.

Khademi, M., & Nakhkob, B. (2016). Predicted increase enrollment in higher education using neural networks and data mining techniques. *Journal of Computer Research and Development*, *7*, 125–140.

Masini, R. P., Medeiros, M. C., & Mendes, E. F. (2023). Machine learning advances for time series forecasting. *Journal of Economic Surveys*, *37*(1), 76–111. DOI: https://doi.org/10.1111/joes.12429.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & and, S. C. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, *24*(3), 45–77. DOI: https://doi.org/10.2753/MIS0742-1222240302.

Penteado, K. (2021, June). Métricas de avaliação para séries temporais [Accessed 22 Feb. 2023]. https://www.alura.com.br/artigos/metricas-de-avaliacao-para-se-%20ries-temporais

Pichler, M., & Hartig, F. (2023). Machine learning and deep learning—A review for ecologists. *Methods in Ecology and Evolution*, *14*(4), 994–1016. DOI: https://doi.org/10.1111/2041-210X.14061.

Robinson, A. P., & Hamann, J. D. (2011). Imputation and interpolation. In *Forest analytics with r: An introduction* (pp. 117–151). Springer New York. DOI: https://doi.org/10.1007/978-1-4419-7762-5_4.

Sammut, C., & Webb, G. I. (Eds.). (2017). *Encyclopedia of machine learning and data mining*. Springer. DOI: https://doi.org/10.1007/978-1-4899-7687-1.

Sarker, I. H. (2021). Machine Learning: Algorithms, Real-World Applications and Research Directions. *SN Computer Science*, *2*(3), 160. DOI: https://doi.org/10.1007/s42979-021-00592-x.

Scholl, H. J. (2024). Digital government research: Evolution of topical directions. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 423–433. DOI: https://doi.org/10.1145/3657054.3657106.

Shao, L., Ieong, M., Levine, R. A., Stronach, J., & Fan, J. (2022). Machine Learning Methods for Course Enrollment Prediction. *Strategic enrollment management quarterly*, *10*(2). Retrieved February 15, 2024, from https://par.nsf.gov/servlets/purl/10389427

Sobrinho, A., Bittencourt, I. I., Silveira, A. C. M., Silva, A. P., Dermeval, D., Marques, L. M., Rodrigues, N. C. I., Souza, A. C. S., Ferreira, R., & Isotani, S. (2023). Towards digital transformation of the validation and triage process of textbooks in the brazilian educational policy. *Sustainability*, *15*(7). DOI: https://doi.org/10.3390/su15075861.

Soltys, M., Dang, H. D., Reyes Reilly, G., & Soltys, K. (2021). Enrollment predictions with machine learning [Last accessed 20 Jun. 2023]. *Strategic Enrollment Management Quarterly*, *9*(2), 11–18. https://eric.ed.gov/?id=EJ1311204

Xu, M., Fralick, D., Zheng, J., Wang, B., Tu, X., & Feng, C. (2017). The differences and similarities between two-sample t-test and paired t-test. *Shanghai Arch Psychiatry*, *29*(3), 184–188.

Interactive Data Visualization for Decision-making in Government-funded Advanced Research Computing Service

Xiaoyue Cheng [a*], *Yu-Che* Chen [b], *Rich* Knepper [c], *Andrew* Burk [d]

[a] Associate Professor, Department of Mathematical and Statistical Sciences, University of Nebraska at Omaha, USA. Email address: xycheng@unomaha.edu.

[b] Isaacson Professor, Interim School Director, School of Public Administration, University of Nebraska at Omaha, USA. Email address: ychen@unomaha.edu.

[c] Director, Cornell University Center for Advanced Computing, Cornell University, USA. Email address: rich.knepper@cornell.edu.

[d] PhD student, College of Public Affairs and Community Service, University of Nebraska at Omaha, USA. Email address: andrewburk@unomaha.edu.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Data-driven decision-making has become more prevalent in the field of digital government. Data visualization as a key tool for data exploration, can help decision makers quickly understand data and grasp insights behind pages of spreadsheets. To better support scientific discovery through advanced research computing, the U.S. National Science Foundation has funded the cyberinfrastructure programs including TeraGrid, XSEDE, and ACCESS for over twenty years. These programs have generated extensive data about the awarded projects along with their resource allocation and usage. However, existing visualization tools for these data were not designed for in-depth analysis or direct decision-making support. This research investigated the needs of resource providers and users, analyzed the data collected from TeraGrid and XSEDE projects between 2003 and 2022, and developed a publicly accessible interactive visualization dashboard. The goal of this visual platform is to enable resource providers and users to independently explore data through graphs and tables and make informed comparisons and decisions. Resource providers can use the platform to study and compare trends in resource allocation and usage across projects funded at various institutions and within different fields, identify more efficient resource users and research directions, and provide personalized services to institutions and principal investigators in need. Resource users can search for potential collaborators and helpers from successful cyberinfrastructure project awardees in similar fields, nearby locations, or related research topics. Additionally, this paper demonstrates the practical application of the visualization dashboard through three examples: a research-intensive institution, an under-represented minority-serving institution, and a junior researcher from a specific field of science, showcasing how each can leverage the platform for decision-making.

Keywords. Data visualization, interactive dashboard, graphical user interface, decision-making, cyberinfrastructure, XSEDE
Research paper, DOI: https://doi.org/10.59490/dgo.2025.946

1. Introduction

In the era of data explosion, making full use of data science can significantly improve comprehensiveness, rationality, timeliness and effectiveness of decision-making. Big data can be employed to depict the comprehensive characteristics of static events and the development trends of dynamic events. This enables decision-makers to

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

more easily identify challenges or issues, determine the most appropriate actions or intervention timings, simulate the potential outcomes and impacts of decisions, and ultimately select the optimal decision under given constraints. However, data science also presents unique challenges, such as how to collect, organize, and store massive amounts of data, how to extract valuable insights from massive data, and how to effectively communicate the summarized data value to policy makers and beneficiaries. Within the chain from data to decision, data visualization serves as a critical link to help stakeholders understand data.

Data visualization uses graphical displays to show data and information (Unwin, 2020). For most people, interpreting information from visual graphs is more direct and efficient than browsing raw data or reading summary tables, without losing accuracy. Data visualization can assist in the decision-making process by presenting important information such as numerical distributions, categorical comparisons, temporal progress, and spatial trends. Statistical graphics can also show comparisons of data distributions under multiple different conditions by selecting correct graphical elements such as graph types, colors, shapes, sizes, and page layouts, etc. Therefore, data visualization can play an essential role in summarizing information and comparing options during decision-making.

In digital government, data-driven decision-making has become more extensive and in-depth (van Ooijen et al., 2019) and the potential of leveraging artificial intelligence (Charles et al., 2022). For instance, statistical data collected by federal, state, and local governments are often publicly available on the government websites like data.gov in the United States. The public can view and understand transparent, data-based government decisions. Meanwhile, individuals may use open data for personal decision-making or to influence government decisions from the bottom up. On government websites, visualization is increasingly being used in the form of data dashboards to provide more convenience to the public.

While significant progress has been made with the growth of data-driven decision-making in digital government, there remain opportunities for further enhancement in some areas like social services (Ryan et al. 2014; van Ooijen et al. 2019; Charles et al. 2022). Although large datasets have been collected in these areas and basic descriptive statistics are often reported, there is a potential to uncover deeper, more valuable insights from the data, such as causal inference, predictive modeling, and equity-focused evaluation. To smooth the decision-making process with data visualization, this study will take the high performance computing services of advanced scientific research projects funded by the U.S. government as a digital government project to showcase the design concept and product examples of interactive visualization platforms; also, to show how the visual products could help both policymakers and potential beneficiaries to explore the value of data and strengthen their analytical and decision-making capabilities.

High performance computing (HPC) is a technology that uses supercomputers or processor clusters to parallelly process massive data and complex calculations at a high speed. HPC is of great significance in accelerating scientific discovery and enhancing technological invention. To provide powerful HPC services for U.S. scientific researchers, the National Science Foundation (NSF) has invested $270 million on the cyberinfrastructure (CI) programs (Chen & Knepper, 2021), including the TeraGrid (Reed & Berman, 2001), the Extreme Science and Engineering Discovery Environment (XSEDE) 1.0 and 2.0 (Towns, et al., 2011; XSEDE, 2016), and the more recent Advanced Cyberinfrastructure Coordination Ecosystem: Services & Support (ACCESS) (Boerner, et al., 2023). And NSF's investment has been well paid off. According to Stewart, et al. (2022), the XSEDE program provided a return of more than $1.5 in value for every $1.0 invested by the U.S. Government during 2014 to 2020.

To further develop the HPC CI programs, both the program operation team and users may be interested in addressing questions such as: How to allocate computing resources more efficiently? How to better support inexperienced users to start their HPC projects conveniently? How to advertise the CI programs and encourage more researchers to apply for and utilize these resources and services? How to broaden participation of under-represented individuals and groups? While domain experts may have answers to these questions based on years of experience, insights can also be gained from a data perspective. By analyzing data collected from the TeraGrid/XSEDE projects across almost 20 years, decision makers and scientific users can reveal user behaviors hidden behind the allocation and usage data, offering valuable answers to these critical questions.

The main contribution of this work is to produce an interactive data visualization platform for government-funded HPC cyberinfrastructure services via the user-centered co-design. This platform will provide decision-making support for two groups. For computing service providers, the platform displays and compares the resource allocation and utilization efficiency of research projects using the XSEDE services over the years, aggregated at the institution, field of science, and individual investigator levels, which would assist in finding ways to optimize CI operations. For novice and potential users of HPC services, the visualization platform can help them find potential research collaborators and topics, build the foundation, and boost the confidence to start their HPC projects.

The second section reviews the literature on data visualization and the application of big data in digital government. The third section examines two data visualization tools of the NSF CI programs and introduces the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

design concept and framework structure of the interactive graphics platform. The fourth section provides a detailed overview of the TeraGrid/XSEDE data and the interactive dashboard, including examples that demonstrate how to utilize the platform. The final section presents a summary of findings and discusses future work.

2. Data Visualization and Decision-making

Data visualization is an important part of Exploratory Data Analysis (EDA). After collecting data, visualizations can be used to examine distributions, outliers, and missing values. This helps assess the discreteness and correlations among variables, handle outliers and missing data, and check the assumptions of statistical models. Moreover, visualizations can uncover key insights or "highlight stories" within the data and effectively communicate statistical results after the analysis is completed.

2.1 Data visualization: types, development, and applications

According to the development stage of data visualization, we divide graphics into static graphics, dynamic graphics, and interactive graphics.

Static graphics are fixed visual displays that do not move or change. They have been used to provide important decision-making information for hundreds of years. For example, in mid-1800s, Florence Nightingale created the polar time series plot to show death rates and causes of British soldiers in the Crimean war (Cohen, 1984). At about the same time, John Snow mapped cholera deaths in London, identifying a water pump as the outbreak's source (Snow, 1856). Modern static graphics usually choose the type of plot based on the types of variables. Univariate distributions can be visualized with histograms or density plots for continuous variables and bar charts for categorical ones; line plots reveal trends in time-series data. For bivariate cases, scatterplots show correlations between continuous variables, mosaic plots display associations between categorical variables, and boxplots or violin plots compare continuous variables across categories. Multivariate relationships can be explored with pairwise plots using univariate visuals on the diagonal and bivariate visuals off-diagonal, or with parallel coordinates plots, where each variable is shown on a vertical axis and observations are connected by lines, revealing patterns such as correlations through line alignment or crossing.

In terms of graphing methods, Cleveland (1984, 1985) discussed the theory of visual perception and the principal elements of graphics. Wilkinson (2005) denoted the grammar of graphics (GoG) system with seven orthogonal class methods to transform data from a raw dataset to a statistical graphic. Wickham (2010) implemented the GoG principles into the R language and developed the well-known graphics package ggplot2. In other software, the design and development of modern graphics packages are also influenced to some extent by GoG and ggplot2 (Morel, 2018; Yim, et al., 2018).

As data volumes grow and software technologies develop, there is a demand for dynamic graphics in the field of visualization. Dynamic graphics are visual displays via a sequence of changing images or animations (Becker, et al., 1987). Like the early film technology, by playing a series of static graphics, users can more intuitively perceive the changing trends or different perspectives in high-dimensional data. Examples of applications include time series, two-dimensional representations of high-dimensional data, visualization on sampling techniques, and so on. For time series data, ordinary static graphics can only display univariate continuous data. If multiple dimensions need to be displayed simultaneously, then each frame can only represent a specific time point. Dynamic graphics, on the other hand, can animate multidimensional data along the time dimension, thereby showing the trends over time. When visualizing high-dimensional data, one challenge is to project high-dimensional data onto a two-dimensional plane. Classic dimension reduction methods have to select optimal projection directions, but dynamic graphics like Grand Tour enable exploration of data by continuously rotating the projection direction (Cook, et al., 1995). Dynamic graphics can also be used to demonstrate sampling techniques by playing static graphics of different random samples, to help students understand concepts more easily in statistical education (Xie, 2013).

Interactive graphics refer to visualizations that allow users to adjust and optimize graphic parameters based on specific needs and highlight interesting areas to gain more effective information perception (McDonald, 1982; Theus & Urbanek, 2008). Modern internet technologies have transformed data visualization from the traditional format where researchers deliver information to users, into a new evolved model that users interactively explore data and customize views from a visualization tool. Common techniques in interactive graphics include selection, deletion, linking, brushing, rotation, scaling, etc. (Cook, et al., 2007) For instance, modifying the bin width of a histogram enables users to shift focus between the overall shape of a numerical variable and local details such as zero values or outliers. Similarly, highlighting a small subset of data points and observing their locations across other variables facilitates deeper understanding of the relationship between variables. An interactive data visualization platform can provide guided graphical options tailored to specific projects and datasets. Users can select datasets, observations, variables, parameters, etc., based on their topics of interest, to generate the optimal static and dynamic graphics that support decision-making. Examples of successful interactive data visualization software include commercial tools like Tableau and PowerBI, as well as open-source software such as R Shiny, Python Dash, and Plotly (Sievert, 2020).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2.2 Data-driven decision-making in digital government

The core values of open government data guide data-driven decision-making in digital government in collaboration with and among organizations and individuals in society. These values are transparency, accountability, and collaboration (Chen, 2017, Ch. 4 on open government, see below). Transparency is about making relevant public policy and service data available to the public. Democratic accountability directs the opening of government data on policies and services to the public. Open government data also creates resources and collaborative opportunities for society, inclusive of organizations and individuals (Janssen, et al., 2015).

Making government data open and available is the first and necessary step to foster transparency, accountability, and collaboration. In the United States, the Data Accountability and Transparency Act of 2014 provides the legal foundation and mandate for the federal government to make data available online. Government can open information and data in three areas to foster transparency: decision-making information such as government procedure, public policy and service data such as budget, and outcome information such as impacts of government expenditure on employment (Grimmelikhuijsen and Welch, 2012).

Government data transparency enhances accountability. Transparency of government policy and service data helps reduce corruption and make the government more accountable (Bertot, et al., 2010). At the local level, the availability of government service information such as the open government data portal for the city of Chicago provides citizenry with information on the variety of government services provided to various districts and neighborhoods. Residents and representatives in these neighborhoods can hold governments accountable for their actions.

Opening government data enables collaboration between government and organizations and individuals in society to create gains in efficiency and effectiveness (Matheus, et al, 2020 and Janssen, et al. 2015). In the United States, the publication of census data and GIS data by the federal government enables citizens and businesses to leverage the government data for economic and efficiency gains. Another mechanism is to have competitions such as hackathons for societal members to create applications leveraging open government data to provide new or improve current public services. The City of New York in the U.S. and the City of Shanghai, China have had annual competition events for such collaboration (Chen, 2017).

Moreover, data science and data visualization for data-driven decision-making enhance the quality and impact of open government data (Matheus, et al. 2020 and Ansari, et al, 2022). The recent advancement in artificial intelligence provides the machine-learning opportunities to analyze a large amount of data to advance public policy-making and public services (Charles, et al., 2022 and Valle-Cruz, et al. 2022). Interactive data visualization enabled by data analytic tools provides organizational and individual users to find answers to public policy and service questions. In addition, such a tool is also used for collaboration between government and citizens in prioritizing government resources such as seen in the area of participatory budgeting at the local level.

Data science and interactive data visualization can advance the values of transparency, accountability, and collaboration that are central to open government data. The use of 311 systems for some major U.S. cities provides residents the ability to track their government service requests and be informed of the local government services for accountability and transparency. The use of data dashboards can enhance collaboration and services such as the 'Waze' app using data from both government and citizens for the City of Rio de Janeiro (Matheus, et al., 2020). The National Science Foundation in the U.S. also has a data dashboard for institutional-based search and analytics to provide useful information.

There are significant opportunities to enhance the usability and use of data visualization to improve the use and usefulness of open government data (Ansari, et al., 2022). These opportunities lie in utilization of qualitative techniques for needs assessment and the involvement of user groups to provide evaluation and input (Ansari, et al., 2022). Acting on these recommendations, our study takes a co-design approach for the development, implementation, and evaluation of the interactive data visualization dashboard.

3. Enabling Visual Exploration on the Cyberinfrastructure Data

3.1 History of the government-funded cyberinfrastructure programs

TeraGrid, XSEDE, and ACCESS are a sequence of CI programs that were funded by NSF. Before TeraGrid, NSF had awarded several programs for large-scale computational infrastructure, including the National Computational Science Alliance and National Partnership for Advanced Computational Infrastructure (NPACI). TeraGrid, operated between 2001-2011, was the earliest distributed terascale facility that coordinated distributed high-performance hardware infrastructures with integrated scalable software and high-speed internet (Reed & Berman, 2001). XSEDE, running between 2011-2022, offered a more powerful virtual organization to provide the dynamic distributed infrastructure and services to scientific researchers (Towns, et al., 2011). ACCESS began in September

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2022 and aimed to provide an agile, integrated, robust, trustworthy and sustainable CI ecosystem for computational- and data-intensive research (Boerner, et al., 2023; Parashar, et al., 2022).

3.2 Data platforms for ACCESS and historical programs

To monitor the services provided by the CI ecosystem, the NSF Office of Advanced Cyberinfrastructure funded the development of the XSEDE Metrics on Demand (XDMoD) auditing tools to measure the CI usage and performance metrics on XSEDE allocated resources for the current and historical project data (Furlani, et al., 2013; Palmer, et al., 2015). The XDMoD portal provides graphical user interfaces of data metrics like service units charged, number of jobs, etc. broken down by principal investigator, field of science, institution, resource, and so on (https://xdmod.access-ci.org/)(Palmer, et al., 2015) . For public users, this dashboard provides two tabs: the "Summary" page contains seven plots to display the aggregated usage, measured by computing or cloud resource, CPU hours, job size, etc. The "Usage" page contains more than 120 subpages of plots and data tables, showing the detailed data about jobs, allocations, requests, etc. with the total summary and breakdown numbers at multiple levels. On both pages, users can select a certain time interval and filter the data with 21 service providers.

Besides the XDMoD data platform, the ACCESS program developed its own interactive dashboard to display the geographical distribution of the allocation and usage data on their website (https://allocations.access-ci.org/geo#3.4/38.88/-111.01). On this dashboard, users could see the names and locations of research institutions with the amounts of resource credit allocation and usage, the names and locations of resource providers with the total amounts of used resource credits, and the connections between research institutions and resource providers. By hooking a certain institution, a few arch curves appear to link the institution with the resource providers they used. Reversely, when clicking a resource provider, the dashboard will show linkages to all institutions that are utilizing the service from this provider. With this dashboard, users could learn the usage preference of PIs from given institutions and reveal how the resource providers are supporting the research community.

The two visualization dashboards for the NSF CI programs were developed to facilitate data communication between service providers and resource users. However, both have their own limitations. The XDMoD user interfaces aim to provide a comprehensive view of a large database, requiring it to include and describe every variable, as well as the basic information about each. Even with only the first level of breakdown and without deeper branching, this tool has generated hundreds of pages, which results in an overwhelming amount of information for normal users. For researchers seeking to answer decision-making questions, current visualization platforms offer only basic statistics, like the total allocation units used by a specific institution or field of science. However, they lack the capability to show further interactions between variables. For instance, given a certain group of institutions, what are their strong fields of science regarding the used amount? Do they have some PIs with low usage rate who may need additional help? The ACCESS map platform focuses on showcasing the breadth and impact of the ACCESS program. It displays the total allocation and used amounts by institution and resource but does not offer data details for in-depth analysis.

3.3 Understanding needs from service providers and users

The focus of this study is how to help service providers, i.e., policy makers, understand and utilize data to optimize the operation of the CI ecosystem and solve existing problems. Our team's previous research has explored problems related to the fair allocation of resources and improving resource utilization efficiency. Chen, et al. (2021) built models to identify factors that influenced usage-allocation ratios and compared the ratios across different fields of sciences. In subsequent research, our team interviewed some leaders of the XSEDE program and learned that one of the issues that service providers are interested in is how to raise awareness, interest, and participation among scientific researchers with HPC needs. Hence the target group of this study has expanded from solely service providers to include both service providers and resource users.

From the perspective of service providers, they want to understand whether the training services they provide, such as the Campus Champion program of TeraGrid and XSEDE, are actually effective. Since NSF training projects are usually awarded based on institutions, and different institutions may also offer various computing services independent of NSF, resource utilization based on institutions is more likely to be influenced by decision-making compared to utilization based on a field of science. Therefore, the data visualization platform created by this work will provide service providers with data breakdown and summaries by institution. This will not only help computing centers participating in the NSF CI programs, but also those institutional computing centers to identify users' needs, discover trends, solve problems, and improve service quality.

For resource users, the journey from being unaware of CI projects to generating resource usage involves multiple barriers. First, researchers with HPC needs usually take the initiative to explore existing computing services. They may discover various resources. If NSF's CI program like XSEDE or ACCESS is not the only available option, then researchers can choose the service with the highest input-output ratio for their demands. Therefore, NSF's CI

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

program needs to enhance their promotion of advantages, such as high performance, low cost, and convenient services, to attract users. Next, when researchers become interested in NSF's CI program, they often want to learn about successful cases. If these successful examples are relevant to their own research projects, these potential users can be more motivated. Once they proceed to the application and usage process, when any procedural or technical problems or obstacles arise, whether there exists assistance support from easily accessible helpers to clarify and solve difficulties will significantly impact their user experience.

Moreover, resource users could be divided into the earlier established advantage groups and the emerging, late starter groups. The advantage groups include research teams led by the top experts in their fields, well-funded, research-intensive large institutions, and researchers who joined early in the TeraGrid program or have been using CI resources for years. The starter groups include rising stars in their fields, researchers from small to medium-sized universities with limited support for research activities, first-time CI project applicants, under-represented minority groups, and so on. The advantage groups are often familiar with the application and usage processes, so they do not need much help. However, the starter groups will need extra assistance, otherwise they are more likely to quit the competition when faced with difficulties.

Summarizing the needs of resource users, we believe that they need successful application examples or potential collaborators, as well as helpers to guide them on how to use CI services and hence accelerate their learning process. Traditional decision-making models may select only a few successful cases to inspire all users, but in the data era, the selection of successful examples can be data driven. This approach can filter and match the most suitable success cases for help seekers, based on the same field of science, institution, region, or similar research topics. This study will establish a data visualization platform to provide scientific researchers who need support with recommended potential collaborators and helpers.

3.4 Needs-based visualization design system for decision-making

In this study, we implemented a needs-based design framework to develop an interactive visualization dashboard for decision-making (Fig. 1). This system begins with identifying the specific needs of decision makers. They will then collaborate with domain experts to clearly articulate their needs and the underlying reasons. Domain experts would validate these requirements with decision makers and then find relevant data or collect data by themselves. Once the data is obtained, it is transferred to data experts for filtering, processing, exploration, and visualization. This stage often involves close communication between data experts and domain experts to understand and solve problems in the data. After reviewing a series of static graphics, data experts, guided by domain experts' insights, will gradually refine their ideas to determine which visuals would be most suitable for interactive features, to ensure the final visualization product effectively supports decision makers in exploring the data independently. Finally, data experts complete and deliver the interactive visualization dashboard to decision makers. Decision makers then provide feedback to both data experts and domain experts, to facilitate the debugging, updating, and improvement of the visualization tool.

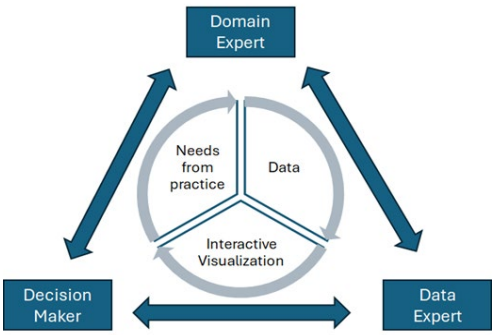


Fig. 1 – Needs-based visualization design system.

4. Data, Application, and Examples

The TeraGrid and XSEDE data are publicly available at the Illinois Data Bank at the University of Illinois at Urbana-Champaign. There are two databases for the allocation award and usage data: the XSEDE (2020) database includes data from the start of TeraGrid in July 2003 to December 2019, while the Towns & Hart (2023) database offers the same data features covering the period from July 2011 to the end of XSEDE in September 2022. Each database consists of two data files: one for awarded CI projects, which includes variables such as grant number, principal investigator (PI) name, institution, field of science, project type, transaction type, project title, abstract, and project start and end dates; and another for detailed resource-level usage information, including variables such as grant number, resource name, transaction type, allocation, used amount, and usage start and end dates.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4.1 Data cleaning and preparation

The two databases were merged as shown in Fig 2. Since the period between July 2011 and December 2019 has overlapped, this segment was excluded from the earlier database. Subsequently, the data from 2003–2011 in XSEDE (2020) was combined with the 2011–2022 data from Towns & Hart (2023). The complete dataset retains two separate files: one for awarded projects and another for resource usage.

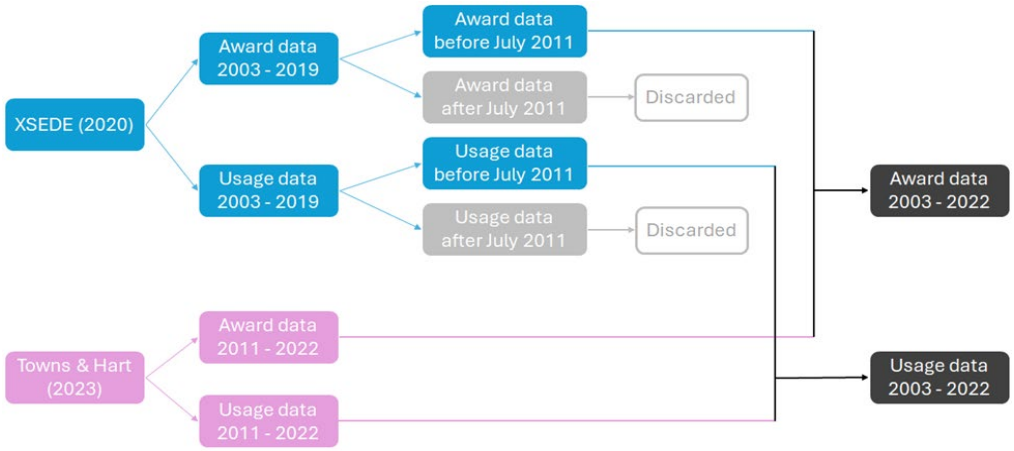


Fig. 2 – Data merging process for two databases, to generate the complete datasets for TeraGrid and XSEDE projects between 2003 and 2022.

The award data comprises 25,798 rows for 16,038 unique grant numbers by 10,277 PIs from 1,044 organizations. The program's peak period occurred between 2016 and 2020, during which nearly 2,000 projects were awarded annually. The usage data includes 85,827 rows covering 16,450 unique grant numbers and 123 unique resource names. Over the 19-year period, the total allocation exceeds 19.5 billion Service Units (SUs), while the total usage surpasses 15.6 billion SUs.

The next step was to merge the award data and the usage data to link the awarded projects with their allocation and usage information (Fig 3). Among the 16,038 unique grant numbers in the award dataset and the 16,450 in the usage dataset, 15,529 grant numbers appeared in both and were retained in the final merged data. The biggest challenge in merging the two data files was compressing information from multiple rows into one row per grant number. While some information about PI and project were duplicated in multiple rows, other variables could have different values for the same grant number. These included fields of science, project types, transaction types, start and end dates, resource names, allocation amounts, used amounts, etc. To resolve this, simple business rules were applied to aggregate the values, such as selecting only one field of science, project type, and transaction type for each project, using the earliest date as the start date, and summing the allocation amount and used amounts from multiple resources. In addition, novel variables were created for each awarded project, such as the number of fields of science, the number of resources utilized, etc.

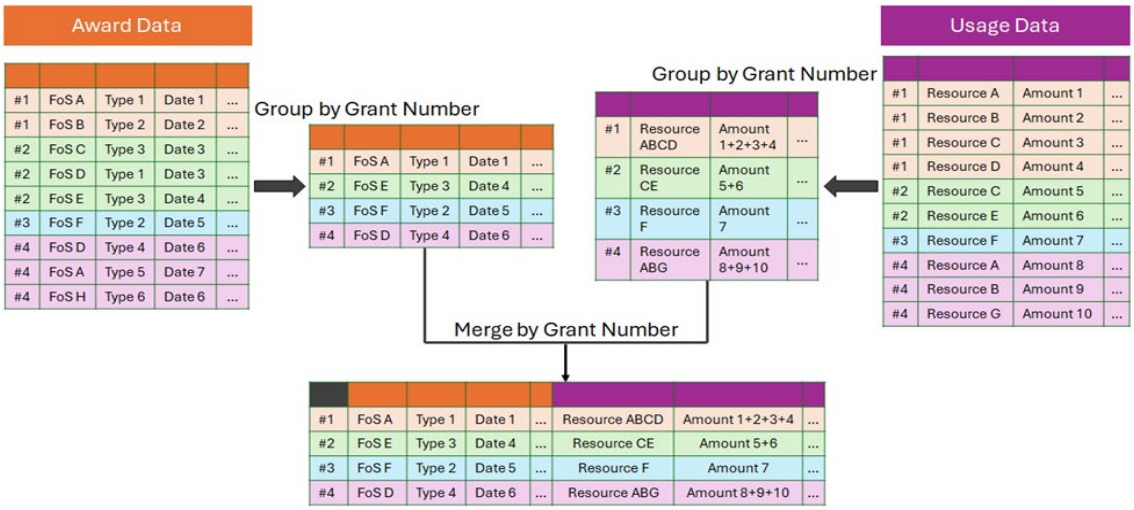


Fig. 3 – Data merging between award and usage datasets. Each row represents one grant project in the merged dataset.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The final step in data cleaning and preparation was to add more useful variables from external data sources, including the longitude and latitude of each searchable organization, generated by the OpenStreetMap API (OpenStreetMap Contributors, 2017), and the Carnegie classification of U.S. institutions published by the Indiana University Center for Postsecondary Research (2021).

4.2 Design and functionality of the interactive dashboard

The interactive visualization dashboard created by this study (https://unodatasci.shinyapps.io/eqci/) was designed with several R packages (R Core Team, 2024) including ggplot2 (Wickham, 2016), shiny (Chang, et al., 2024), flexdashboard (Aden-Buie, et al., 2023), and leaflet (Cheng, et al., 2024). There are two pages for the two groups of decision-makers: an institutional view for the service providers and institutional computing centers, and a researcher's view for the potential service users.

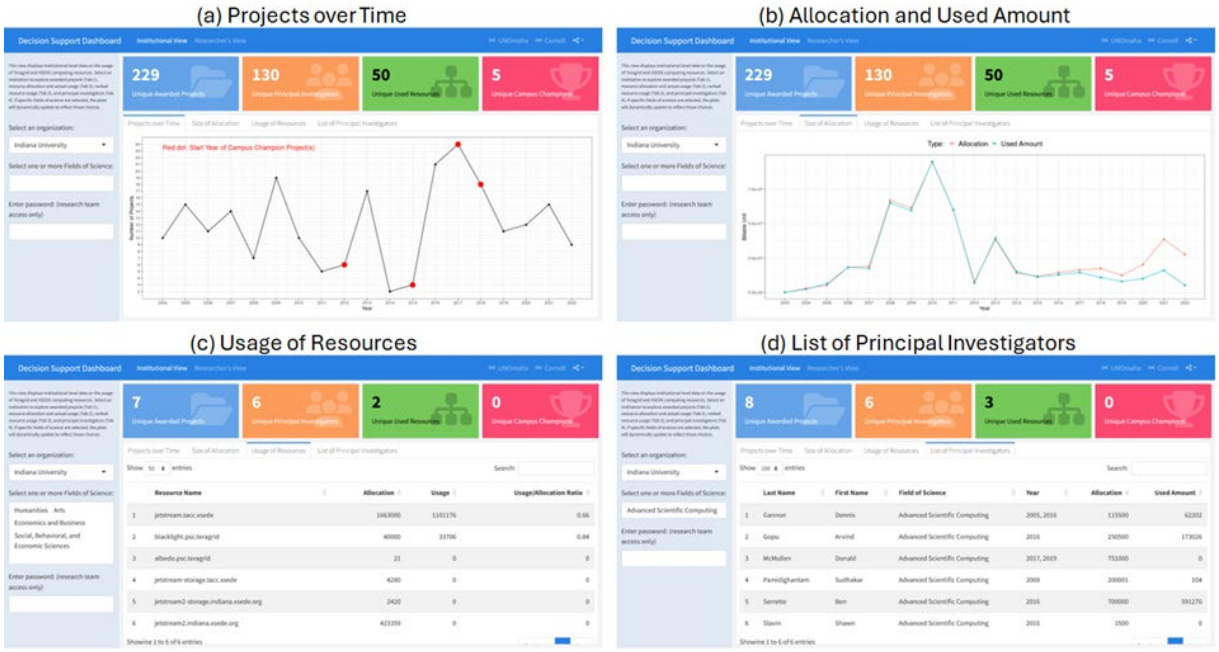


Fig. 4 – Institutional View of the dashboard with Indiana University as an example. Four tabs of visualization can be chosen: (a) Time series plot of the number of awarded projects by year. (b) Time series plot of allocation and used amount comparison. (c) Table of allocation amounts, used amounts, and ratios by resource name for the selected fields of science. (d) Table of the PI's names, fields of science, project start years, allocation, and used amounts.

The design and functionality of the institutional view are shown in Fig 4. The page design includes a title bar, a navigation panel, four data boxes, and a graphical area. The title bar includes the title of the dashboard and the tab buttons of the two views. The left navigation panel contains a page introduction, two data filter boxes, and a password input area. With data filter boxes, users can select the institution and fields of science. This enables users to apply the intersection between the two and to compare results using the generated plots. The password input area is used to protect certain sensitive data, such as the usage rate for each PI. Only the specific research team can enter the password to view sensitive data for further analysis. Above the chart area on the right are four data boxes, representing four key data pieces: numbers of awarded projects, PIs, resource providers, and campus champions. Below the data boxes, users can click to select one chart page. Fig 4(a) shows the number of awarded projects from 2003 to 2022 for the selected institution and field(s) of science. Red dots represent years when the campus champion projects started. This plot helps service providers identify trends in awarded projects for the selected institution and determine whether campus champion projects contribute to an increase in XSEDE projects. Trends of development can be compared by selecting different institutions in the same field of science or the same institution in different fields. Fig 4(b) displays the temporal trends in total allocation (red) and usage (blue). For example, Indiana University's resource usage closely matched allocations from 2003 to 2017. However, starting from 2018 they began to diverge and by 2022, total usage only reached one-fourth of total allocation. These trends may motivate service providers to investigate the reasons behind such discrepancies. Fig 4(c) provides a breakdown of total allocation, used amount, and usage-to-allocation ratio by resource. The table is sorted in descending order of the used amount, but users can sort by allocation or usage-to-allocation ratio by clicking the respective column headers. For instance, four fields of science in Indiana University, including humanities, economics, social, behavioral, etc. had seven awarded projects but only two of the six allocated resources were used. Why these resources were underutilized could be investigated starting from the table. Fig 4(d) presents allocations and used amounts based on PIs. The usage-to-allocation ratio is hidden in this view. By setting

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

thresholds for allocation or used amount, service providers can identify PIs with high or low usage. If further combined with interviews to those PIs, more valuable insights will be obtained to help improve service effectiveness.

The design of researchers' view aims to assist late starters and potential applicants in finding PIs or mentors with successful CI experience in the same field, nearby locations, or with similar research topics. To support this, we provided four search methods: by research field and location, PI name, keywords in project title, and keywords in project abstract. Layout of this page is shown in Fig. 5: the left column contains a page description, search options, and search content settings. The middle column displays the search result of PIs, sorted by project start year from the most recent to the oldest. The upper right column features a map marking the locations of PIs. Clicking on a highlighted dot on the map will pop up the name of the institution, which can then be further used to filter PI search results by institution name. The lower right column provides detailed information about the awarded projects. By clicking on any PI row in the middle column, title and abstract of the corresponding project can be displayed for review.

Fig 5(a) illustrates how to find potential collaborators by the combination of field of science and user's location. The drop-down list for the field of science includes 215 fields from the XSEDE award data, allowing users to choose one area of interest. The search radius drop-down menu has three options: 20 miles, 100 miles, and “everywhere”, indicating the same city (20 miles), within a commutable distance (100 miles), or across the entire United States if no local collaborators are available (“everywhere”). Users can enter their location as a city name, institution name, or specific address in the location input box. After clicking the "Confirm" button, the dashboard will search for the location using OpenStreetMap and then mark it with a blue label on the map as the center of the search radius. Yellow dots on the map represent the locations of all PIs in the middle column list, while red dots indicate the locations of selected PIs. Fig 5(b) enables users to search for collaborators by entering a PI's last name, and the results list is sorted by project start year and displayed as yellow dots on the map. To narrow the search result, users can enter an institution name in the search bar of the table. Figs 5(c) and 5(d) allow users to search by keywords in project titles and abstracts. Users can enter one or more keywords, separated by commas, into the keyword input box. Projects that match exactly with all the keywords will be returned, and those that do not match exactly will be sorted by the number of matched keywords, with the top 20 displayed. This keyword search rule ensures users can identify PIs associated with relevant projects from recent years without being overwhelmed by an excessive number of results.

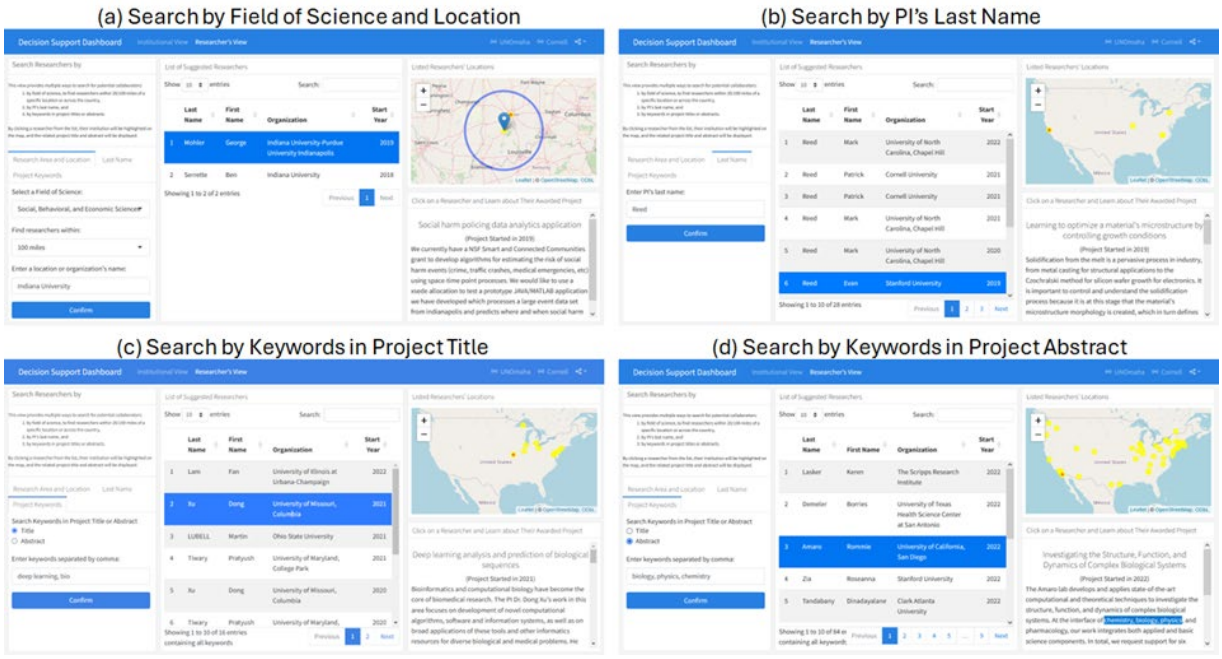


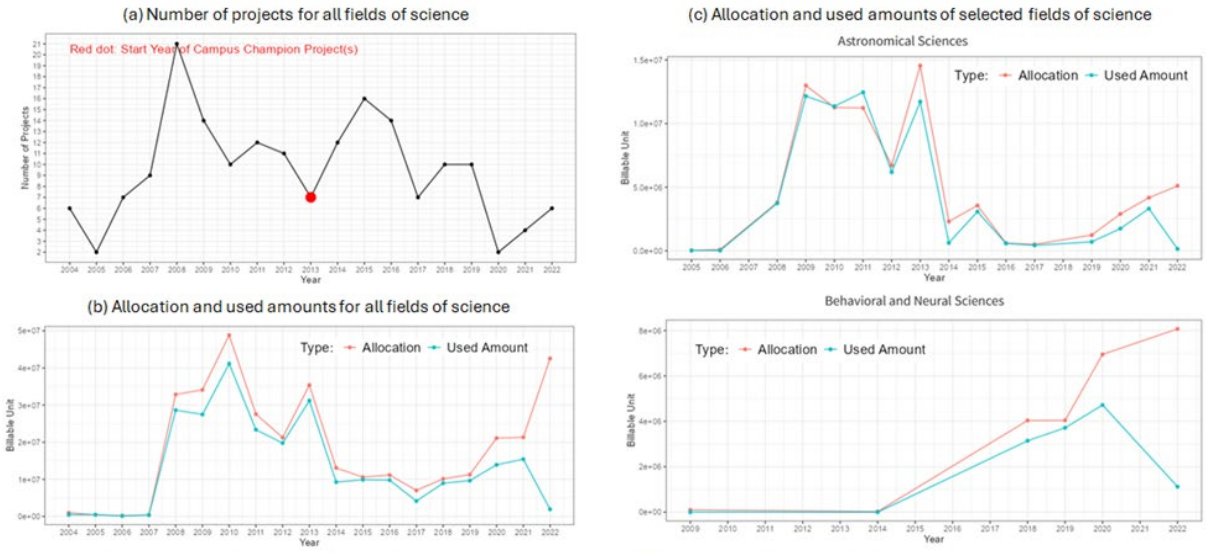
Fig. 5 – Researcher’s View of the dashboard. (a) Indiana University is the default searching location. Search radius was set to 100 miles, which generated a blue circle on the map. Clicking the first row of results will display the project title and abstract in the bottom-right panel. (b) By entering the last name “Reed”, a list of 28 PIs is obtained with their institutions, locations, and project information. (c) and (d) can match the keywords of interest, separated by commas, with the awarded project titles or abstracts, then corresponding PI names will be shown in the list.

4.3 Example demonstration on the dashboard

Three examples will be demonstrated to explain how the visualization dashboard can assist in decision-making.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Example #1 focuses on a research-intensive institution which also hosts a supercomputing center for the NSF CI program. Researchers at this institution naturally receive early and easy access to training on advanced computing services. We will examine whether any issues need to be addressed here. Example #2 highlights a late-starter institution, specifically an under-represented minority-serving institution. Following the 2021 Carnegie Classification definition on minority-serving institution as "Hispanic Serving Institution, Historically Black College or University, or Tribal College or University only," we matched institution names between the Carnegie Classification and CI data, and identified 96 institutions. One of these, with a moderate level of resource usage, will be explored. Example #3 considers a Midwest junior researcher in Social, Behavioral, and Economic Sciences. If this researcher seeks a potential collaborator or mentor in the field, we will demonstrate how the dashboard can be used to facilitate this search.



(d) Computing resources ordered by used amount

	Resource Name	Allocation	Usage	Usage/Allocation Ratio
1	ranger.tacc.teragrid	132786339	116234599	0.88
2	stampede.tacc.xsede	52091302	48247878	0.93
3	jetstream.tacc.xsede	21795054	16528202	0.76
4	kraken.nics.teragrid	16274125	16412450	1.01
5	comet.sdsc.xsede	17497071	14737523	0.84
6	expanse.sdsc.xsede.org	27675098	10822504	0.39
7	lonestar4.tacc.teragrid	14250501	10679908	0.75
8	bridges2-rm.psc.xsede.org	8461353	6198967	0.73
9	stampede2.tacc.xsede	6826629	5499208	0.81
10	staff.teragrid	7929999	3709158	0.47
11	anvil.purdue.xsede.org	24119410	1689822	0.07
12	trestles.sdsc.teragrid	1146915	1022280	0.89
13	lonestar.tacc.teragrid	1526000	947159	0.62
14	lemieux.psc.teragrid	896323	596368	0.67
15	abe-queenbee-steele.teragrid	1249029	497091	0.4
16	bridges.psc.xsede	472603	455650	0.96
17	teragrid_roaming	415020	381142	0.92

(e) Principal investigators ordered by used amount

Last Name	First Name	Field of Science	Year	Allocation	Used Amount
Shapiro	Paul	Astronomical Sciences	2006, 2008, 2019, 2020	161948374	151953698
Shapiro	Paul	Astronomy and Planetary Sciences	2021	161948374	151953698
Shapiro	Paul	Extragalactic Astronomy and Cosmology	2009, 2010, 2011, 2012, 2013, 2015, 2017	161948374	151953698
Aluru	Narayana	Advanced Scientific Computing	2019, 2020	101275830	74333977
Aluru	Narayana	Cross-Disciplinary Activities	2013	101275830	74333977
Aluru	Narayana	Interfacial, Transport, and Separations Processes	2016	101275830	74333977
Aluru	Narayana	Materials Research	2015, 2018	101275830	74333977
Aluru	Narayana	Nanotechnology	2021	101275830	74333977
Laguna	Pablo	Astronomy and Planetary Sciences	2022	91376038	66291779
Laguna	Pablo	Gravitational Physics	2012, 2013, 2014, 2016, 2017, 2018, 2019, 2020	91376038	66291779
Laguna	Pablo	Physics	2015	91376038	66291779
Chelikowsky	James	Materials Engineering	2021	63208954	60536849
Chelikowsky	James	Materials Research	2008, 2009, 2010, 2011, 2012, 2013, 2015, 2016, 2017, 2019, 2020	63208954	60536849
Chelikowsky	James	Physics	2008	63208954	60536849
Pestilli	Franco	Behavioral Sciences Biology	2022	46625568	25667256
Pestilli	Franco	Behavioral and Neural Sciences	2018, 2019, 2020	46625568	25667256
Pestilli	Franco	Neuroscience Biology	2016, 2017	46625568	25667256

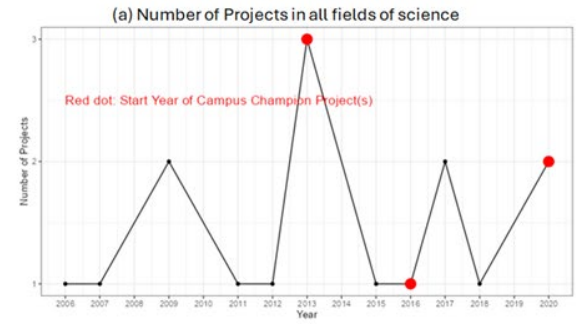
Fig. 6 – Data exploration for University of Texas at Austin. (a) Time series plot for the number of awarded projects in all fields of science. (b) Time series plot for the allocation and used amounts from all fields of science. (c) Comparison between two fields of science: Astronomical Sciences and Behavioral and Neural Sciences. (d) Top 17 computing resources ordered by their used amounts. (e) PIs with the highest used amounts.

Research-intensive institution. University of Texas at Austin (UTA) is the host of Texas Advanced Computing Center (TACC), which provides big convenience for computing resource users in the university and local area. By selecting the university name in the dashboard, users can obtain the plots shown in Fig 6 (a), (b), (d), and (e) from the Institutional View. Since 2004, UTA has received a total of 180 unique projects, including one campus champion project, involving 119 PIs. These projects have used 44 different resources. According to Fig 6 (a), the number of projects fluctuated over the years, peaking in 2008 before declining, and has remained at a relatively low level since 2020. Fig 6 (b) shows the changes in allocation and usage amounts over time. From 2008 to 2013, both allocation and usage were at their highest levels, followed by a decline between 2014 and 2019. After 2020, allocation increased again, reaching another peak in 2022. However, the used amount did not increase accordingly

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

but instead declined, which is a concerning trend. Fig 6 (c) compares UTA's two strong research fields: Astronomical Sciences and Behavioral and Neural Sciences. These fields reveal very different allocation and usage patterns. Astronomical Sciences used a large amount of resources from 2009 to 2013. In 2010 and 2011, the used amount was even higher than the allocation. But their usage dropped significantly after 2014. In contrast, Behavioral and Neural Sciences were relatively underdeveloped before 2018, with low project numbers and resource usage. However, after 2018, this field grew rapidly, with resource allocation steadily increasing. Fig 6 (d) compares the usage of different resources. The top three most popular resources all belong to TACC, and the leading resources generally receive high usage/allocation ratios. Fig 6 (e) lists the PIs with the largest allocation and usage amounts, along with their research fields. In some strong fields like Astronomical Sciences, UTA often has multiple PIs with awarded CI projects, and the usage/allocation ratios are relatively high. However, in fields with fewer PIs, such as Biological Sciences and Engineering Systems, the resource usage rate tends to be lower. This pattern suggests that internal collaboration within the research field may influence resource usage significantly.

Minority-serving institution. Florida International University (FIU) is a Hispanic-Serving Institution. Compared to other minority-serving institutions, FIU has a moderate level of experience with CI projects. Since 2006, the university has undertaken a total of 16 unique projects led by 10 PIs. As revealed in Fig 7 (a) and (b), FIU had no more than three new projects per year, and resource usage remained low for most years, except for a significant spike in 2018. This increase was driven by a Nuclear Physics PI who received an award that year (Fig 7 (d)). Most of FIU's allocations and resource usage came from the San Diego Supercomputer Center (SDSC), as shown in Fig. 7 (c). FIU's other strong research fields include computer science, earth science, and networking and communications, as indicated by the list of PIs with the highest resource usage. The usage-to-allocation ratios were below 0.5 for nearly all projects, except for three physics-related projects. Note that FIU received three campus champion projects in 2013, 2016, and 2020, all granted to the same PI. The first two projects were in the field of training, while the third was in physics. However, the allocated resources for these projects were ultimately not utilized, raising questions about the effectiveness of the campus champion projects for this institution.



(c) Computing resources ordered by used amount

	Resource Name	Allocation	Usage	Usage/Allocation Ratio
1	comet.sdsc.xsede	4835728	4768581	0.99
2	stampede.tacc.xsede	167000	67413	0.4
3	abe-queenbee.teragrid	59840	61185	1.02
4	bridges.psc.xsede	50000	51997	1.04
5	supermic.cct-lsu.xsede	50000	48649	0.97
6	expanse.sdsc.xsede.org	121000	25607	0.21
7	gordon.sdsc.teragrid	28001	18454	0.66
8	kraken.nics.teragrid	39672	15571	0.39

(d) Principal investigators ordered by used amount

Last Name	First Name	Field of Science	Year	Allocation	Used Amount
Narayanan	Rajamani	Elementary Particle Physics	2017	4655563	4680743
Narayanan	Rajamani	Nuclear Physics	2018	4655563	4680743
Saeed	Fahad	Algorithm Development	2020	822437	402756
Saeed	Fahad	Computer Science	2021, 2022	822437	402756
Saeed	Fahad	Computer and Computation Research	2015, 2016, 2017, 2019	822437	402756
Liu	Xiaowen	Computer and Computation Research	2012, 2013	583396	94896
Liu	Xiaowen	Networking and Communications Research	2007	583396	94896

Fig. 7 – Data exploration for Florida International University. (a) Time series plot for the number of awarded projects in all fields of science. (b) Time series plot for the allocation and used amounts from all fields of science. (c) Top 8 computing resources ordered by their used amounts. (d) PIs with the highest used amounts.

Junior researchers or potential resource users. A junior researcher in the Midwest may face challenges finding a local collaborator in Social, Behavioral, and Economic Sciences who uses computing services frequently. In states like Nebraska or Iowa, there may be no such collaborators within 100 miles. To address this, the researcher should first select "everywhere" in the Researcher's View (Fig 8(a)) to check the locations of researchers. This reveals some potential collaborators near Chicago, making it a suitable search location (Fig 8(b)). The map highlights three universities: the University of Chicago, Northwestern University, and the University of Wisconsin–Milwaukee. The dashboard would also list corresponding PI names from these institutions. At Northwestern, one researcher specializes in large network modeling and has been awarded four CI projects between 2015 and 2019. The University of Chicago has a researcher in socioeconomic modeling, while Wisconsin-Milwaukee has one studying CEOs outside directorships. If none of these projects meet the junior researcher's interests, she can expand the search to nearby regions, using "Indiana" or "UIUC" as the search location. If choices in the Midwest are still too

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

limited, then keyword-based searches can help. Searching "government" yields two results in project titles (Fig 8(c) left) and 176 in abstracts, with locations shown on the map (Fig 8(c) middle). Clicking on a location, such as the University of California, Los Angeles, allows further exploration of potential collaborators at this institution and details of their research projects.

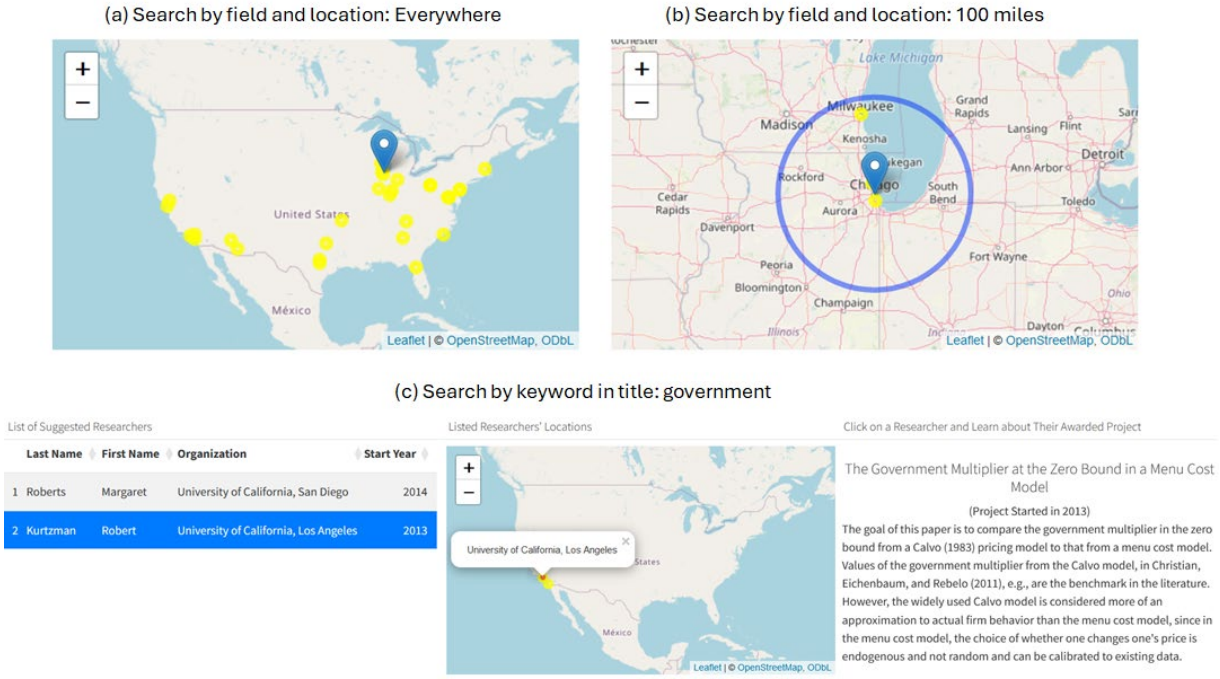


Fig. 8 – Searching for collaborators using multiple approaches. (a) and (b) used Chicago as the location and Social, Behavioral, and Economic Sciences as the field, with different search radius settings. (c) used "government" as a keyword to search project titles, yielding two results.

Through these three examples, we hope the interactive visualization dashboard users can learn how to effectively utilize the graphs and tables to search for useful information, identify potential issues, make comparisons, and support their decision-making process.

5. Conclusions and Future Work

This research reviewed the historical development of data visualization and its applications in the digital government domain, proposed a collaboration model among decision makers, domain experts, and data experts, and applied the model to the field of advanced research computing. Since 2003, the U. S. government has funded cyberinfrastructure programs such as TeraGrid, XSEDE, and ACCESS to promote scientific discovery. These programs have generated a large amount of data on the awarded projects with their resource allocation and usage. However, existing visualization tools for these data were not designed for in-depth analysis or direct decision-making support. This study investigated the needs of resource providers and users, analyzed the data collected from TeraGrid and XSEDE projects (2003-2022), and developed a publicly available interactive visualization dashboard. This dashboard enables resource providers and users to independently explore data through graphs and tables and make informed comparisons and decisions. In addition, this study demonstrates the practical application of the dashboard through three examples: a research-intensive institution, an under-represented minority-serving institution, and a junior researcher from a specific field of science. These examples highlight how data visualization could support and enhance decision-making. A broader impact of this study is the introduction of a collaboration model that does not only apply to the cyberinfrastructure and advanced computing area, but also to other digital government fields that generate and utilize data.

There are some shortcomings in research design and data processing procedures. First, when designing this visualization tool, our perspective mainly focused on the specific needs of CI service providers and potential users: to identify user groups with successful experiences, analyze their models, connect them with the groups who could benefit from these proven models, and improve the service of resource providers within the entire network. However, we may have overlooked the other needs of these two groups, or needs of other groups, such as the long-term, high-ability users of CI services. Second, the data aggregation step combined multiple rows of data into a single row based on the grant number, to merge award data and usage data (Fig. 3). This process resulted in some information loss. For example, a campus champion project may be renewed several times over years after the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

initial award. However, since the grant number remains the same, the data merging process kept only the most recent renewal and removed all the previous records. As a result, it is impossible to visualize whether this campus champion project has been supporting other projects of this institution in early years or not. If the resource usage pattern of a project changed before and after renewal, the data merging approach would also obscure the information. Third, due to the limitations of the shiny package itself, the user graphical interface of our platform may appear differently on different web browsers or operating systems. The display on mobile devices, such as smartphones, may not be convenient for users to operate.

In the future, the interactive visualization dashboard will be improved in two aspects. From the data perspective, this platform currently only includes data from TeraGrid and XSEDE between 2003 to 2022 and does not involve data from the ACCESS program. We will use the XDMoD API to extract more detailed job-level data generated by ACCESS users when submitting job requests and receiving output from computing resources. This will help identify potential barriers and problems that resource users may encounter during their usage. From the user experience perspective, we plan to interview researchers from different types of institutions to better understand their actual needs. We will have them test the visualization dashboard and improve the design and functionality based on their feedback. Additionally, we will promote the dashboard through workshops and other outreach efforts to expand its user group and serve more people for decision making with cyberinfrastructure data.

Acknowledgement

- **Funding or Grant:** We acknowledge the support of the U.S. NSF Grant Award 2346631.
- **Data/Software Access Statement**: Datasets used for this research can be downloaded at https://databank.illinois.edu/datasets/IDB-0757799 and https://databank.illinois.edu/datasets/IDB-3731847. The visualization dashboard developed by the authors are available at https://unodatasci.shinyapps.io/eqci/.
- **Contributor Statement***:
  - Xiaoyue Cheng: Conceptualisation, Formal analysis, Methodology, Software, Validation, Visualisation, Writing-Original Draft
  - Yu-Che Chen: Conceptualisation, Methodology, Project administration, Supervision, Writing – Review & Editing
  - Rich Knepper: Conceptualisation, Methodology, Supervision, Writing - Review & Editing
  - Andrew Burk: Writing – Review & Editing
- **Use of AI***: During the preparation of this work, the author(s) used ChatGPT in order to improve grammar and refine the language. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Aden-Buie, G., Sievert, C., Iannone, R., Allaire, J., & Borges, B. (2023). *flexdashboard: R Markdown Format for Flexible Dashboards (Version 0.6.2)* [R]. https://doi.org/10.32614/CRAN.package.flexdashboard

Ansari, B., Barati, M., & Martin, E. G. (2022). Enhancing the usability and usefulness of open government data: A comprehensive review of the state of open government data visualization research. *Government Information Quarterly*, 39(1), 101657. https://doi.org/10.1016/j.giq.2021.101657

Becker, R. A., Cleveland, W. S., & Wilks, A. R. (1987). Dynamic graphics for data analysis. *Statistical science*, 2(4), 355-383.

Bertot, J. C., Jaeger, P. T., & Grimes, J. M. (2010). Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. *Government Information Quarterly*, 27(3), 264–271. https://doi.org/10.1016/j.giq.2010.03.001

Boerner, T. J., Deems, S., Furlani, T. R., Knuth, S. L., & Towns, J. (2023). Access: Advancing innovation: NSF's advanced cyberinfrastructure coordination ecosystem: Services & support. In *Practice and Experience in Advanced Research Computing* (pp. 173-176).

Brazil, M., Brunson, D., Culich, A., DeStefano, L., Jennewein, D., Jolley, T., Middelkoop, T., Neeman, H., Rivera, L., Smith, J., & Wernert, J. (2019). Campus champions: Building and sustaining a thriving community of practice around research computing and data. In *Proceedings of the Practice and Experience in Advanced Research Computing on Rise of the Machines (learning)* (pp. 1-7).

Chang, W., Cheng, J., Allaire, J. J., Sievert, C., Schloerke, B., Xie, Y., Allen, J., McPherson, J., Dipert, A., & Borges, B. (2024). *shiny: Web Application Framework for R (Version 1.10.0)* [R]. https://doi.org/10.32614/CRAN.package.shiny

Charles, V., Rana, N. P., & Carter, L. (2022). Artificial Intelligence for data-driven decision-making and governance in public affairs. *Government Information Quarterly*, 39(4), 101742. https://doi.org/10.1016/j.giq.2022.101742

Chen, Y.-C. (2017). *Managing digital governance: Issues, challenges, and solutions*. Routledge, Taylor & Francis Group.

Chen, Y.-C., & Knepper, R. (2021). US cyberinfrastructure for scientific innovation: adaptation, management, and performance. In *Research Handbook on E-Government* (pp. 222-241). Edward Elgar Publishing.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Chen, Y.-C., Cheng, X., & Knepper, R. (2021, June). Performance of US Scientific Research Cyberinfrastructure: Structural and Relational Factors for Usage. In *DG. O2021: The 22nd Annual International Conference on Digital Government Research* (pp. 424-436).
Cheng, J., Schloerke, B., Karambelkar, B., & Xie, Y. (2024). *leaflet: Create Interactive Web Maps with the JavaScript "Leaflet" Library (Version 2.2.2)* [R]. https://doi.org/10.32614/CRAN.package.leaflet
Cleveland, W. S., & McGill, R. (1984). Graphical perception: Theory, experimentation, and application to the development of graphical methods. *Journal of the American statistical association*, 79(387), 531-554.
Cleveland, W. S. (1985). *The elements of graphing data*. Wadsworth Advanced Books and Software.
Cleveland, W. S. (1993). A model for studying display methods of statistical graphics. *Journal of Computational and Graphical Statistics*, 2(4), 323-343.
Cohen, I. B. (1984). Florence nightingale. *Scientific American*, 250(3), 128-137.
Cook, D., Buja, A., Cabrera, J., & Hurley, C. (1995). Grand tour and projection pursuit. *Journal of Computational and Graphical Statistics*, 4(3), 155-172.
Cook, D., & Swayne, D. F. (with Buja, A., Lang, D. T., Hofmann, H., Wickham, H., & Lawrence, M.). (2007). *Interactive and Dynamic Graphics for Data Analysis: With R and GGobi* (2007 edition). Springer.
Edwards, P. N., Jackson, S. J., Bowker, G., & Knobel, C. (2007). Understanding Infrastructure: Dynamics, Tensions, and Design. National Science Foundation. https://deepblue.lib.umich.edu/handle/2027.42/49353
Furlani, T. R., Schneider, B. L., Jones, M. D., Towns, J., Hart, D. L., Gallo, S. M., DeLeon, R. L., Lu, C.-D., Ghadersohi, A., Gentner, R. J., Patra, A. K., von Laszewski, G., Wang, F., Palmer, J. T., & Simakov, N. (2013). Using XDMoD to facilitate XSEDE operations, planning and analysis. *Proceedings of the Conference on Extreme Science and Engineering Discovery Environment: Gateway to Discovery*, 1–8. https://doi.org/10.1145/2484762.2484763
Grimmelikhuijsen, S. G., & Welch, E. W. (2012). Developing and Testing a Theoretical Framework for Computer-Mediated Transparency of Local Governments. *Public Administration Review*, 72(4), 562–571.
Indiana University Center for Postsecondary Research (2021). The Carnegie Classification of Institutions of Higher Education, 2021 edition, Bloomington, IN. https://carnegieclassifications.acenet.edu/
Janssen, M., Matheus, R., & Zuiderwijk, A. (2015). Big and Open Linked Data (BOLD) to Create Smart Cities and Citizens: Insights from Smart Energy and Mobility Cases. In E. Tambouris, M. Janssen, H. J. Scholl, M. A. Wimmer, K. Tarabanis, M. Gascó, B. Klievink, I. Lindgren, & P. Parycek (Eds.), *14th International Conference on Electronic Government (EGOV)*: Vol. LNCS-9248 (pp. 79–90). https://doi.org/10.1007/978-3-319-22479-4_6
Matheus, R., Janssen, M., & Maheshwari, D. (2020). Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities. *Government Information Quarterly*, 37(3), 101284.
McDonald, J. A. (1982). INTERACTIVE GRAPHICS FOR DATA ANALYSIS (Technical Report No. SLAC-253). Stanford Linear Accelerator Center, Stanford University. https://purl.stanford.edu/tg751vg9206
Morel, P. (2018). Gramm: grammar of graphics plotting in Matlab. *Journal of Open Source Software*, 3(23), 568.
National Science Foundation's Cyberinfrastructure Council. (2007). *Cyberinfrastructure Vision for 21st Century Discovery*. https://www.nsf.gov/pubs/2007/nsf0728/
NSF. (2016). NSF awards $110 million to bring advanced cyberinfrastructure to nation's scientists, engineers. Retrieved from https://www.nsf.gov/news/news_summ.jsp?preview=y&cntn_id=189573
OpenStreetMap Contributors. (2017). Planet dump retrieved from https://planet.osm.org [Dataset]. https://www.openstreetmap.org/
Palmer, J. T., Gallo, S. M., Furlani, T. R., Jones, M. D., DeLeon, R. L., White, J. P., Simakov, N., Patra, A. K., Sperhac, J., Yearke, T., Rathsam, R., Innus, M., Cornelius, C. D., Browne, J. C., Barth, W. L., & Evans, R. T. (2015). Open XDMoD: A Tool for the Comprehensive Management of High-Performance Computing Resources. *Computing in Science & Engineering*, 17(4), 52–62. https://doi.org/10.1109/MCSE.2015.68
Parashar, M., Friedlander, A., Gianchandani, E., & Martonosi, M. (2022). Transforming science through cyberinfrastructure. *Communications of the ACM*, 65(8), 30-32.
R Core Team. (2024). R: A Language and Environment for Statistical Computing [Computer software]. R Foundation for Statistical Computing. https://www.R-project.org
Reed, D. A., & Berman, F. (2001). The TeraGrid: Cyberinfrastructure for 21st Century Science and Engineering. National Science Foundation. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=58fba1297dfcd11783f37674770dff10c80435a7
Ryan, G. W., Bloom, E. W., Lowsky, D. J., Linthicum, M. T., Juday, T., Rosenblatt, L., Kulkarni, S., Goldman, D., & Sayles, J. N. (2014). Data-driven decision-making tools to improve public resource allocation for care and prevention of HIV/AIDS. *Health Affairs*, 33(3), 410-417.
Sievert, C. (2020). *Interactive web-based data visualization with R, plotly, and shiny (1st edition)*. Chapman and Hall/CRC.
Snow, J. (1856). On the mode of communication of cholera. *Edinburgh medical journal*, 1(7), 668.
Stewart, C. A., Costa, C. M., Wernert, J. A., Hancock, D. Y., McMullen, D. F., Blood, P., Sinkovits, R., Mehringer, S., Knepper, R., Fischer, J., Bland, M., Rogers, G., Couvares, P., Campbell, T., Jankowski, H., Snapp-Childs, W., & Towns, J. (2022). Metrics of financial effectiveness: Return On Investment in XSEDE, a national cyberinfrastructure coordination and support organization. *Practice and Experience in Advanced Research Computing 2022: Revolutionary: Computing, Connections, You*, 1–9. https://doi.org/10.1145/3491418.3530287
Theus, M., & Urbanek, S. (2008). *Interactive graphics for data analysis: principles and examples*. CRC Press.
Towns, J., Roskies, R., Boisseau, J., Kovatch, P., & Andrews, P. (2011). XSEDE: eXtreme Science and Engineering Discovery Environment. *National Science Foundation*.
Towns, J., Cockerill, T., Dahan, M., Foster, I., Gaither, K., Grimshaw, A., Hazlewood, V., Lathrop, S., Lifka, D., Peterson, G. D., Roskies, R., Scott, J. R., & Wilkins-Diehr, N. (2014). XSEDE: Accelerating Scientific Discovery. *Computing in Science & Engineering*, 16(5), 62–74. https://doi.org/10.1109/MCSE.2014.80
Towns, J., & Hart, D. (2023). XSEDE: Allocations Awards and Usage for the NSF Cyberfrastructure Portfolio, 2004-2022. https://doi.org/10.13012/B2IDB-3731847_V1

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Unwin, A. (2020). Why is data visualization important? What is important in data visualization? *Harvard Data Science Review*, 2(1), 1.
Valle-Cruz, D., Criado, J. I., Sandoval-Almazán, R., & Ruvalcaba-Gomez, E. A. (2020). Assessing the public policy-cycle framework in the age of artificial intelligence: From agenda-setting to policy evaluation. *Government Information Quarterly*, 37(4), 101509. https://doi.org/10.1016/j.giq.2020.101509
van Ooijen, C., Ubaldi, B., & Welby, B. (2019). *A data-driven public sector: Enabling the strategic use of data for productive, inclusive and trustworthy governance* (No. No. 33; OECD Working Papers on Public Governance). OECD Publishing. https://doi.org/10.1787/09ab162c-en
Wickham, H. (2010). A layered grammar of graphics. *Journal of computational and graphical statistics*, 19(1), 3-28.
Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis (2nd ed.)*. Springer.
Wilkinson, L., Wills, D., Rope, D., Norton, A., & Dubbs, R. (2005). *The Grammar of Graphics (2nd edition)*. Springer.
Xie, Y. (2013). animation: An R package for creating animations and demonstrating statistical methods. *Journal of Statistical Software*, 53, 1-27.
XSEDE. (2016). XSEDE PY5 Annual Report: July 1, 2011 through June 30, 2016. Washington D.C.: XSEDE Office.
XSEDE-Extreme Science and Engineering Discovery Environment. (2020). XSEDE: Allocations Awards for the NSF Cyberinfrastructure Portfolio, 2004-2019 [Dataset]. University of Illinois at Urbana-Champaign. https://doi.org/10.13012/B2IDB-0757799_V1
Yim, A., Chung, C., & Yu, A. (2018). *Matplotlib for Python Developers: Effective techniques for data visualization with Python*. Packt Publishing Ltd.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Leveraging String Similarity Algorithms for Educational Data Validation: A Scalable Approach for Digital Governance

Débora Barbosa Leite Silva[a], Emanuel Marques Queiroga[c,a*], Abílio Nogueira Barros[b], Markson Rebelo Marcolino[d,a], Diego Dermeval[a], André Lima[a], Leonardo Brandão Marques[a], Cristian Cechinel[d,a] and Thales Vieira[a]

[a]Center of Excellence for Social Technologies (NEES), Universidade Federal de Alagoas, Maceió 57072, Brazil, {debora.silva, diego.matos, andre.lima, leonardo.marques, thales.vieira}@nees.ufal.br

[b]Departamento de Computação, Universidade Federal Rural de Pernambuco (UFRPE), Recife 52171, Brazil, abilionbarros@gmail.com

[c]Instituto Federal de Educação, Ciência e Tecnologia Sul-Rio-Grandense (IFSul), Pelotas 96.015-360, Brazil, emanuel.marques@nees.ufal.br

[d]Centro de Ciências, Tecnologias e Saúde, Universidade Federal de Santa Catarina, Araranguá 88040, Brazil, cristian.cechinel@ufsc.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Data validation is critical for ensuring the reliability of information in educational systems, particularly in the context of digital governance. In Brazil, fragmented student records across various governmental databases hinder the implementation of educational public policies that rely on massive, high-quality student data. One effective method for validating these records is cross-referencing data across different databases. However, textual data, such as student names, are often prone to errors, including misspellings. Applying overly strict validation rules may result in the exclusion of valid records, while too lenient rules may allow incorrect data to slip through undetected. This study addresses these challenges by proposing a new data validation methodology that uses the Levenshtein distance algorithm. The approach identifies an optimal similarity threshold by taking into account the capacity of the manual validation team since excluded students are manually verified as a subsequent step, allowing for a balanced solution. We applied this methodology to validate student data from the Sistema Gestão Presente (SGP), which manages around 7 million student records and integrated it with the Brazilian Federal Revenue database. Through two key experiments, we demonstrated how an optimal validation threshold could be determined by considering the manual validation team capacity. In this case study, we found an optimal 80% similarity threshold when the manual validation capacity is approximately 950,000.

Keywords. Data Governance, String Similarity, Educational Data Interoperability, Levenshtein distance, public policies.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.942

1. Introduction

Data interoperability emerges as a fundamental concept in the current landscape, characterized by constant technological evolution and the increasing use of data across various sectors (McBride et al., 2022; Wimmer et al., 2018). Data interoperability is primarily defined as the ability of different systems and organizations to exchange, understand, and use data and information securely, efficiently, and in a structured manner. Sectors such as healthcare, education, government systems, and businesses increasingly rely on effective data integration and analysis processes to ensure data-driven decision-making.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In public policy management and implementation, data interoperability between different systems is key, enabling cross-referencing information from various sources (Campmas et al., 2022; Wimmer et al., 2018). However, this process faces technical challenges, such as the lack of data standardization, inconsistent communication protocols, and issues related to data trustworthiness (Almeida et al., 2020; Styrin et al., 2022). In education, these challenges are exacerbated by data fragmentation, often arising from different federative entities, which undermines the quality and reliability of the records used (Ali et al., 2019; Harron et al., 2017; Loureiro et al., 2021).

In this context, data validation is indispensable in ensuring that information is consistent and reliable. Validation is particularly critical in educational settings, where errors and inconsistencies can directly impact the effectiveness of public policies (Cohen, 2000). In Brazil, challenges related to the fragmentation of educational information hinder large-scale data analysis and the formulation and implementation of policies to address educational inequalities (Barbalho et al., 2022; Queiroga, Siqueira, et al., 2024; Tavares & Bitencourt, 2024). This fragmentation is inherent to the country's educational structure, where responsibilities are distributed across federal, state, and municipal levels, each managing their own educational networks and information systems (Costin & Pontual, 2020).

The decentralized nature of Brazil's educational system, while promoting local autonomy, creates significant challenges in data integration and validation processes (Arretche, 2004). School systems often operate with different technological infrastructures, data collection methodologies, and reporting schedules, making it particularly challenging to establish standardized validation protocols and achieve consistent data quality across all educational networks (Segatto et al., 2022). These challenges are further amplified by the substantial regional disparities in technological infrastructure and institutional capacity among different educational administrative units (Queiroz et al., 2020; Rocha et al., 2024; Wanke et al., 2024).

The Sistema Gestão Presente (SGP) was developed to centralize high school student information into a single, integrated system to address the challenges of integrating students' attendance data on a centralized system. This system aims to facilitate data cross-referencing and support the implementation of public policies focused on education, such as the Pé-de-Meia Program (PDM)[1]. Established by the Brazilian government in 2024 (Ministério da Educação, 2025b), the PDM is part of the pay-for-attendance programs and is a Conditional Cash Transfer Program, similar to the Mexican Progresa, a pioneering initiative that links financial incentives to school attendance and health checkups (Fiszbein & Schady, 2009; Kremer, 2003; Parker & Todd, 2017). The PDM provides financial incentives to public high school students to promote school retention, encourage the completion of their studies, and stimulate participation in the National High School Exam (Enem)(Ministério da Educação, 2025a), which was created in 1998 by the Anísio Teixeira National Institute for Educational Studies and Research (INEP).

The PDM operates based on enrollment, attendance, annual approval, and exam participation criteria. However, its effectiveness is heavily dependent on the quality of the data used. The SGP, which manages approximately 7 million unique student records, faces substantial challenges in data validation. Issues such as incorrect names, missing essential information, and registration inconsistencies undermine the database's reliability and hinder payment authorization, directly impacting students who depend on these incentives. These challenges emphasize the complexities of aligning large, heterogeneous databases and the critical need for robust technological solutions and rigorous methodologies to ensure accuracy and minimize student disruptions.

The present paper introduces a case study focused on improving the accuracy of student records in Brazil through data validation processes that leverage text similarity algorithms. The rest of this paper is structured as follows. Section 2 presents the related literature about interoperability in governmental systems and the use of similarity algorithms to improve data quality. Section 3 of the paper details the student data validation process implemented by the SGP, focusing on ensuring data reliability and accuracy under ideal conditions. Section 4 illustrates the proposed approach for the problem of students' data validation. Section 5 describes the experiments conducted to suggest the threshold similarity for validating the records. At last, Section 6 discusses the work results, and Section 7 concludes the paper.

[1] Pé-de-meia is a Brazilian expression that refers to money saved for future use

2. Literature review

Data validation and interoperability are fundamental pillars for efficient information management in government systems. Developing data interoperability platforms that facilitate data exchange, validation, and utilization is a critical priority in the digital transformation of governments (McBride et al., 2022). These efforts represent a significant step toward unifying the databases of complex systems, particularly those in key sectors such as education, health, and governance (Das et al., 2022; Malodia et al., 2021; Saffady, 2021; Styrin et al., 2022).

The challenges in these sectors, such as high data fragmentation and the lack of standardization, pose significant obstacles to the implementation and monitoring of effective public policies (Almeida et al., 2020; Queiroga, Siqueira, et al., 2024; Styrin et al., 2022). Specifically in education, these issues become even more evident due to the high variability of records and the need to integrate local, state, and federal systems (Ali et al., 2019; Almeida et al., 2020; Harron et al., 2017; Loureiro et al., 2021). In Brazil, legislation structures different federative levels of responsibility over public education, fragmenting data on enrollment, attendance, and performance among thousands of municipal, state, and federal education departments. This variability alone presents a significant challenge in the creation of data interoperability platforms, as data often follow different standards or include minor inconsistencies at the source, such as missing surnames or their abbreviations (Almeida et al., 2020; Queiroga, Santana, et al., 2024). Techniques like the Levenshtein distance and the Jaro-Winkler distance effectively address these inconsistencies, ensuring greater reliability in the records (Almeida et al., 2020; Handijono & Suhatman, 2024; Loureiro et al., 2021).

Thus, several authors demonstrate how data interoperability can yield significant results in knowledge discovery and supporting decision-making processes. Queiroga, Siqueira, et al., 2024 proposes a model for extracting key factors from the interoperability of educational data in Brazil. To achieve this, factor analysis techniques are applied to identify eight main factors related to structural equity in the educational system, aiming to provide personalized recommendations supporting digital governance and formulating context-specific public policies. However, the absence of unique identifiers posed a significant challenge, limiting the practical application of the research, particularly in addressing the needs of specific student groups.

In this context, the search for techniques that can help to identify degrees of integrated different databases and enable more automated data validation has been widely explored. One of these methods is string similarity (Kaufman & Klevs, 2022). Entity matching is another recurring challenge in systems aiming to integrate data from different sources. Sakai et al., 2021 investigated the combination of string transformations and similarity metrics to consolidate duplicate records. Similarly, Handijono and Suhatman, 2024 applied the Jaro-Winkler technique to identify strings with a high degree of similarity for detecting duplicate data in records. This approach seeks to optimize databases by reducing inconsistencies and redundancies. By clustering similar records based on names and registration data into single entities, the authors achieved satisfactory results in minimizing data duplication and improving data consistency.

Research on the use of semantic embedding models has also advanced progress. Asadollahi et al., 2024 demonstrated how models adapted to specific contexts can accurately capture textual and semantic nuances. In their study, the authors used construction data to train models aimed at improving the identification of semantic texts, with a focus on data interoperability between different systems and the development of a standardized data pipeline. The results indicate that techniques based on adapted string decomposition outperformed traditional methodologies and even advanced language models while maintaining a significantly lower application cost.

Data modeling, in turn, requires flexible approaches to address the diversity of contexts. Kouremenou et al., 2024 found that among 100 healthcare institutions participating in their study, 23 experienced data management or interoperability issues over the past five years. To address this, the authors proposed a generic and accessible framework designed to facilitate data exchange and mapping. This type of tool proved particularly useful for integrating data from systems where the lack of unified standards often creates redundancies and inconsistencies, enabling interoperability through data modeling prior to transfer.

Similarity metrics, such as TF-IDF and cosine similarity, also play an important role in data validation (Cohen, 2000; Downs et al., 2019). Gómez and Vázquez, 2022 conducted an empirical analysis of different similarity search methods within academic articles and theses. Their results showed that advanced techniques have a

significant computational cost, without this cost translating into substantially better outcomes. Conversely, simpler techniques, such as those based on distance measurement, achieved comparable results to advanced methods with a significantly lower computational cost. This is particularly noteworthy as the scalability of solutions becomes critical with the increasing volume of data. Machine learning-based methods offer promising alternatives but still face limitations related to record variability and computational expense. Tools that combine computational efficiency with analytical precision are increasingly necessary to meet the growing demands of governmental systems, especially in the education sector.

Practical approaches have shown significant results. Damasceno et al., 2021 presented SimClear, a tool that leverages similarity functions, such as Levenshtein distance, to standardize educational records during the data cleaning phase. This tool has been successfully applied to correct textual errors, increasing data reliability and reducing the need for manual review.

It is also worth noting that while recent advances in Machine Learning techniques and semantic embedding have significantly expanded the possibilities for data validation and interoperability, traditional methods, such as text similarity algorithms (e.g., Levenshtein and Jaro-Winkler), continue to deliver satisfactory results with a favorable cost-benefit ratio. This is particularly true in scenarios where computational efficiency, scalability, and simplicity of implementation are critical (Gómez & Vázquez, 2022).

3. Student Data Validation

Data validation in educational systems is critical to ensuring the reliability and efficacy of the information used to formulate public policies (Almeida et al., 2020; Cohen, 2000; Tavares & Bitencourt, 2024). The Brazilian educational system is highly decentralized, leading to fragmented data and posing challenges for managing and implementing centralized programs or policies. The data validation flow at SGP is an essential component to assure information integrity, and it was carefully designed to avoid inconsistencies, assure record accuracy, and ease the identification of errors. The general flow of data collection and validation at SGP is presented in Figure 1.

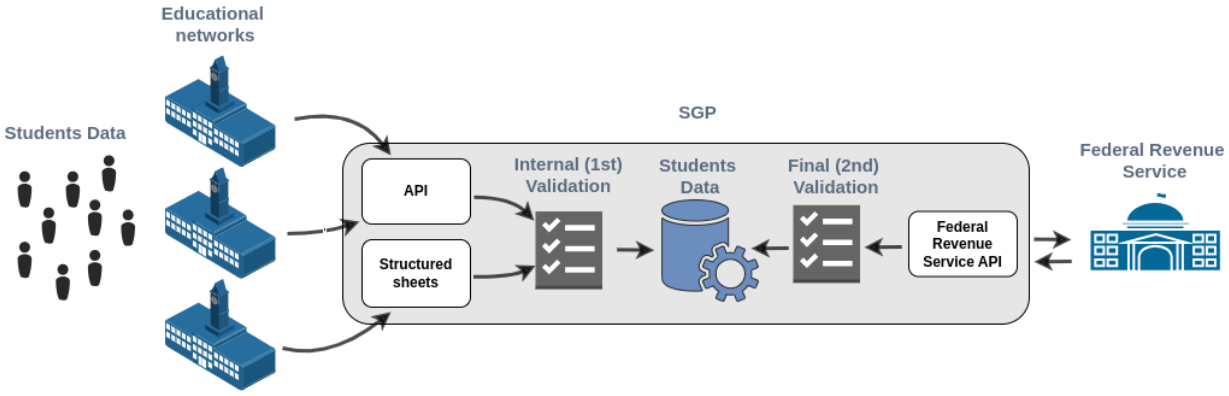


Fig. 1 – Data Validation Flow.

As seen in the figure, Educational networks (formed by the state, federal, and municipal entities) are responsible for initially submitting student data to the SGP through two methods: an integrated API for automated communication between their systems and SGP and direct submission of spreadsheet files on the platform. SGP administration encourages using the API to enhance security, improve efficiency, and reduce errors. However, as educational networks may not yet possess the required infrastructure for API integration, the submission of structured file sheets provides a viable alternative.

After receiving the data from educational networks, the system processes a first validation step that involves some basic verifications, such as ensuring the correct format of the fields, fulfilling all mandatory information, and identifying duplicates. Once verified, the data is preprocessed and stored in the system's database for the next validation stage. The tax identification numbers of students are then sent to the Federal Revenue Service of Brazil to verify consistency with government records.

The primary key for this validation with the Federal Revenue Service is the Brazilian Tax Identification Number (CPF, from the Portuguese Cadastro de Pessoa Física). The SGP sends the student's CPF to the Federal Revenue Service and receives the following information associated with him/her: day of birth, full name, and mother's name. These data are then compared to the information stored in the SGP database; if identical, the register is considered valid. This represents the ideal scenario where no additional intervention is needed. However, the decentralized nature of Brazil's educational system, combined with differences in data structure and update timeframes among educational departments, introduces substantial challenges. Initial checks already indicate an 11.97% inconsistency in student records, further emphasizing the need for robust validation methodologies. Thus, for those cases where only the date of birth coincides, but the full name and the mother's name present differences, we propose to apply similarity algorithms to assess the correspondence between the data.

4. Proposed Approach

Figure 2 provides a general overview of the proposed students' data validation approach. The process begins with data preprocessing, where names are normalized, abbreviations are standardized, and uniformity is ensured. This is followed by the data understanding phase, identifying patterns, inconsistencies, and duplicated or incomplete records. The output of these steps is fed into the similarity threshold evaluation, which is designed to learn the optimal threshold that ensures high validation accuracy, minimizes false positives, while still being tolerant to subtle differences in names that usually do not invalidate the identification of the students. The suggestion of a similarity threshold is possible after the conduction of two key experiments: (E1) Analyzes the impact of different similarity thresholds on the validation of records, considering both the student's name and the mother's name, to determine the optimal threshold (80% in our case study) for balancing accuracy and operational efficiency; and (E2) demonstrating the optimal threshold's ability to capture expected variations and to reduce matching errors.

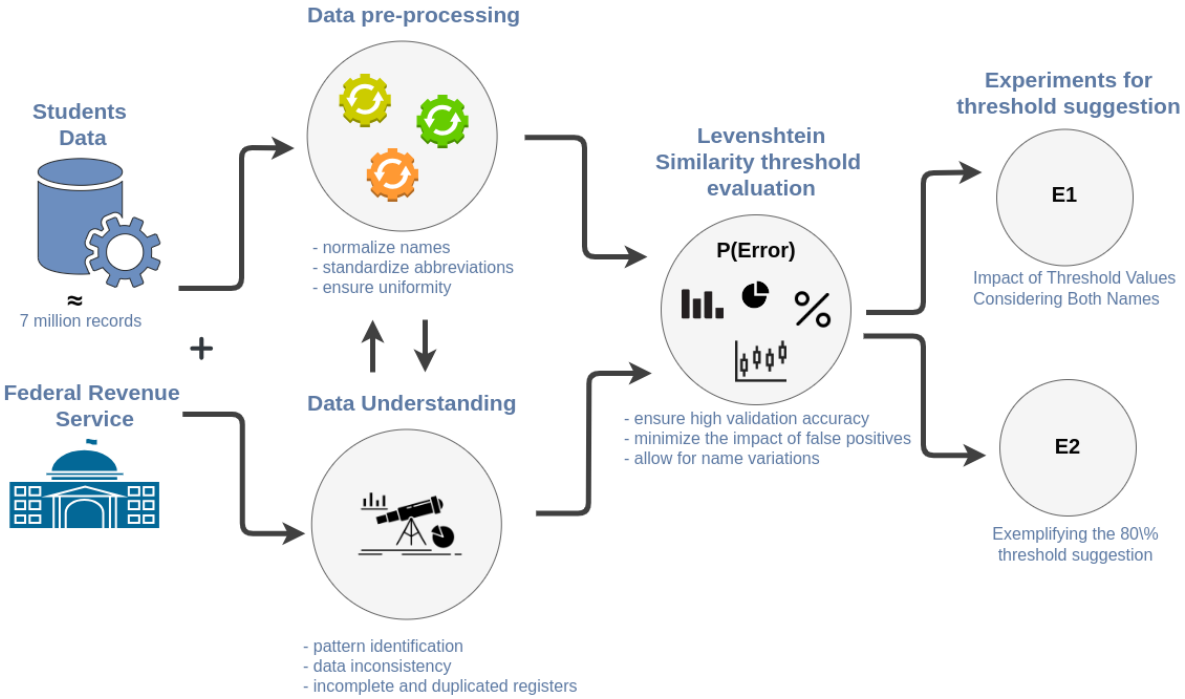


Fig. 2 – Approach followed for student's data validation.

Given two pairs of strings representing a student's name and their mother's name, extracted from two different databases (SGP and the Federal Revenue database), their similarity is measured separately using the Levenshtein distance algorithm. This helps quantify differences due to typos, formatting inconsistencies, or minor spelling variations, allowing for more accurate data reconciliation. If the data are completely identical, no alert is issued, and the student's registration is successfully validated. If the similarity rate equals or exceeds the minimum similarity threshold for both pairs, the record is classified as valid with an inconsistency alert, which is saved to enable future monitoring and auditing. If, on the other hand, the similarity rate of one

of the pairs is below the minimum similarity threshold, the record is classified as invalid, and an alert is issued on the SGP platform, notifying the education network to review and correct the submitted data (see Figure 3). This alert promotes continuous database improvement, preventing inconsistent information from hindering the program's progress.

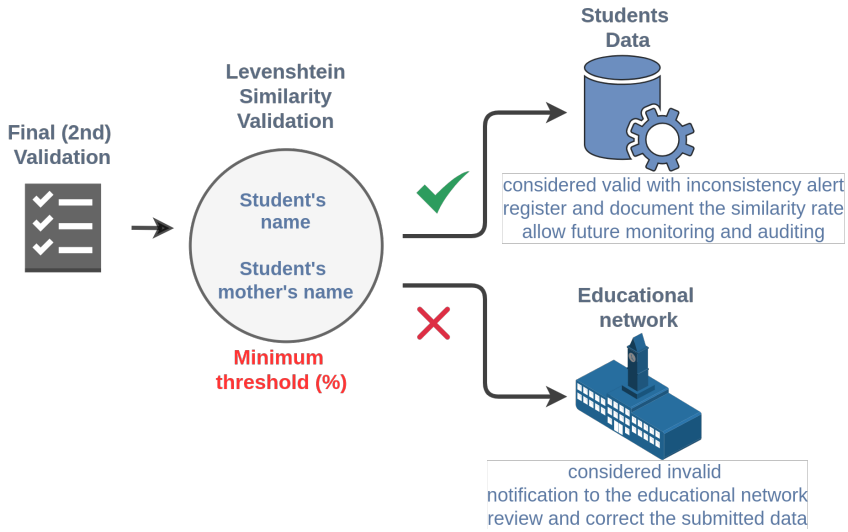


Fig. 3 – Using Levenshtein distance algorithm.

4.1. Data preprocessing and understanding

Data preprocessing was performed to ensure a standardized format for the data, minimizing the impact of irrelevant variations and increasing the precision of the similarity algorithm, as follows:

- Removal of accents and special characters to normalize the spelling of names.
- Standardization of abbreviations and removal of stopwords, such as "de," "da," and "do," which are common in Brazilian names and can interfere with similarity calculations.
- Elimination of extra spaces and conversion to lowercase, ensuring greater uniformity in the data.

Exploratory data analysis was conducted to understand structural features and underlying patterns existing in the data. The database, with approximately seven million registers of students from the high school level, presented a high variability in the names of the students and their mothers. The initial analysis focused on the frequencies of the most common students' names registered in the database. Around 5,73% of the students' full names correspond to records with a high probability of repetition; the top five most common names had 1,150; 685; 603; 582; and 405 occurrences, respectively. This high frequency of repetition in names highlights the possibility of ambiguities, making it difficult to distinguish unique records without using complementary variables, such as the date of birth and the mother's name.

In this sense, the probability of coincidences rate was estimated that approximately 7% of the students in the SGP database have a name that exactly matches another student's name. A similar percentage was found for mother's names. Consequently, the probability of a validation error when simultaneously considering a student's name and mother's name is estimated to be 0.49%.

A second challenge involves identifying students across different databases when their names exhibit slight spelling differences due to typographical errors, abbreviations, or orthographic variations. The analysis identified inconsistencies such as differences in accentuation (e.g., "María Eduarda" versus "Maria Eduarda"), standard abbreviations (e.g., "José Antônio" versus "José A."), and typos (e.g., "João Vítor" versus "Jão Vitor"). These variations complicate the process of reconciling records between databases and require robust similarity measures to ensure accurate data integration.

A correlation analysis was conducted among the variables available in the database to minimize false positives (acceptance of incorrect records) and false negatives (rejection of valid records) in validation. The date of birth

stood out as a robust variable less prone to errors, making it an excellent candidate for use as a reference point in validation. The combination of names and dates of birth proved effective in distinguishing duplicate records or identifying inconsistencies, particularly in cases of prevalent names. The analysis revealed the following most common problems related to data quality:

- **Empty fields**: Approximately 2.8% of the records lacked complete information about the mother's name.
- **Formatting errors**: Presence of special characters and multiple spaces in some records.
- **Duplicate data**: Around 0.9% of the records showed evident duplications, such as two entries with the same CPF and similar names.

The exploratory analysis provided a comprehensive view of the database's challenges and characteristics. The results highlight the importance of using additional variables, such as the date of birth, to enhance name validation. Observations on name repetition and spelling variations were crucial for fine-tuning the similarity algorithm and adjusting the matching threshold to improve accuracy. The analysis also underscored the need for data cleaning and standardization techniques to improve database quality and facilitate interoperability with other governmental systems.

4.2. Levenshtein Distance Algorithm

The Levenshtein distance algorithm, also known as edit distance, is a widely used technique for measuring the similarity between two strings. It calculates the minimum number of operations needed to transform one string into another, which includes insertion (adding a character at any position), deletion (removing a character from any position), and substitution (changing one character to another at a specific position) (Gómez & Vázquez, 2022; Ouarda et al., 2023).

For example, to transform the string *"cat"* into the string *"rat"*, only one substitution is required (changing "c" to "r"). In this case, the Levenshtein distance is equal to 1. To transform *"par"* into *"parallel"*, five insertion operations are needed, resulting in a distance of 5.

The calculation of the Levenshtein distance is based on a dynamic programming model, where a two-dimensional matrix is constructed to represent the cumulative cost of transforming prefixes of one string into another. The steps include:

1. Inicialization of matrix D of size $(m+1) \times (n+1)$, where m and n are the lenghts of the strings A and B, respectively.
2. Filling the boundary conditions:

$$D[i][0] = i \quad \text{and} \quad D[0][j] = j$$

   representing the cost of transforming a string into an empty one.
3. Iteratively filling the matrix using the formula:

$$D[i][j] = \min \begin{cases} D[i-1][j] + 1 & \text{(deletion)} \\ D[i][j-1] + 1 & \text{(insertion)} \\ D[i-1][j-1] + c & \text{(substitution, where } c = 0 \text{ if } A[i] = B[j], \text{ or 1 otherwise)} \end{cases}$$

4. The final value $D[m][n]$ indicates the Levenshtein distance between A and B.

The interpretation of the distance can be normalized into a percentage similarity metric, called *Edit Similarity* (EDS):

$$\text{EDS} = \left(1 - \frac{\text{Levenshtein Distance}}{\text{Maximum possible length between the two strings}}\right) \times 100$$

5. Defining the optimal similarity threshold

This work proposes a series of experiments to establish the optimal similarity threshold necessary for validating student records. These tests were aimed to tackle the following tradeoff:

- a higher threshold diminishes the probability of erroneous instances being validated, but requires a larger amount of manual checks - possibly for valid students.
- a lower threshold would increase the probability of erroneous instances being validated, but requires a smaller amount of manual checks.

Thus, we propose to consider as input the capacity of the manual validation team, since excluded students are manually verified in a subsequent step. The optimal similarity threshold is defined as the larger value that results in an amount of manual checks that can be handled by the manual validation team.

This approach allows the identification of an effective balance, ensuring that the system accurately identifies and corrects mistakes in student records without overloading the process with unnecessary manual checks. In this section, we describe two experiments performed on the SGP and Federal Revenue databases to test the effect of different thresholds and better understand how variability in the threshold influences the detection of potentially invalid records. Each experiment addresses a specific aspect of the issue, as follows:

- **Experiment 1 (E1):** Analyzes the impact of different similarity thresholds on the validation of records, simultaneously considering both the student's name and the mother's name, to determine the optimal threshold (80% in our case study) for balancing accuracy and operational efficiency;
- **Experiment 2 (E2):** Examines simulated examples from the database to demonstrate if the optimal threshold found in our case study for both attribute captures expected name variations, minimizing false positives and false negatives.

5.1. Experiment 1: Impact of Threshold Values Considering Both Names Simultaneously

This experiment was designed to investigate how different threshold values influence the validation process, assessing their impact on the rejection or acceptance of records. The initial goal was to calibrate a threshold that balances the number of invalidated records and the probability of erroneous instances being validated, while accounting for the variability of both the student's name and the mother's name, two critical identification variables in the Brazilian context.

For each record of the SGP database, we use its CPF as the primary key to retrieve its potential match record from the Federal Revenue database. Then, we perform a hard validation by verifying whether its day of birth, full name and mother's name are identical, in which case the SGP record is considered valid. Otherwise, it is considered for experiment 1, composing a subset named $\mathcal{M} = \{m_{,1}, m_2, \ldots, m_n\}$ that is comprised of pairs of records $m_i = (s_i, r_i)$, where s_i is a record from SGP and r_i is a record from the Federal Revenue database.

We aim to assess how many records in M are rejected based on a soft-validation process with varying threshold values. A pair m_i is considered soft-validated if it meets the following conditions:

1. the day of birth of s_i and r_i matches;
2. the EDS score for the student names in s_i and r_i exceeds the threshold;
3. he EDS score for the student's mother's names in s_i and r_i exceeds the threshold.

The methodology involved testing thresholds ranging from 60% to 100% in units increments.

Figure 4 shows the number of records rejected per threshold. As expected, lower thresholds (e.g. 60%-70%) resulted in fewer rejections but increased the risk of false positives, where inconsistent records were incorrectly validated. However, higher thresholds (e.g., 90%-100%) significantly increased the number of rejections, potentially leading to false negatives, where valid records were improperly rejected. To address this, we propose calibrating the threshold based on the capacity of the manual validation team, considering that it can handle a maximum of 950,000 manual verifications. This led to the selection of 80% as the optimal threshold for the student's name.

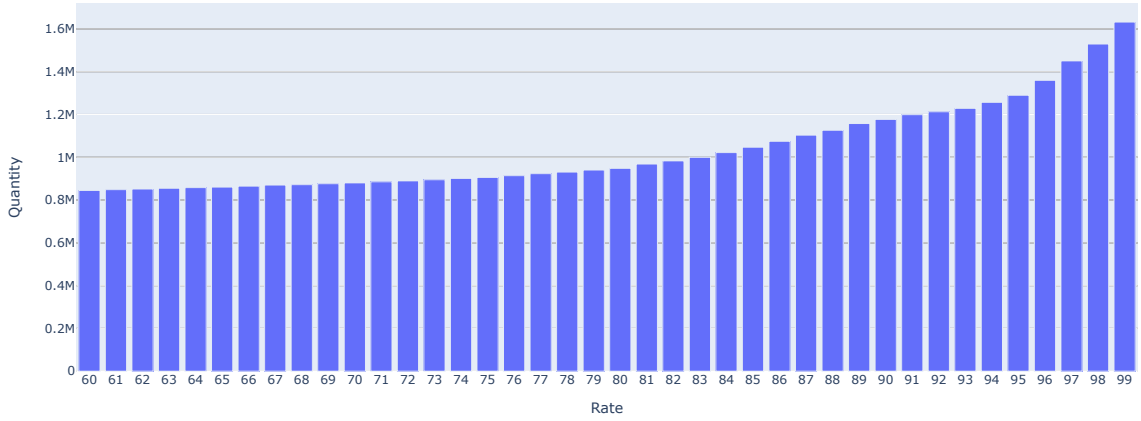


Fig. 4 – Amount of students that are invalidated for different thresholds.

5.2. Experiment 2: Exemplifying the 80% threshold suggestion

Experiment 2 was designed to illustrate, through practical examples, how the 80% threshold plays a crucial role in classifying records as valid or invalid. This experiment complements the quantitative analyses of the previous experiments by providing a qualitative and detailed view of how the model operates in real-world scenarios. The motivation for this experiment stems from the need to validate the suitability of the 80% threshold in real situations, highlighting representative cases where the choice of this value directly impacts the accuracy and scope of the validation process. Data such as the student's and mother's names are particularly sensitive to subtle variations, such as typographical errors, abbreviations, and marital status changes. Thus, understanding how the model handles these variations in real-world contexts is essential for refining its practical applicability.

To conduct this experiment, we present a simulated example and calculate the similarity between string pairs using the Levenshtein distance algorithm. Two cases were analyzed, representing scenarios of positive and negative validation, as described below:

- **Positive Example:** "Maria Eduarda da Silva Rodrigues" and "Maria Eduarda da Silva Rodigues" have a similarity of 96.43%, passing the 80% threshold. This high similarity is due to a single discrepancy: the absence of the letter "r" in the second "Rodrigues" last name. The Levenshtein algorithm identified this minimal difference as a substitution, resulting in a successful validation. This example highlights the robustness of the model in handling minor variations that do not compromise individual identification.
- **Negative Example:** "Maria Eduarda da Silva Rodrigues" and "Maria Eduarda Silva Antunes" have a similarity of 60.71%, falling below the 80% threshold and being rejected. The discrepancies include the absence of "da" and the substitution of the last name "Rodrigues" with "Antunes," totaling an edit distance of 11 characters. These significant differences justify the rejection of the record, demonstrating the model's sensitivity to variations that may compromise data integrity.

These practical examples reinforce that the 80% threshold provides an appropriate balance for capturing acceptable variations while rejecting more significant discrepancies that could compromise record integrity. Additionally, the examples highlight the effectiveness of the Levenshtein distance algorithm in identifying subtle patterns of difference, making it a suitable choice for applications in educational data validation.

6. Discussion

The results obtained in this study reinforce the importance of adequately calibrating the similarity threshold in educational data validation systems. The experiments demonstrated how an optimal threshold can be chosen quantitatively and qualitatively. The threshold value of 80% was capable of keeping the required number

of manual validations below 950,000 while maintaining robustness in the challenging cases presented in Experiment 2. This finding is particularly relevant for large-scale systems such as the SGP, which operates with a database of approximately 7 million records.

Based on the results of Experiment 1, the 80% similarity threshold was determined as the optimal balance between precision and recall. This threshold minimizes false positives by rejecting records with significant discrepancies while tolerating minor variations such as typos, abbreviations, and orthographic inconsistencies.

The effectiveness of using similarity thresholds above 70% in string comparison has also been validated in previous studies (Gali et al., 2019; Libuy et al., 2021; Yu et al., 2016). For instance, the work by Valeriano, 2024 tested different thresholds for string matching and consistently found the best results with values above 70%. This aligns with our findings, where the 80% threshold provided a robust trade-off between validation accuracy and operational efficiency.

Compared to the work of Libuy et al., 2021, our study highlights the scalability of the proposed approach. Reducing the similarity threshold from 99% to 80% resulted in a reduction of over 40% in the number of rejected records without compromising data integrity. On the other hand, in relation to the scope of operations discussed in Cohen, 2000, it was necessary to adopt stricter criteria to ensure that minor name discrepancies did not result in the acceptance of invalid records. This decision reflects the specificities of the educational context, where imprecise data can significantly impact the distribution of government benefits.

The choice of an 80% threshold also had a profound impact on the workload of the teams responsible for data validation. With thresholds lower than 80%, the likelihood of false positives increased, requiring additional manual checks to ensure data consistency. Conversely, thresholds above 80% rejected a greater number of valid records, creating an excessive demand for manual review. By adopting the 80% threshold, the system optimized human resources, allowing teams to focus on more complex cases instead of addressing minor inconsistencies.

Practical examples reinforced the effectiveness of this threshold. For instance, a similarity score of 96.43% successfully validated minor discrepancies (e.g., “Rodrigues” vs. “Rodigues”), while a score of 60.71% appropriately rejected significant mismatches (e.g., “Rodrigues” vs. “Antunes”). These results demonstrate that the 80% threshold ensures reliable validation without overburdening the system with excessive manual checks.

Additionally, the results demonstrate that the Levenshtein distance algorithm is a practical solution for the analyzed context, offering simplicity and computational efficiency. While more advanced techniques, such as machine learning, could provide higher accuracy, their computational cost makes them impractical for a database the size of the SGP. This highlights the importance of solutions tailored to operational constraints and the need for scalability.

Although the presented results demonstrate the proposed approach’s effectiveness, some limitations must be highlighted. The reliance on auxiliary variables, such as the CPF and date of birth, ensures accuracy but creates dependency. The absence or inconsistency of these variables can introduce challenges, particularly in regions with less rigorous data collection practices. Future research could explore complementary variables, such as school history or address data, to enhance the robustness of the model. In addition, the optimal threshold found in this work may not be the optimal one in other scenarios. Thus, we recommend conducting similar experiments to calibrate the threshold according to the manual validation team capacity, and perform qualitative experiments to assure that the optimal threshold is robust.

Another relevant point in the process is the non-use of more advanced techniques based on artificial intelligence or machine learning and the motivations behind this choice. Although such techniques were initially considered, the Levenshtein distance algorithm was strategic due to its simplicity, computational efficiency, and scalability. However, it is essential to acknowledge that using artificial intelligence-based models could identify more complex patterns of inconsistency. Nevertheless, the computational cost generated by these techniques is a considerable barrier, especially in massive datasets like the SGP, which manages around 7 million records. Furthermore, implementing these solutions requires advanced technical infrastructure and specialized teams, which are not always available in educational systems with limited budgets.

At the same time, we do not rule out the use of machine learning techniques in the future, combined with traditional methods, such as dynamic adjustment of similarity thresholds, metric learning, name preprocessing, and automated alerts to system operators about potential inconsistencies. Thus, although this study focused on a low computational cost solution, there is considerable room for expanding and improving the developed practices, aiming for greater efficiency in the system and ensuring increasingly reliable data.

Finally, data interoperability proved to be a powerful tool for improving the quality of information within the context of the SGP. Integration with the Federal Revenue database enabled the identification of inconsistencies and error reduction, ensuring greater reliability for public policies such as the Pé-de-Meia Program. Future work can explore expanding this model to other government databases, increasing the system's scope and reliability.

7. Final Remarks

This study consolidated the importance of digital transformation and data interoperability in the context of digital governments, with an emphasis on large-scale educational systems such as the SGP. The adoption of the Levenshtein distance algorithm, combined with a similarity threshold of 80%, proved to be an effective solution for addressing discrepancies in records, ensuring the quality and integrity of processed data. By prioritizing scalable and accessible solutions, this work exemplifies how simple technologies can be adapted to tackle complex operational challenges, contributing to the modernization of the SGP and the implementation of more efficient public policies, such as the Pé-de-Meia program.

Furthermore, the interoperability between the SGP and the Federal Revenue database highlighted the potential of data integration to optimize processes and increase the reliability of governmental systems. This model, although developed for the Brazilian educational context, presents principles that can be adapted to other sectors and countries, especially those facing similar challenges of data heterogeneity and fragmentation.

For future work, it is proposed to expand interoperability with other governmental databases, such as the Cadastro Único and the National Basic Education Assessment System (SAEB). Additionally, adopting hybrid techniques that combine traditional methods with machine learning can open new opportunities to address even more complex contexts, preserving efficiency and scalability as priorities. Thus, this study not only meets a practical demand but also makes a significant contribution to the literature on data interoperability and educational management.

Acknowledgement

This work was supported by the Ministry of Education (MEC), Brazil, under Grant TED13914. The funders had no role in the study design, data collection and analysis, the decision to publish, or the preparation of the manuscript. Additionally, the funders had no influence on the interpretation of data and the final conclusions drawn.

References

Ali, M. S., Ichihara, M. Y., Lopes, L. C., Barbosa, G. C., Pita, R., Carreiro, R. P., Dos Santos, D. B., Ramos, D., Bispo, N., Raynal, F., et al. (2019). Administrative data linkage in brazil: Potentials for health technology assessment. *Frontiers in pharmacology*, *10*, 984.

Almeida, D., Gorender, D., Ichihara, M. Y., Sena, S., Menezes, L., Barbosa, G. C., Fiaccone, R. L., Paixão, E. S., Pita, R., & Barreto, M. L. (2020). Examining the quality of record linkage process using nationwide brazilian administrative databases to build a large birth cohort. *BMC medical informatics and decision making*, *20*(1), 173.

Arretche, M. (2004). Federalismo e políticas sociais no brasil: Problemas de coordenação e autonomia. *São Paulo em perspectiva*, *18*(2), 17–26.

Asadollahi, H., Meouche, R. E., Zheng, Z., Eslahi, M., & Farazdaghi, E. (2024). Semantic text similarity in the civil engineer domain to enhance data interoperability: A domain-specific embedding approach. *SSRN Electronic Journal*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=5064591

Barbalho, I. M. P., Fernandes, F., Barros, D. M. S., Paiva, J. C., Henriques, J., Morais, A. H. F., Coutinho, K. D., Coelho Neto, G. C., Chioro, A., & Valentim, R. A. M. (2022). Electronic health records in brazil: Prospects and technological challenges. *Frontiers in Public Health*, *10*. DOI: https://doi.org/10.3389/fpubh.2022.963841.

Campmas, A., Iacob, N., & Simonelli, F. (2022). How can interoperability stimulate the use of digital public services? an analysis of national interoperability frameworks and e-government in the european union. *Data & Policy*, *4*, e19. DOI: https://doi.org/10.1017/dap.2022.11.

Cohen, W. W. (2000). Data integration using similarity joins and a word-based information representation language. *ACM Trans. Inf. Syst.*, *18*(3), 288–321. DOI: https://doi.org/10.1145/352595.352598.

Costin, C., & Pontual, T. (2020). Curriculum reform in brazil to develop skills for the twenty-first century. In F. M. Reimers (Ed.), *Audacious education purposes: How governments transform the goals of education systems* (pp. 47–64). Springer International Publishing. DOI: https://doi.org/10.1007/978-3-030-41882-3_2.

Damasceno, C. D. N., Lobato, F. M. F., Moutinho, E. R., França, A. S. d., Oliveira, I. I. d., & Santana, Á. L. d. (2021). Simcleaner – sistema de padronização de bases de dados utilizando funções de similaridade. *arXiv preprint arXiv:2107.12884*. https://arxiv.org/abs/2107.12884

Das, M., Tao, X., Liu, Y., & Cheng, J. C. (2022). A blockchain-based integrated document management framework for construction applications. *Automation in Construction*, *133*, 104001.

Downs, J. M., Ford, T., Stewart, R., Epstein, S., Shetty, H., Little, R., Jewell, A., Broadbent, M., Deighton, J., Mostafa, T., Gilbert, R., Hotopf, M., & Hayes, R. (2019). An approach to linking education, social care and electronic health records for children and young people in south london: A linkage study of child and adolescent mental health service data. *BMJ Open*, *9*(1). DOI: https://doi.org/10.1136/bmjopen-2018-024355.

Fiszbein, A., & Schady, N. R. (2009). *Conditional cash transfers: Reducing present and future poverty*. World Bank Publications.

Gali, N., Mariescu-Istodor, R., Hostettler, D., & Fränti, P. (2019). Framework for syntactic string similarity measures. *Expert Systems with Applications*, *129*, 169–185.

Gómez, J., & Vázquez, P.-P. (2022). An empirical evaluation of document embeddings and similarity metrics for scientific articles. *Applied Sciences*, *12*(11), 5664.

Handijono, A., & Suhatman, Z. (2024). Meningkatkan deduplikasi data melalui kesamaan teks dalam pembelajaran mesin: Pendekatan komprehensif. *AKADEMIK: Jurnal Mahasiswa Humanis*, *4*(2), 602–615.

Harron, K., Dibben, C., Boyd, J., Hjern, A., Azimaee, M., Barreto, M. L., & Goldstein, H. (2017). Challenges in administrative data linkage for research. *Big data & society*, *4*(2), 2053951717745678.

Kaufman, A. R., & Klevs, A. (2022). Adaptive fuzzy string matching: How to merge datasets with only one (messy) identifying field. *Political Analysis*, *30*(4), 590–596.

Kouremenou, E., Kiourtis, A., & Kyriazis, D. (2024). A data modeling process for achieving interoperability. *Advances in Digital Health and Medical Bioengineering*, 711–719. https://link.springer.com/chapter/10.1007/978-3-031-62502-2_80

Kremer, M. (2003). Randomized evaluations of educational programs in developing countries: Some lessons. *American Economic Review*, *93*(2), 102–106.

Libuy, N., Harron, K., Gilbert, R., Caulton, R., Cameron, E., & Blackburn, R. (2021). Linking education and hospital data in england: Linkage process and quality. *International Journal of Population Data Science*, *6*(1). DOI: https://doi.org/10.23889/ijpds.v6i1.1671.

Loureiro, A., Cruz, L., & Mello, U. (2021). Brazil case study. *The Role of Intergovernmental Fiscal Transfers in Improving Education Outcomes*, *201*, 201–233.

Malodia, S., Dhir, A., Mishra, M., & Bhatti, Z. A. (2021). Future of e-government: An integrated conceptual framework. *Technological Forecasting and Social Change*, *173*, 121102.

McBride, K., Kamalanathan, S., Valdma, S.-M., Toomere, T., & Freudenthal, M. (2022). Digital government interoperability and data exchange platforms: Insights from a twenty country comparative study. *Proceedings of the 15th International Conference on Theory and Practice of Electronic Governance*, 90–97. DOI: https://doi.org/10.1145/3560107.3560123.

Ministério da Educação. (2025a). ENEM: Sua porta de entrada para a educação superior [Acessado em: 20 jan. 2025]. https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enem

Ministério da Educação. (2025b). Pé-de-Meia: Ministério da Educação Brasileiro [Acessado em: 19 jan. 2025]. https://www.gov.br/mec/pt-br/pe-de-meia

Ouarda, L., Malika, B., & Brahim, B. (2023). Towards a better similarity algorithm for host-based intrusion detection system. *Journal of Intelligent Systems*, *32*(1), 20220259.

Parker, S. W., & Todd, P. E. (2017). Conditional cash transfers: The case of progresa/oportunidades. *Journal of Economic Literature*, *55*(3), 866–915.

Queiroga, E. M., Santana, D., da Silva, M., de Aguiar, M., dos Santos, V., Mello, R. F., Bittencourt, I. I., & Cechinel, C. (2024). Anticipating student abandonment and failure: Predictive models in high school settings. *International Conference on Artificial Intelligence in Education*, 351–364.

Queiroga, E. M., Siqueira, E. S., dos Santos Portela, C., Cordeiro, T. D., Bittencourt, I. I., Isotani, S., Melo, R. F., Muñoz, R., & Cechinel, C. (2024). Data-driven strategies for achieving school equity: Insights from brazil and policy recommendations. *IEEE Access*.

Queiroz, M. V. A. B., Sampaio, R. M. B., & Sampaio, L. M. B. (2020). Dynamic efficiency of primary education in brazil: Socioeconomic and infrastructure influence on school performance. *Socio-Economic Planning Sciences*, *70*, 100738. DOI: https://doi.org/https://doi.org/10.1016/j.seps.2019.100738.

Rocha, J. C., Ramos, V., Cechinel, C., Hernández-Leal, E. J., Muñoz, R., & Primo, T. T. (2024). Data interoperability in learning analytics - review of literature, 1–8. DOI: https://doi.org/10.1109/clei64178.2024.10700464.

Saffady, W. (2021). *Records and information management: Fundamentals of professional practice*. Rowman & Littlefield.

Sakai, K., Dong, Y., Oyamada, M., Takeoka, K., & Okadome, T. (2021). Entity matching with string transformation and similarity-based features. *International Workshop on Software Foundations for Data Interoperability*, 76–87.

Segatto, C. I., Santos, F. B. P. d., Bichir, R. M., & Morandi, E. L. (2022). Inequalities and the covid-19 pandemic in brazil: Analyzing un-coordinated responses in social assistance and education. *Policy and Society*, *41*(2), 306–320. DOI: https://doi.org/10.1093/polsoc/puac005.

Styrin, E., Mossberger, K., & Zhulin, A. (2022). Government as a platform: Intergovernmental participation for public services in the russian federation. *Government Information Quarterly*, *39*(1), 101627.

Tavares, A. A., & Bitencourt, C. M. (2024). Evaluation of public policies and interoperability from the perspective of digital public governance. In D. K. Kang & D. L. Li (Eds.), *E-government digital frontiers - transforming public administration through technology*. IntechOpen. DOI: https://doi.org/10.5772/intechopen.1007596.

Valeriano, E. S. (2024). Deduplication methods using levenshtein distance algorithm. *Journal of Electrical Systems*, *20*(7s), 997–1006.

Wanke, P., Lauro, A., dos Santos Figueiredo, O. H., Faria, J. R., & Franklin G. Mixon, J. (2024). The impact of school infrastructure and teachers' human capital on academic performance in brazil [PMID: 37610037]. *Evaluation Review*, *48*(4), 636–662. DOI: https://doi.org/10.1177/0193841X231197741.

Wimmer, M. A., Boneva, R., & di Giacomo, D. (2018). Interoperability governance: A definition and insights from case studies in europe. *Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age*. DOI: https://doi.org/10.1145/3209281.3209306.

Yu, M., Li, G., Deng, D., & Feng, J. (2016). String similarity search and join: A survey. *Frontiers of Computer Science*, *10*, 399–417.

Track 2: Artificial Intelligence Transforming the Public Sector

Track Description

AI diffusion across government levels and domains has continued to grow, including policy development, implementation, execution, monitoring, and enforcement. The emergence and rapid diffusion of AI applications in society have led to a growing consensus on the need for AI governance and the transformation of practices, organizations, and institutions. Next to the opportunities, AI might impact society negatively. In response, there is a growing stock of AI design, implementation, and governance frameworks and tools to support AI developers and AI practitioners in government organizations in ensuring the responsible deployment of AI in transforming public services and policy-making. However, empirical studies of government use of AI technologies are sparse. Hence, the purpose of this track is to investigate how AI is being implemented, adopted, used and governed at different levels of government, how the institutional contexts are shaping AI systems in government, and how to ensure that AI adoption in government remains trustworthy and beneficial to the public at large.

Track Chairs

M. Janssen, Delft University of Technology, The Netherlands
A. Ojo, Carleton University, Canada
S. Mellouli, Université Laval, Canada

Contents

AI drifting and converting emergency policies: an institutional theory perspective 166
F. Gualdi and V. Ong

AI-Driven Innovation and Collaboration in Public Services: A Review and Taxonomy 176
R. Chaves, G. A. de Oliveira, C. E. Barbosa, and J. M. de Souza

AI-driven public consultation platforms: Transforming civic engagement in local governments 197
M. Dedema and L. Hagen

Algorithmic fairness as sociotechnical system: A typology of the information construct 212
M. S. Bargh, S. Choenni, and F. ter Braak

Developing competences for AI in the Public Sector: The AI4GOV Canvas 224
G. C. Misuraca, R. Medaglia, C. Faijoo, M. Mortati, and C. van Noordt

Emerging models of national competent authorities under the EU AI Act 243
E. Parisini and E. Dervishaj

Transforming Justice: The Rise of AI in Brazilian Courts 256
F. Suriani and E. Pacheco

AI drifting and converting emergency policies: an institutional theory perspective.

Francesco Gualdi [a*], *Vincent* Ong [b].

[a] Department of International Business, Regent's University London, London, United Kingdom, francesco.gualdi@regents.ac.uk, ORCID number 0000-0003-4975-9133.

[b] Department of International Business, Regent's University London, London, United Kingdom, vincent.ong@regents.ac.uk, ORCID number 0000-0002-3864-0535.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. The impact of Artificial Intelligence (AI) on emergency policies has been widely examined in digital government literature, focusing primarily on AI's role in policy design and delivery and on its effects on policy outcomes. However, limited attention has been given to how AI directly impacts emergency policies' change, that is, in which ways AI reshapes and steers the policies it mediates. Drawing on Hacker et al. (2015) framework of institutional change, particularly the concepts of drift and conversion, this research provides a novel lens to understand policy change in emergency contexts. Drift occurs when policies remain formally unchanged but fail to adapt to evolving contexts, altering their effects. Conversion refers to the redirection of policies towards new purposes without modifying their formal structure. By applying this framework, the paper investigates AI's dual role in changing emergency policies, both as a source of resistance to formal policy change and a catalyst for policy redirection. The research adopts an explanatory case study of Peru's welfare policies during the COVID-19 pandemic, focusing on the use of the SISFOH AI system to allocate emergency subsidies. Findings demonstrate how AI changes the policies it mediates by drifting formal policy modification and enabling conversion by reshaping policy ends. This paper contributes to the digital government literature by highlighting AI's ambivalent role in emergency policy change and offering fresh insights into the intersection of AI and emergency policies.

Keywords. Artificial Intelligence, emergency policies, policy change, COVID-19 pandemic, drift, conversion.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.949

1. Introduction

Artificial Intelligence (AI) is increasingly recognized as a pivotal tool in shaping public policies, particularly in emergency contexts where time-sensitive, data-driven decisions are crucial (Scholl, 2023). The integration of AI into public administration has transformed how governments respond to emergencies, enabling more efficient resource allocation, enhanced impact assessments, and targeted interventions (Nasseef et al., 2022). In the domain of emergency policies, AI's role has been predominantly examined through its contributions to policy design and delivery, as well as its influence on policy outcomes (Agarwal et al., 2024; Yu et al., 2024). However, a critical dimension remains underexplored: how AI actively reshapes and steers the evolution of the policies it mediates. Very limited knowledge is offered on what happens between the ex-ante policy design and the post-facto assessment of the outcomes: indeed, policies are not fixed, they evolve and mutate over time (Pierson, 2006). Understanding the impact of AI on policy change is crucial because often emergency policies relying on AI evolve, which requires additional policymaking efforts to ensure expected goals are achieved without distortions (Milan et al., 2021). This paper addresses this gap by investigating how AI impacts emergency policy change, advancing our understanding of the intricate ways in which AI drives different forms of policy evolution.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

To unravel how AI impacts emergency policy change, the paper adopts an institutional theory perspective, and it builds on the theoretical framework of institutional hidden change as outlined by Hacker et al. (2015). This framework introduces the concepts of "drift" and "conversion" to explain hidden forms of policy change. This research applies the drift and conversion framework to the context of AI-driven emergency policies, positing that AI can act as both a source of resistance to formal policy change (drift) and as a catalyst for policy redirection (conversion).

To shed light on this phenomenon, this paper addresses the following Research Question: *How does AI act as a source of drift and conversion affecting emergency policy change?*

To empirically explore these dynamics, the paper examines the case of the Peruvian government's AI-based Households Targeting System (*Sistema de Focalización de Hogares*, herein SISFOH), which played a central role in allocating emergency subsidies during the COVID-19 pandemic. Qualitative data from interviews with key policymakers provide evidence to illustrate how AI can simultaneously constrain and enable policy evolution, reflecting the dual processes of drift and conversion.

Building on the findings of the case study, the paper provides two main contributions. First, it extends the theoretical application of institutional change frameworks to the study of AI in governments' emergency policies, offering a nuanced perspective on how AI interacts with those policies. Second, it theorizes the ambivalent nature of AI's impact on policy change, illustrating its capacity to both resist and facilitate change. In doing so, this paper bridges a critical gap in the literature, addressing the underexplored intersection of AI and policy change in emergency contexts. It underscores the importance of understanding AI not merely as a tool for policy implementation but as an active agent that influences the trajectory of policy development.

2. Background

Literature has addressed the impact of Artificial Intelligence (AI) on governments' emergency policies in the context of the COVID-19 pandemic looking at two main issues: the use of AI to design and deliver emergency policies (Hagen et al., 2021; Nasseef et al., 2022; Rodriguez-Hidalgo, 2020), and the effects of AI on the outcomes of the emergency policies (Agarwal et al., 2024; Mhlanga, 2022; Qureshi, 2021). The first stream of research has investigated how AI can be utilized in the public sector to support an enhanced emergency policy provision (Yu et al., 2024). Specifically, there is now increasing evidence about the impact of AI in assisting policymakers by maximising the data available and offering improved impact assessments and forecasts (Agostino et al., 2021; Anshari et al., 2023). The adoption of AI instruments in the early stages of the decision-making process, including policy formulation and design, has enabled the public sector to reach a more informed and data-driven awareness (Moser-Plautz & Schmidthuber, 2023) that could limit the mismatches between the purpose of the policies and the means available in the policymakers' hands, which is crucial in emergency circumstances (Kummitha, 2020).

The second stream of research has mainly focused on the effects of AI on the outcomes of the policies (Agarwal et al., 2024). Contributions to this research effort have shown a more mixed picture. AI adoption in the public sector has often triggered unexpected outcomes. For example, AI tools to streamline service delivery have created misallocations that have unevenly impacted the population which is deeply problematic in countries already affected by social inequalities (Cerna Aragon, 2021). Moreover, AI adoption has been challenged by social groups due to discrimination and distortions (Milan et al., 2021; Naudé & Vinuesa, 2021). To complicate even more the picture, increased attention on the ethical issues related to AI-driven public policies has requested scholars and policymakers to closely scrutinize the effects of AI on the policies it informed (Qureshi, 2021).

The relevance of these two streams of research is undeniable and it is likely to be enhanced as the adoption of AI instruments to address emergencies is increasing at a fast pace (Urueña, 2023). However, in the complex entanglement between AI and emergency policies, the study of how AI impacts policy change has not received adequate attention. The literature has widely addressed how AI can be utilized before the policy is designed (Agarwal et al., 2024; Agostino et al., 2021) and what are the effects of AI after the policy has been implemented (Naudé & Vinuesa, 2021), however, there is a scarcity of works that examine the impact of AI on the change of the policy. Regrettably, literature has overlooked policy change for a long time, focusing more on other aspects such as the design, implementation, and evaluation of policies (Kuziemski & Misuraca, 2020; Lundgren et al., 2020; Moser-Plautz & Schmidthuber, 2023). However, this approach has shown limits because the space between the design and the implementation offers many opportunities for AI to deploy its effects and shape the evolution of the policy. Indeed, scholars reflecting on emergency policy design have called for a more dynamic perspective on the impact of AI on the whole phases of policymaking (Meijer & Webster, 2020). Although valuable, this stream of research mostly focuses on the process as a unit of analysis. Despite its relevance, scarce and limited knowledge exists on the study of how emergency policy evolves and modifies when AI is used to inform it.

To address this gap, the paper aims to explore policy change through a more nuanced understanding of the impact of AI on policies. By unpacking the different ways in which AI affects policy change, the paper accounts for the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

effects of AI that reshapes and steers the evolution of the policies it mediates. This research aims to connect with the longstanding research stream that has discussed how digital technologies – including AI – entangle emergency policies (Scholl, 2023). Beyond that, the paper aims to add to the limited works on the impact of AI on emergency policy change, adding fresh knowledge and theorization to a crucial phenomenon.

3. Theoretical Framework

To shed light on how AI impacts emergency policy change, the paper relies on the theoretical framework used by Hacker et al. (2015) to explain institutional change. In this section, justifications are provided to explain (a) what the framework is about; (b) why this framework has been selected to investigate the phenomenon; and (c) how to operationalize the key dimensions of the framework in the analysis.

The work by Hacker et al. (2015) is rooted in the discipline of public policies and aims to investigate how policies evolve and change without formal revision (Hacker et al., 2015). Challenging the predominant stream of research of institutional theory that focuses on major changes in a long-term timeframe (March & Olsen, 1983; Powell & DiMaggio, 2012), public policies scholars have advanced the idea of "hidden forms of institutional change" (Hacker et al., 2015, p. 181). Hidden change refers to the modification of the policies that happens without a formal revision of the rules. Hidden change happens through two forms: drift and conversion (Hacker et al., 2015).

The concept of drift is explained as the failure of policymakers to update policies to reflect mutated social circumstances (Hacker et al., 2015). In other words, the change of the policy is resisted despite significant pressures to adapt the policy to a new context. It is worth noting that the concept of drift here is presented slightly differently from the one portrayed in other disciplines that have studied change related to technology, e.g. Information Systems, where drift is referred to as the deviation from planned purposes due to reasons beyond the control of actors (Ciborra & Hanseth, 2000). While the origin is similar – drift occurs when there is a modification of the surrounding context that triggers change – the emphasis on drift as presented by Hacker and colleagues lies on the attempts to maintain the status quo ante by not adapting policies despite the context transformations, which results in altered effects of the policies.

Conversion is a form of change occurring when a policy is redirected towards new ends (Hacker et al., 2015). In a similar fashion to drift, conversion happens without modifying formal aspects of the policy. However, the key difference is that while drift explains how a change in the policy is resisted despite context modifications, conversion accounts for how policy change is enabled by redirecting the policy to different purposes than those originally engineered. In other words, conversion occurs when policies designed and deployed to achieve specific sets of goals are harnessed by actors to execute different tasks within the same formal (legal-institutional) framework (Hacker et al., 2015). Similarities and differences between drift and conversion are presented in Table 1 below.

Tab. 1 – Key characteristics of drift and conversion. Source: authors' elaboration building on Hacker et al. (2015)

	Source of change	Substantial impact on policy	Formal impact on policy	Driving force
Drift	Context discontinuity	Policy's effects altered because of modified circumstances	Left unchanged	Resistance
Conversion	Actors' initiative	Policy's purposes shifted towards different ends	Left unchanged	Redirection

The above-presented framework has been selected for several reasons. First, it enables an investigation of the impact of AI on emergency policy change using a lens that focuses on the policy as the unity of analysis. In this light, the representation of policies as formal institutions (Pierson, 2006) is crucial because it accounts for how policies "set rules for social interactions that are enforced through the exercise of public authority" (Hacker et al., 2015, p. 183). The paper aligns with this conceptualization that enables a more specific investigation at the policy level. Second, it offers a new angle on an emerging phenomenon. The institutionalist perspective has widely been used to investigate the effects of technology on organizational change (Avgerou, 2004; Fountain, 2001; Luna-Reyes & Gil-Garcia, 2011). However, very limited works have utilized institutionalism to understand the impact of AI (Caplan & boyd, 2018; Rudko et al., 2024) and, specifically, the impact of AI on policy change. Third, the theorization advanced by Hacker et al. (2015) provides adequate granularity to unpack how AI influences emergency policy change. The identification of drift and conversion as key forms of change offers analytical tools to shed light on how the policy change happens.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The framework by Hacker et al. (2015) is a powerful analytical tool to appreciate the impact of AI on policy change. Indeed, the original framework is outlined by the authors to study public policies, that is, to understand which political actors drive drift and conversion in policy change. Utilizing the framework in the field of digital government requires a retuning of the focus, which includes not only the activity of political actors but also the role of digital technology, and in this case AI, as a factor that impacts policy change. Specifically, this research posits that AI triggers both drift and conversion, acting as an ambivalent catalyst for policy change. To validate this assumption, the paper outlines two propositions that are going to be tested in the following sections.

Proposition 1: AI is a source of drift because it reinforces resistance to policy change despite evolving contextual circumstances.

Proposition 2: AI is a source of conversion because it shapes the redirection of the policy to achieve distinct outcomes.

4. Methodology

4.1 Research settings

To shed light on the way by which AI impacts policy change, the research adopts an explanatory case study method which is suitable to illustrate how "conditions came to be" (Yin, 2018, p. 238) in specific settings over which the researchers have no control or influence. Explanatory research requires precise methodological choices. First, a review of the relevant literature that enables a thorough definition of the research question (Yin, 2018). Second, the outline of a theoretical foundation that drives the formulation of initial propositions in advance of the data collection (Yin, 2018). To study the impact of AI on policy change, we focus on the provision of emergency welfare measures by the Peruvian public administration, following the occurrence of the COVID-19 pandemic. This case is particularly suitable for the research because the government decided to rely on the SISFOH AI system that was driving the provision of welfare policies in ordinary time to deliver pandemic-related policies. The study of the impact of AI on Peruvian policies provides critical findings to understand how AI generates drift and conversion that underpin policy change.

4.2 Case study

The Peruvian government's welfare provision builds on a "targeting logic", that is, identifying the citizens in need to correctly provide services, avoiding unnecessary expenditures, and streamlining the delivery of measures such as pensions, subsidies, and loans (Silva Huerta & Stampini, 2018). Specifically, SISFOH's main task was to release a Socio-Economic Classification (SEC) of citizens, clustering users as "not poor", "poor", or "very poor", based on their level of poverty. The AI algorithm relied on a combination of criteria, variables and filters: for instance, possessing a vehicle and/or private health insurance, pre-determined levels of salary, and electricity consumption are the critical factors used to determine citizens' levels of poverty (Cerna Aragon, 2021).

In response to the COVID-19 pandemic, the Peruvian government took immediate action to sustain the citizens in need after the imposition of extraordinary decisions like lockdowns and restrictions on movement and business. Therefore, the government designed and released an emergency welfare policy named "Bono YoMeQuedoEnCasa" (I'm Staying at Home), a one-off subsidy of 380 soles (approximately USD 110) per household to support citizens who had lost their job or saw their activity disrupted due to the lockdown. Eligibility for the subsidy was determined prioritizing households (a) classified as "poor" or "very poor", (b) residing in urban areas, (c) that included other adults and not only minors, and (d) where nobody had a job in the public sector. To correctly target those eligible for the emergency subsidy, the government relied on the SISFOH AI, which was used to elaborate a database of the households.

However, implementation challenges arose: the resulting databases provided by SISFOH AI reflected errors in inclusion and exclusion: with citizens not entitled who nevertheless received the subsidy, and citizens in need who were excluded. In aggregate, misallocations concerned nearly 10% of the policy recipients (Contraloria General de la Republica del Perù, 2020). Acknowledging these shortcomings, the government introduced additional subsidies to expand coverage (e.g., self-employed workers, rural households, families). Peruvian policymakers relentlessly transitioned from the targeting approach utilized in the initial phase to the universal approach of the later stage, addressing gaps in the initial program.

4.3 Data collection and analysis

After an initial phase in which the researchers consulted secondary sources to get a background understanding of the issues at stake, the main data collection focused on interviews with high-level policymakers who played a critical role in the design and delivery of emergency policies. As the focus of this research is to understand how the policy changes, we privileged quality over quantity in the number of interviews: therefore, we limited our sample

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

to pivotal policymakers who took the key decisions in the emergency policymaking process (Hansen et al., 2025). In aggregate, we reached out to six key policymakers: three former ministers of the Minister for Development and Social Inclusion (herein MIDIS) who took key decisions in the design and application of the SISFOH system; one former MIDIS deputy minister, and two senior civil servants who designed and delivered the emergency policy. Each interview lasted between 50 to 80 minutes. Interviews were effectuated in late 2022. Four interviews out of six were conducted in English, and two in Spanish (the latter were transcribed and translated to English before beginning the data analysis).

The collected data from the interviews were subsequentially coded using NVivo software. A combination of inductive and deductive approaches was chosen (Charmaz, 2014). Data were coded data relying on the key concepts of drift and conversion from the theoretical framework to assess whether alignment could be identified. Simultaneously, the coding process remained open to recognizing new codes emerging directly from the data. Researchers eventually discussed the codes and reviewed the outcomes, clearing discrepancies.

5. Findings

The findings from the case study mainly show three elements: (a) the relevance of the AI-based policy in defining the status quo ante; (b) how the AI impacted the drift of the policy; and (c) how the AI impacted the conversion of the policy. In this section, we are going to analyse each of these elements in detail with support of primary data.

5.1 Relevance of the AI policy in the Peruvian welfare

When asked about the provision of welfare in Peru, the policymakers interviewed remarked that, before the outbreak of the pandemic, the SISFOH AI was the backbone of the public services distribution. Over the years, increasing public agencies and ministries utilized SISFOH AI as a key information system to assess the eligibility of citizens for distinct social and welfare measures. A former Minister of the MIDIS points out: *"If people wanted to use welfare, they had to stick with SISFOH. Then, the need to have information was not only of a few sectors but was also shared by many actors within the Peruvian government: at that point, many other programs were aggregated to SISFOH, like SALUD, JUNTOS, PENSION65, CONTIGO"* (Interviewee-1). SISFOH AI centralized the information collection, processing, and management within the Peruvian welfare. As such, it established a standardized way to provide welfare services because it engrained the technological characteristics of the AI into the targeting logic of the Peruvian approach to welfare. In other words, the AI had been designed to fulfil a specific task – correctly target those eligible for welfare measures – and it became the standard for distributing welfare measures. Another former Minister explains the centrality of the SISFOH AI with respect not only to the whole welfare provision, but to the definition of the policy itself: *"The creation of SISFOH has provided to the social policy of Peru an instrument that it already had, but that was not an instrument within a policy"* (I-6). In other words, the AI became constitutive of the policy. The AI algorithms engrained into SISFOH provided the public administration with the information without which it would have been impossible to deliver services.

5.2 Challenges of the AI policy in the pandemic context

The outbreak of the pandemic was the contextual event that modified the status quo ante. The immediate response of Peruvian policymakers to the deteriorating living conditions of the citizens was to deliver a monetary subsidy. However, the external context altered the effects of the Peruvian welfare policy based on SISFOH AI. Before the pandemic, the AI-driven policy achieved targeting purposes: those clustered as "poor" and "very poor" received welfare measures, while those not in need didn't. After the pandemic, the effects of the policy generated further exclusion as many people classified by the AI as "not poor" found themselves left out of the database of eligible citizens despite being severely impacted by the pandemic. This aspect is emphasized by a former deputy Minister: *"We only can target people who are poor or extremely poor, but that was before the pandemic"* (I-4). This happened without any formal modification of the policy based on AI: what changed was the social environment. However, vis-à-vis these modified circumstances, the Peruvian policymakers resisted changing the policy, which would have required significant resources given the centrality of SISFOH and the AI engrained into it. Hence, the AI-calculated categories of "very poor", "poor", and "not poor" were applied in the emergency context in the same manner as they would have been during ordinary times. Resistances to change the policy emerged among civil servants and actors tasked to utilize the AI to deliver the first monetary subsidy, as noted by a senior civil servant: *"People* [in the Peruvian public sector] *were used to SISFOH, they had knowledge and expertise"* (I-5). At the time of the pandemic, the Peruvian public administration had relied on the SISFOH AI for several years with considerable success. However, in a situation of a modified environment, the targeting effects of the policy, embodied in the functioning of the AI, generated misallocations in the recipients of the subsidy, exposing the whole policy to *"challenges related to coverage and leakage"* (I-3). Eventually, the government realized that the attempts to leave the welfare policy formally unchanged could expose the emergency measures to significant flaws and weaknesses.

5.3 Adopting the AI policy

The misallocations of the first monetary subsidy urged Peruvian policymakers to pursue an adaptation of the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

SISFOH AI policy to achieve different ends. The modification of the formal aspects of the policy was excluded as it would have required dismantling not only the policy architecture but also the technological infrastructure of the AI engrained at the core of SISFOH. A former Minister emphasizes this point, reinforcing the boundary conditions within which Peruvian policymakers had to operate: "*Without SISFOH, we would not have been able to design the emergency policy at all. SISFOH did impact, it has radically changed the social policy in Peru"* (I-6). Hence, Peruvian policymakers began efforts to redirect the purpose of the policy leveraging on the potentiality of the SISFOH. The strategy of Peruvian policymakers focused on utilizing the data produced by SISFOH AI with a distinct purpose. While in ordinary time the database of citizens eligible for a specific welfare service was the landing point of SISFOH, in emergency time it became the basis for further subsidies provided by other ministries and agencies building on the information provided by SISFOH AI. The first monetary subsidy was designed and delivered to citizens in less than two weeks: however, due to the prolonged restrictions, several other subsidies were provided to other categories and social groups. Further measures were released to expand the number of people eligible beyond the "poor" and "very poor" citizens classified by SISFOH AI, as explained by a former deputy Minister who accounts for the many queries received about SISFOH data*: "People who lost their jobs, artists, informal workers… All these categories needed Bonos [subsidies], but they weren't poor! We also needed to reach people who weren't poor, but not all of them. So, we used SISFOH data to identify the non-poor"* (I-4). Therefore, building on AI classifications, the Peruvian public administration began to provide subsidies to those who were initially excluded from the recipients of the first monetary measure. This ultimately led to a situation in which the SISFOH AI, designed to increase efficiency and effectiveness in targeting, was the instrument that enabled the Peruvian government to effectuate reverse targeting. Policymakers pursued reverse targeting until the recipients of the subsidies reached almost universal coverage. This is confirmed by a former Minister who explains how the provision of a subsequent subsidy to informal workers occurred: "*They had the national ID registry; they took out from that registry all the people that remained with a formal job. And that's it: everybody else should receive a Bono, that was the reverse targeting"* (I-2).

6. Discussion

The purpose of the research is to understand the impact of AI on emergency policy change. To achieve this goal, findings from the case study of the Peruvian government's emergency measures are discussed through the analytical lens of drift and conversion framework as portrayed by Hacker et al. (2015) to validate Propositions 1 and 2 above presented.

6.1 AI as a source of drift

Proposition 1 upholds that AI can be a source of drift underpinning resistance to policy change when the contextual circumstances modify. Key characteristics of drift, as summarized in Table 1, are (a) context discontinuity; (b) alteration of policy's effects due to evolved context; (c) formal policy unchanged; and (d) resistance as a driving force.

Concerning context discontinuity, findings from the case study indicate that the outbreak of the COVID-19 pandemic represents the transformation of the social circumstances altering the status quo ante. Specifically, the context discontinuity observed in the case takes the shape of a major disruption that overturns the social order. An event like the pandemic – without the reasonable control of any of the actors – embodies a more than sufficient modification of the context to trigger the policy change in the form of drift.

The context discontinuity impacts the effects of the policy: the AI was originally designed to target citizens eligible for welfare services and to exclude those not eligible. The engrained technology at the core of the policy – SISFOH's AI – produced altered effects in the pandemic context generating additional leakages and distortions in the subsidy administration. The SISFOH AI had been designed to provide only a static understanding of poverty, based on data that did not capture the modified poverty circumstances.

In these settings, Peruvian policymakers decided to avoid the formal modification of the policy, which would have requested an alteration of the technological infrastructure of the AI at the core of SISFOH. The formal scaffolding of the Peruvian welfare system relying on SISFOH remained in place without modifications. Two motivations can explain this choice. First, civil servants tasked with administering the policy were accustomed to the use of SISFOH, and an abrupt discontinuation such as a policy formal change would have impacted the chances of the monetary subsidy being delivered effectively. However, there is a second element that deserves to be unravelled: the specific role of AI in the formal constitution (Pierson, 2006) of the policy. The centrality of the AI algorithm within SISFOH, and the pervasiveness of SISFOH within the Peruvian welfare system, generated an additional source of resistance towards a formal modification of the policy.

Drift elucidates a substantial change in the effects of the policy without formal modifications, as a consequence of an evolved context (Hacker et al., 2015). In this respect, policy change is supported not only by actors' behaviour but also, and more significantly, by the impact of AI. When the context shifts the effects of the policy, the AI shapes

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the policy change by creating resistance to any formal modification, drifting the policy towards unexplored territory. In other words, the policy changes not only because the context has altered its effects, but also because the AI has prevented any formal modifications to the policy itself. Accordingly, proposition 1 can be considered validated.

6.2 AI as a source of conversion

Proposition 2 upholds that AI can be a source of conversion, shaping the redirection of the policy to achieve different outcomes. Key characteristics of conversion, as summarized in Table 1, are (a) actors' initiative; (b) adaptation of policy's purposes towards different ends; (c) formal policy unchanged; (d) redirection as driving force.

Actors' initiatives refer to the proactive decisions taken by relevant policymakers to modify the circumstances (Hacker et al., 2015). In contrast to drift, the source that triggers policy change is not the context – although the context is not irrelevant – but rather the behaviours of policymakers. Findings from the case study show that Peruvian policymakers reacted to the misallocations and disruptions generated by the delivery of the first monetary subsidy. Policymakers acted under the pressure of providing immediate relief to those impacted by the pandemic and excluded by the AI classification of "poor" and "very poor".

Similarly to the drift form of change, conversion occurs when the actors leave unchanged the formal constitution of the policy. The modification of the SISFOH infrastructure at the core of the welfare provision encounters the same challenges characterizing drift: it is impossible to disentangle the AI engrained in SISFOH from the policy architecture, which is diffused across several branches of the government. Further, despite its limitation, the AI had released enough information to deliver an initial subsidy provision, even if incomplete. The design and delivery of the first monetary subsidy constituted a benchmark for policymakers who aimed to rely on AI to provide further measures. Indeed, the SISFOH AI turns out to be a necessary condition for implementing other policies, not only because the rigidity of the AI-driven policy limits the options available to policymakers, but also because without the use of AI, delivering further policies becomes impossible.

This specific nature of the AI leaves the policymakers with the only option to adapt to the purposes of the policy without changing its formal constitution. Furthermore, the actors engage in a redirection of the policy towards completely different purposes than those that drove its design: from targeting, aimed to exclude those not eligible, to reverse targeting, to include those not yet covered by any measure. Concerning the adaptation of the policy, the role of AI deserves further discussion. The findings of the case study account for the policymakers' decisions and acts, however, the impact of AI in constraining the options available cannot be neglected. The AI, setting boundaries between what is possible to achieve and what is not, has a critical role in substantially adapting the policy towards new and distinct purposes. It is the SISFOH AI installed base that orientates the redirection of the policy.

Conversion happens because policymakers aim to adapt the ends of the policies vis-à-vis the unfeasibility of formally changing the policy (Hacker et al., 2015). In this context, policy change occurs because the redirection of the policy is steered by an entanglement made of policymakers' actions and AI-defined boundaries of the redirection. Accordingly, proposition 2 can be considered validated.

6.3 The ambivalence of AI in drifting and converting policies

The validation of the propositions outlined building on the framework by Hacker et al. (2015) accounts for the role of AI impacting policy change: when AI is engrained at the core of the policy, it acts as a source for drift and conversion. However, the analysis emphasizes an additional element: AI possesses the capacity to drive both drift and conversion forms of policy change.

On the one hand, AI drifts the policy change by creating resistance to formal policy modifications which overshadows the need to adjust the mutated effects of the policy. On the other hand, AI enables a substantial redirection of the policy ends that enable policymakers to achieve significant outcomes without formally altering the policy. The embedding of the AI within the policy and the diffusion of the policy within the welfare system confers the AI a critical relevance in the whole public administration scaffolding, up to the point that a formal modification of the AI-driven policy encounters several challenges. However, the same factors that make the formal modifications unfeasible – the centrality of AI engrained in the policy and the centrality of the policy within the system – drive the adaptation of the policy towards other ends which ultimately serves the interests of the policymakers. In other words, the AI possesses an ambivalent capacity to impact policy change because it is both a source of drift and conversion.

7. Conclusions

This research has explored the transformative role of Artificial Intelligence (AI) in emergency policy change,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

focusing on its dual capacity to resist and enable policy change through the theoretical lens of drift and conversion (Hacker et al., 2015). By analysing the case of Peru's SISFOH AI system during the COVID-19 pandemic, the research has illustrated how AI reshapes policies in ways that extend beyond their original design, highlighting its ambivalent role in both stabilising and adapting policy frameworks.

The findings demonstrate that AI systems when embedded into policy processes, act as powerful institutional actors (Avgerou, 2004; Rudko et al., 2024). On one hand, the SISFOH system triggered drift, resisting formal policy changes even as the pandemic dramatically altered the socio-economic context. This resistance stemmed not only from the public administrators' inertia but also from the structural centrality of the AI itself, which constrained policymakers' capacity for formal reform. On the other hand, the same system enabled significant policy redirection through conversion, as policymakers leveraged SISFOH's capabilities to expand welfare coverage and address emergent challenges. By facilitating reverse targeting and reorienting policy goals, AI proved instrumental in adapting to the demands of a rapidly evolving crisis.

These findings contribute to the digital government literature in several ways. First, they underscore the importance of studying AI not merely as a technical tool but as a dynamic force that interacts with institutional structures to shape policy change (Agostino et al., 2021; Luna-Reyes & Gil-Garcia, 2011). Second, they offer empirical insights into the complexities of AI-driven policy change in emergency contexts, where resource constraints and socio-economic inequalities amplify the stakes of emergency response (Firmino & Evangelista, 2023; Meijer & Webster, 2020).

However, this research also raises important questions about the governance of AI in public administration. The dual capacity of AI to resist and facilitate change suggests that its integration into policy processes must be carefully managed to balance stability and adaptability (Valle-Cruz & Sandoval-Almazán, 2024). This implies the need for a more robust, modular approach to AI design, that facilitates reprogramming and re-tailoring to achieve desirable outcomes. Moreover, policymakers must consider the ethical and operational implications of AI-driven systems, particularly in contexts where technological limitations may exacerbate social inequities (Milan et al., 2021). Furthermore, the findings point to the need for ongoing scrutiny of how AI shapes policy outcomes over time, calling for future research into its long-term institutional effects (Cordella & Gualdi, 2024).

In conclusion, this research highlights the ambivalent role of AI as both a source of drift and conversion forms of policy change. As governments increasingly turn to AI to address complex challenges (Scholl, 2023), it is crucial to recognise and navigate its dual nature, ensuring that the integration of AI into policymaking serves not only to optimise outcomes but also to uphold principles of equity and inclusivity. By advancing the understanding of how AI drives hidden forms of policy change, this research contributes to a deeper appreciation of the transformative potential of digital technologies.

Acknowledgement

- **Funding or Grant:** This project has received the support of the Regent's University London Vice-Chancellor Fund.
- **Data/Software Access Statement**: The data that support the findings of this study are available from the corresponding author upon reasonable request.
- **Contributor Statement***: Francesco Gualdi: Conceptualisation, Writing-Original Draft, Methodology, Writing-Editing, Validation, Funding Acquisition. Vincent Ong: Conceptualisation, Writing-Editing, Validation, Funding Acquisition.
- **Use of AI***: During the preparation of this work, the authors used Grammarly to check the appropriateness of language, and ChatGPT to check the correctness of the translation from Spanish to English. After using these tools, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Agarwal, P., Swami, S., & Malhotra, S. K. (2024). Artificial Intelligence Adoption in the Post COVID-19 New-Normal and Role of Smart Technologies in Transforming Business: a Review. *Journal of Science and Technology Policy Management*, *15*(3), 506-529. https://doi.org/10.1108/JSTPM-08-2021-0122

Agostino, D., Arnaboldi, M., & Lema, M. D. (2021). New development: COVID-19 as an accelerator of digital transformation in public service delivery. *Public Money & Management*, *41*(1), 69-72. https://doi.org/10.1080/09540962.2020.1764206

Anshari, M., Hamdan, M., Ahmad, N., Ali, E., & Haidi, H. (2023). COVID-19, artificial intelligence, ethical challenges and policy implications. *AI & SOCIETY*, *38*(2), 707-720. https://doi.org/10.1007/s00146-022-01471-6

Avgerou, C. (2004). IT as an institutional actor in developing countries. In S. Krishna & S. Madon (Eds.), *The digital*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

challenge: Information technology in the development context (pp. 46-63). Ashgate Publishing.
Caplan, R., & boyd, d. (2018). Isomorphism through algorithms: Institutional dependencies in the case of Facebook. *Big Data & Society*, *5*(1), 2053951718757253. https://doi.org/10.1177/2053951718757253
Cerna Aragon, D. (2021). On not being visibile to the state: The case of Peru. In S. Milan, E. Treré, & S. Masiero (Eds.), *COVID-19 from the margins. Pandemic invisibilities, policies and resistance in the datafied society* (pp. 282). Institute of Network Cultures.
Charmaz, K. (2014). *Constructing Grounded Theory*. SAGE.
Ciborra, C. U., & Hanseth, O. (2000). Introduction: From Control to Drift. In C. U. Ciborra & Associates (Eds.), *From Control to Drift: The Dynamics of Corporate Information Infrastructures* (pp. 1-12). Oxford University Press.
Contraloria General de la Republica del Perù, t. (2020). *"Formulacion y aprobacion del padron de los hogares beneficiarios del subsidio monetario en el marco del decreto de urgencia n° 027-2020"*. San Isidro (Perù)
Cordella, A., & Gualdi, F. (2024). Algorithmic formalization: Impacts on administrative processes. *Public Administration*. https://doi.org/10.1111/padm.13030
Firmino, R., & Evangelista, R. (2023). Pandemic techno-politics in the Global South. *Information Polity*, *28*(4), 453-467. https://doi.org/10.3233/ip-211514
Fountain, J. E. (2001). *Building the Virtual State: Information Technology and Institutional Change*. Brookings Institution Press.
Hacker, J. S., Pierson, P., & Thelen, K. (2015). Drift and conversion: hidden faces of institutional change. In J. Mahoney & K. Thelen (Eds.), *Advances in Comparative-Historical Analysis* (pp. 180-208). Cambridge University Press. https://doi.org/10.1017/CBO9781316273104.008
Hagen, L., Sandoval-Almazan, R., Okhuijsen, S., Cabaco, S., Ruvalcaba-Gomez, E. A., Villodre, J., Sung, W., & Valle-Cruz, D. (2021). *Open Government and Open Data in Times of COVID-19* Proceedings of the 22nd Annual International Conference on Digital Government Research, Omaha, NE, USA. https://doi.org/10.1145/3463677.3463740
Hansen, H., Elias, S. R. S. T. A., Stevenson, A., Smith, A. D., Alexander, B. N. B., & Barros, M. (2025). Resisting the Objectification of Qualitative Research: The Unsilencing of Context, Researchers, and Noninterview Data. *Organizational Research Methods*, *28*(1), 3-31. https://doi.org/10.1177/10944281231215119
Kummitha, R. K. R. (2020). Smart technologies for fighting pandemics: The techno- and human- driven approaches in controlling the virus transmission. *Government Information Quarterly*, *37*(3), 101481. https://doi.org/10.1016/j.giq.2020.101481
Kuziemski, M., & Misuraca, G. (2020). AI governance in the public sector: Three tales from the frontiers of automated decision-making in democratic settings. *Telecommunications Policy*, *44*(6), 101976. https://doi.org/10.1016/j.telpol.2020.101976
Luna-Reyes, L. F., & Gil-Garcia, J. R. (2011). Using institutional theory and dynamic simulation to understand complex e-Government phenomena. *Government Information Quarterly*, *28*(3), 329-345. https://doi.org/10.1016/j.giq.2010.08.007
Lundgren, M., Klamberg, M., Sundström, K., & Dahlqvist, J. (2020). Emergency powers in response to COVID-19: Policy diffusion, democracy, and preparedness. *Nordic Journal of Human Rights*, *38*(4), 305-318. https://doi.org/10.1080/18918131.2021.1899406
March, J. G., & Olsen, J. P. (1983). The new institutionalism: Organizational factors in political life. *American Political Science Review*, *78*(3), 734-749. https://doi.org/10.2307/1961840
Meijer, A., & Webster, C. W. R. (2020). The COVID-19 crisis and the information polity: An overview of responses and discussions in twenty-one countries from six continents. *Information Polity*, *25*(3), 243-274. https://doi.org/10.3233/ip-200006
Mhlanga, D. (2022). The Role of Artificial Intelligence and Machine Learning Amid the COVID-19 Pandemic: What Lessons Are We Learning on 4IR and the Sustainable Development Goals. *International Journal of Environmental Research and Public Health*, *19*(3), 1879. https://www.mdpi.com/1660-4601/19/3/1879
Milan, S., Treré, E., & Masiero, S. (2021). *COVID-19 from the Margins. Pandemic invisibilities, policies and resistance in the datafied society* (Vol. 40). Institute of Network Cultures.
Moser-Plautz, B., & Schmidthuber, L. (2023). Digital government transformation as an organizational response to the COVID-19 pandemic. *Government Information Quarterly*, *40*(3), 101815. https://doi.org/10.1016/j.giq.2023.101815
Nasseef, O. A., Baabdullah, A. M., Alalwan, A. A., Lal, B., & Dwivedi, Y. K. (2022). Artificial intelligence-based public healthcare systems: G2G knowledge-based exchange to enhance the decision-making process. *Government Information Quarterly*, *39*(4), 101618. https://doi.org/10.1016/j.giq.2021.101618
Naudé, W., & Vinuesa, R. (2021). Data deprivations, data gaps and digital divides: Lessons from the COVID-19 pandemic. *Big Data & Society*, *8*(2), 20539517211025545. https://doi.org/10.1177/20539517211025545
Pierson, P. (2006). Public Policies as Institutions. In I. Shapiro, S. Skowronek, & D. Galvin (Eds.), *Rethinking political institutions: the art of the State* (pp. 114–131). NYU Press.
Powell, W. W., & DiMaggio, P. J. (2012). *The new institutionalism in organizational analysis*. University of Chicago Press.
Qureshi, S. (2021). Pandemics within the pandemic: Confronting socio-economic inequities in a datafied world. *Information Technology for Development*, *27*(2), 151-170. https://doi.org/10.1080/02681102.2021.1911020
Rodriguez-Hidalgo, C. (2020). Using functional and social robots to help during the COVID-19 pandemic. In A. Plaw, B. Gurgel, & D. Plascencia (Eds.), *The Politics of Technology in Latin America: Data Protection, Homeland Security and the Labor Market* (1st ed., pp. 218). Routledge.
Rudko, I., Bashirpour Bonab, A., Fedele, M., & Formisano, A. V. (2024). New institutional theory and AI: toward rethinking of artificial intelligence in organizations. *Journal of Management History*, *31*(2), 261-284. https://doi.org/10.1108/JMH-09-2023-0097
Scholl, H. J. (2023). The Past Two Decades in Disaster Information Management: Academic Contributors and Topical

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Evolution. Proceedings of the 56th Hawaii International Conference on System Sciences, Maui, Hawaii. https://doi.org/10.24251/HICSS.2023.230
Silva Huerta, R. C., & Stampini, M. (2018). *¿Cómo funciona el Programa Juntos?: Mejores prácticas en la implementación de programas de transferencias monetarias condicionadas en América Latina y el Caribe*. Inter American Development Bank. https://doi.org/10.18235/0001144
Urueña, R. (2023). *Regulating the Algorithmic Welfare State in Latin America*. Max Planck Institute for Comparative Public Law & International Law (MPIL). https://doi.org/10.2139/ssrn.4670480
Valle-Cruz, D., & Sandoval-Almazán, R. (2024). Role and Governance of Artificial Intelligence in the Public Policy Cycle. In J. B. Bullock, Y.-C. Chen, J. Himmelreich, V. M. Hudson, A. Korinek, M. M. Young, & B. Zhang (Eds.), *The Oxford Handbook of AI Governance* (pp. 534–550). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197579329.013.25
Yin, R. K. (2018). *Case study research and applications: design and methods* (6th ed.). Sage.
Yu, H.-T., Chiu, Y., Chen, H.-M., Chu, D., Yi, T.-H., Lee, D., & Chao, S.-L. (2024). *COVID-19 Control and Prevention in Taipei: A Data-Driven Approach: Utilizing data on pandemic prevention.* Proceedings of the 25th Annual International Conference on Digital Government Research, Taipei, Taiwan. https://doi.org/10.1145/3657054.3657087

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

AI-Driven Innovation and Collaboration in Public Services: A Review and Taxonomy

Ramon Chaves[*] [a], *Gustavo Araujo de Oliveira* [a], *Carlos Eduardo Barbosa* [ab], *Jano Moreira de Souza* [a]

[a] Systems Engineering and Computer Science Program (PESC/COPPE), Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

[b] Centro de Análises de Sistemas Navais, Marinha do Brasil, Rio de Janeiro, Brazil

*Corresponding author: ramonchaves@cos.ufrj.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Recently, governments and organizations have expanded their interest and efforts toward acquiring Artificial Intelligence-powered systems to support the delivery of public services. However, there is insufficient information in the literature to help us understand how different types of public services are supported by AI, particularly regarding aspects such as collaboration support and the innovation achieved within organizations. To address these literature gaps, we conducted a rapid review to identify types of AI applications, problem solved, government functions supported, their impacts on innovation in public organizations, and the collaborative arrangements they have fostered among various stakeholders. Furthermore, in this same scope, we also designed a taxonomy as an analytical framework to answer the literature review questions. The review found that AI in the public sector is mainly used for prediction, data visualization, predictive analysis, and automating repetitive processes, particularly in economic affairs, health, and public order. Governments develop AI solutions primarily for administrative and repetitive tasks. In this sense, there is potential growth for new AI adoption forms and public management innovations, benefiting public service delivery and society. These contributions aim to help researchers, public managers, and tech companies better understand and analyze the complex domain of AI in public services, enabling them to develop and responsibly implement new AI solutions in the future.

Keywords. Artificial Intelligence, Public Services, Taxonomy, Digital Government, Human-AI interaction, Collaboration
Research paper, DOI: https://doi.org/10.59490/dgo.2025.950

1. Introduction

Recently, governments and organizations responsible for providing public services have increased their interest in acquiring Artificial Intelligence (AI) technologies to support public services (Sousa et al., 2019). Potential benefits are pointed out in several sectors related to the public sector, such as public health, climate change, disaster prevention and response, and government-citizen interaction, among others (Luusua et al.,2023), (Valle-Cruz et al., 2019). Such AI-powered services can be incorporated into the urban environment (Luusua et al.,2023), be made available in digital services such as citizen inquiries and information (Mehr, 2017), or be directly linked to the bureaucratic functioning of public entities or directly related to the decision-making process. of decision-making by public managers (Kuziemski and Misuraca, 2020).

In this context, many researchers have been investigating the topic of AI in the public sector. For example, Wirtz et al. (2019) present a conceptual approach to and analysis of AI applications and challenges. They identify ten AI application areas and discuss their value creation and functioning, as well as specific public use cases. Similarly, Sousa et al. (2019) discuss insights from AI projects in government and present a classification framework for AI applications in the public sector. Their framework aims to facilitate the deployment of AI in the public sector by providing a lens to different deployment-related questions.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Nevertheless, Desouza et al. (2020) and Zuiderwijk et al (2021) highlight governments and public organizations' increasing interest in and adoption of AI systems. More specifically, the first offers a systematic review of existing literature on the implications of AI in public governance, and the latter reviews a sample of 250 cases across the European Union and finds that AI is primarily used to support improving public service delivery, followed by enhancing internal management. They both also discuss the complexities and risks of implementing those systems. Also, through a systematic review, Valle-Cruz et al. (2019) collected 78 publications and applied a public policy framework to identify future areas of implementation. In addition to these, Straub et al. (2023) also conducted a literature review and developed a typology addressing concepts such as operational fitness, epistemic alignment, and normative divergence.

Despite the advancements in the field and the efforts from academia to understand this phenomenon, some aspects related to the impact of AI adoption on innovation and collaboration in the public sector remain open. Besides, it is noted that there is a need to create more robust classification structures that allow organizing knowledge about AI applications in public services.

In this sense, this work has two complementary objectives: (i) to conduct a literature review aimed at mapping how AI applications have been used, their impacts on innovation in the public sector, and the collaborative arrangements they have fostered among various stakeholders; (ii) to design a taxonomy that allows for the classification of AI applications in the public sector, including aspects related to innovation and collaboration. Furthermore, we validated the taxonomy as an analytical framework to answer the literature review questions. Finally, we expect that these contributions can support researchers, public managers, and tech companies in understanding and analyzing the complex domain of AI in public services to create and responsibly adopt new AI solutions.

2. Theoretical background

2.1 Public Services and Government Functions Definitions

As presented by Denhardt and Denhardt (2000), although the execution of services conducted by complex and organized governments is ancient, public administration as a field of practice and reflection dates back to the late 19th century. The traditional public management practice, primarily centered on hierarchy and efficiency, and the perception of the public interest has evolved. The two main contemporary streams of thought regarding models of public service revolve around the clash of market-based models focusing on efficiency versus models based on democratic values and the effectiveness of government work.

The concept of Public Services in this work is associated with the idea of Services of General Interest (SGIs), which are services provided by government and private organizations operating under some form of state regulation or public contract. The term SGI was coined within the context of the European Union and reasonably avoids the semantic ambiguities that the term' public services' may carry due to the philosophical perspective one holds on the subject. The term primarily refers to tasks and functions assumed as essential services for the quality of life of citizens, their well-being, and the functioning of society (Bjørnsen et al., 2015).

Given the differing perceptions of what constitutes public services, this work will utilize the Classification of the Functions of Government (COFOG) developed by the Organisation for Economic Cooperation and Development (OECD), as presented in Table 1, to reference the context or function of public services that AI tools support. COFOG consists of 10 first-level groups of government functions divided into 69 second-level subgroups.

Tab. 1 - Classification of the Functions of Government (COFOG).

First-level	Second-level
General public services	Executive and legislative organs, financial and fiscal affairs, external affairs
	Foreign economic aid
	General services
	Basic research
	R&D general public services
	General public services n.e.c.
	Public debt transactions
	Transfers of a general character between different levels of government
Defense	Military defense
	Civil defence

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

	Foreign military aid
	R&D defense
	Defense n.e.c.
Public order and safety	Police services
	Fire-protection services
	Law courts
	Prisons
	R&D public order and safety
	Public order and safety n.e.c.
Economic affairs	General economic, commercial and labor affairs
	Agriculture, forestry, fishing and hunting
	Fuel and energy
	Mining, manufacturing and construction
	Transport
	Communication
	Other industries
	R&D economic affairs
	Economic affairs n.e.c.
Environmental protection	Waste management
	Waste water management
	Pollution abatement
	Protection of biodiversity and landscape
	R&D environmental protection
	Environmental protection n.e.c.
Housing and community amenities	Housing development
	Community development
	Water supply
	Street lighting
	R&D housing and community amenities
	Housing and community amenities n.e.c.
Health	Medical products, appliances and equipment
	Outpatient services
	Hospital services
	Public health services
	R&D health
	Health n.e.c.
Recreation, culture and religion	Recreational and sporting services
	Cultural services
	Broadcasting and publishing services
	Religious and other community services
	R&D recreation, culture and religion

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

	Recreation, culture and religion n.e.c.
Education	Pre-primary and primary education
	Secondary education
	Post-secondary non-tertiary education
	Tertiary education
	Education not definable by level
	Subsidiary services to education
	R&D education
	Education n.e.c.
Social protection	Sickness and disability
	Old age
	Survivors
	Family and children
	Unemployment
	Housing
	Social exclusion n.e.c.
	R&D social protection
	Social protection n.e.c.

2.2 Types of problems and AI applications in Public Services

Wirtz et al. (2019) discussed types of AI applications, describing various categories of AI-based systems, their functional propositions, and public sector use cases. The systems addressed in this research are AI-Based Knowledge Management (KM) Software, AI Process Automation Systems, Virtual Agents, Predictive Analytics & Data Visualization, Identity Analytics, Cognitive Robotics & Autonomous Systems, Recommendation Systems, Intelligent Digital Assistants (IDA), Speech Analytics, Cognitive Security Analytics & Threat Intelligence. Wirtz et al. applied an AI value creation and functional proposition within each of them, as well as its use cases in the public sector.

• AI-Based Knowledge Management Software: Generation and systematization of knowledge – gathering, sorting, transforming, recording, and sharing knowledge. Distribution, sharing, and analysis of knowledge with neural networks, with its usage in the public sector on clinical documentation powered by AI.

• AI Process Automation Systems: Automation of standard tasks; performing formal logical tasks with unpredictable conditions, complex human action processes, and robotic process automation, with its usage in the public sector on Faster and higher quality request processing for immigration applications, automated image diagnoses, human-computer interaction for repetitive tasks.

• Virtual Agents: Computer-based systems that interact with users through speech analysis, computer vision, and written data input. For example, it is used in the public sector in virtual nursing assistance and chatbots to help refugees seeking asylum.

• Predictive Analysis & Data Visualization: Analytics based on quantitative and statistical data analysis. Processing of Big data for reporting, prescriptive and predictive analysis. Its usage in the public sector is in control, performance, and monitoring of public areas for police departments to determine terror threats and crime hotspots for preventive action.

• Identity Analytics: Software combined with big data, advanced analytics and identity access management to control access to IT systems with deep and machine learning. Facial recognition software is used in the public sector to verify and identify criminals in public spaces.

• Cognitive Robotics & Autonomous Systems: Higher-level cognitive function systems involving knowledge representation that can learn and respond. Its usage in the public sector in electric-powered autonomous vehicles for public transportation.

• Recommendation Systems: An information filtering system. Its usage in the public sector in E-service for government offices to provide personalized information for employees.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

• Intelligent Digital Assistants (IDA): Software based on speech analytics, providing an intuitive interface between user and system. Its public sector usage connects federal programs to IDAs to make public service information available to customers.

• Speech Analytics: Software for intelligent recognition and processing of language, translation from spoken to written language, or from one to another natural language. Its usage in the public sector in Real-time universal translation to translate speech and text in face-to-face communications in public service settings.

• Cognitive Security Analytics & Threat Intelligence: Additional application for cognitive technologies to analyze security information through natural language processing and machine learning. Its usage in the public sector in Applications like Watson for cybersecurity to support human security analysis.

Mehr et al. (2017) also acknowledge the potential benefits of AI in the public sector, such as improving government efficiency, enhancing citizen engagement, and modernizing service delivery. However, they also highlight several significant concerns, difficulties, and obstacles that must be addressed.

• Resource Allocation: Require administrative support to speed up task completion. Its Inquire response times are long due to insufficient support.

• Large Datasets: The dataset is too extensive for employees to work efficiently. Internal and external can be combined to enhance outputs and insights.

• Predictable Scenario: The situation is predictable based on historical data. Prediction will help with time-sensitive responses.

• Procedural: The task is repetitive by its nature. Its inputs and outputs have a binary answer.

• Diverse Data: It includes visual/spatial and auditory/linguistic information. Quantitative and qualitative data need to be summarized regularly.

2.3 A typology of Public Service innovation

Processing of Big data for reporting, prescriptive and predictive analysis. Its usage in the public sector is in control, performance, and monitoring of public areas for police departments to determine terror threats and crime hotspots for preventive action.

Chen et al. (2020) introduced a comprehensive typology to elucidate and classify innovative endeavors within public service organizations. This typology is characterized by two pivotal dimensions: 'innovation focus,' which encompasses three distinct public value creation processes, namely strategy, capacity, and operations, and 'innovation locus,' which discerns between internal and external innovation sources. The confluence of these dimensions yields an intricate taxonomy comprising six distinct categories of innovation, each delineated as follows:

• Mission Innovation: This classification introduces a novel worldview, mission, or overarching purpose that transcends the entirety of the organization, encapsulating a holistic transformation in its fundamental ethos.

• Policy Innovation: Within this purview, the emphasis lies in introducing new paradigms of benefits and obligations to stakeholders, aiming to address and alleviate societal issues. Policy innovation extends beyond traditional frameworks to encompass a broader societal perspective.

• Management Innovation: This facet pertains to the infusion of innovative management practices, processes, structures, or techniques, with the express objective of enhancing the organization's capacity for advancement and effectiveness.

• Partner Innovation: This category is characterized by establishing innovative partnerships to augment the organization's prowess in achieving its strategic goals and objectives. Partner innovation underscores the value of external collaborations in catalyzing organizational progress.

• Service Innovation: Under this rubric, the focus is on the inception and provision of innovative services meticulously designed to align with and fulfill the organization's overarching goals and mission.

• Citizen Innovation: This genre encompasses the creation of novel platforms and avenues geared explicitly towards facilitating citizen engagement and collaboration in pursuing organizational objectives. Citizen innovation heralds a shift towards inclusive governance models.

This typology will help identify the focus and locus of AI solutions and their contribution to innovation in public services.

2.4 Collaboration between Agents and Human-Machine Networks

Artificial intelligence can significantly enhance collaboration among diverse agents, thus facilitating innovation in public services. Hartley et al. (2013) explain that theories of collaborative innovation in the public sector emphasize the importance of network governance and inter-organizational learning. These theories highlight how

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

collaborative networks can solve complex problems and drive significant changes through interaction. Another widely recognized theory addressing how innovation is a product of interaction among multiple agents is presented by Leydesdorff & Etzkowitz (1998). Through the concept of the triple helix of innovation and entrepreneurship, the authors argue that the key agents responsible for innovation are universities, industry, and government through their interactions. Therefore, this collaboration is essential for knowledge-based economic growth, as it allows the public sector to benefit from the knowledge and expertise of academia and industry. The innovations resulting from this process can potentially transform the delivery of public services, making them more efficient, accessible, and tailored to societal needs.

Furthermore, Linders (2012) highlights citizens as another important agent by emphasizing the growing significance of "citizen co-production" in public service provision. Instead of being passive clients, citizens play an active role as partners in service delivery. This approach helps mitigate budgetary challenges in the public sector and leverages new technological tools that enable mass collaboration. As technology advances, the relationship between government and citizens evolves, with "citizen co-production" becoming more relevant and feasible. This phenomenon means that citizens can actively contribute to innovation in the delivery of public services by participating in policy definition and service improvement.

Kattel et al. (2020) focus on the increasing adoption of technology and automation in the public sector, presenting intelligent machines as yet another agent. As intelligent machines play a greater role in delivering public services, collaboration includes machine-machine and human-machine interactions. These interactions are shaping the space for innovation as new technologies and approaches are developed to enhance the efficiency and quality of public services. Automation and artificial intelligence can play a fundamental role in process optimization, data collection and analysis, and personalization of services to meet individual citizens' needs. Furthermore, Tsvetkova et al. (2017) demonstrated that we can represent the collaboration between human agents and intelligent machines through graphical schemes illustrating human-machine networks and their fundamental interactions. In this research context, hybrid arrangements produce synergistic effects in the provision of public services.

3. Methodology

In broad terms, the research design developed to conduct this study integrates, in a complementary manner, the methodological procedures of the Rapid Review method (Tricco et al., 2015) and a method for developing taxonomies in the Information Systems (Nickerson et al., 2013). A Rapid Review is a simplified approach to Systematic Review, where some steps, such as information search and synthesis, can be omitted (Tricco et al., 2015). On the other hand, Nickerson et al. (2013) proposed a method for developing taxonomies that incorporates the Design Science Research (DSR) (Iivari, 2007) approach to generate new knowledge about AI applications in government while designing the artifact, in this case, the taxonomy.

Figure 1 illustrates the methodological procedures carried out in parallel for the rapid review and taxonomy development. After defining the research questions, conducting the search process, and selecting the studies, the extracted data was utilized to develop the taxonomy. This section provides an overview of the review process as well as the systematic approach to creating a comprehensive taxonomy. It details each phase, from establishing the initial meta-characteristics and ending conditions to the iterative refinement cycles, transitioning between conceptual-to-empirical and empirical-to-conceptual stages.

In the first iteration, following a Conceptual-Deductive approach, 60 AI use cases from the selected publications in the review are examined based on the conceptualized characteristics and dimensions. Subsequently, during the second iteration, employing an empirical-inductive approach, all the 103 AI use cases in the selected publications in the review are utilized to identify common characteristics and perform object groupings. After grouping the characteristics into dimensions, we refined the taxonomy. Once finalized, we validated the taxonomy using an analytical framework for data analysis and synthesis of the 103 AI use cases described in the publications.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

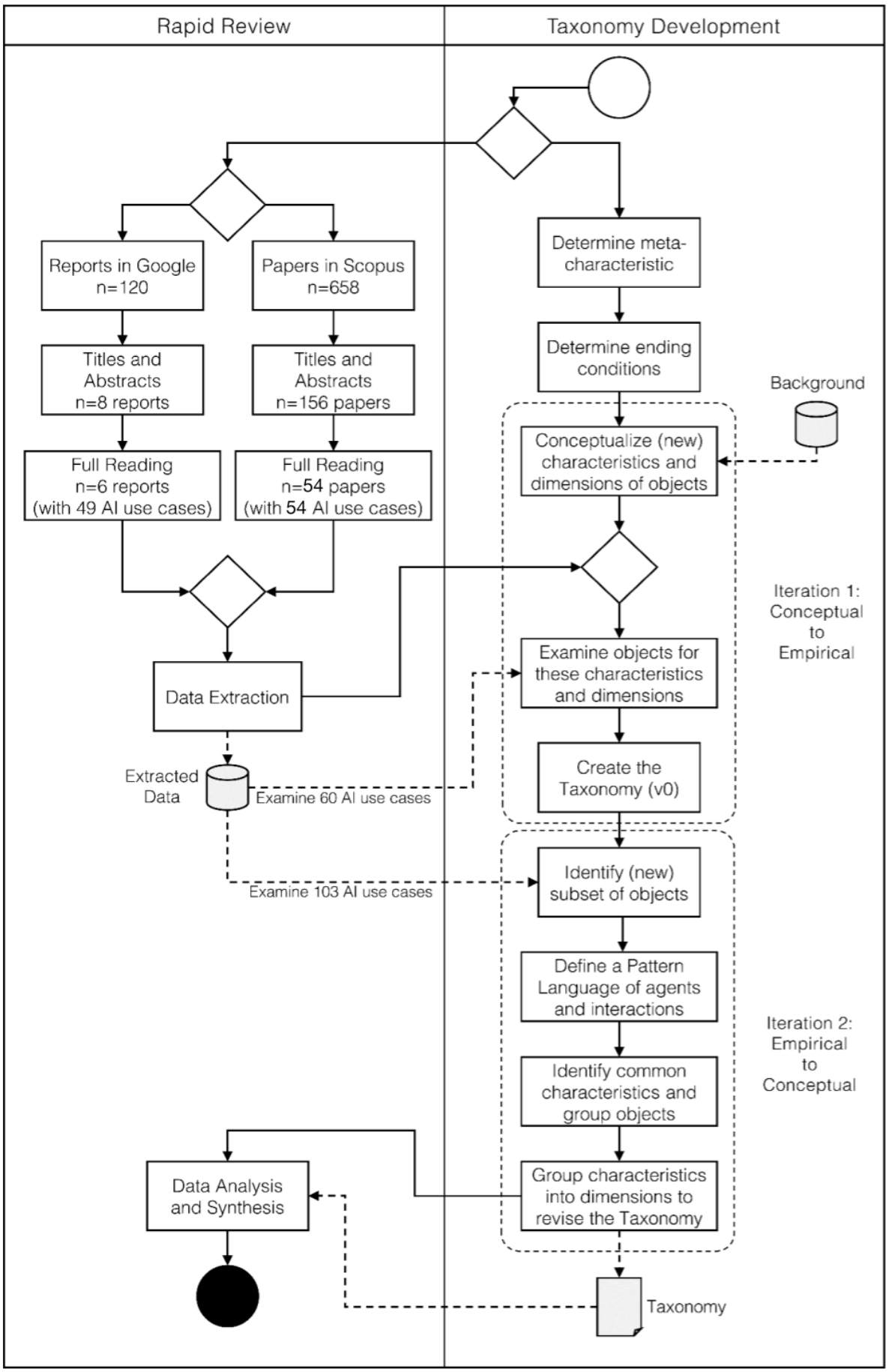


Fig. 1. Diagram of the Research Process.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3.1 Research Questions and Search Process

The planning of this review enables the identification of objectives and the construction of a protocol that presents the research methodology used. Table 2 shows three research questions (RQs) developed to characterize how AI applications have been used, their impacts on innovation in the public sector, and the collaborative arrangements they have fostered among various stakeholders.

Tab. 2 - Research Questions.

ID	Research Question
RQ1	What are the types of AI solutions developed to support public services? And what problems do they solve?
RQ2	Which government functions are using artificial intelligence? And what is the extent of these government functions covered by AI?
RQ3	In what ways do AI solutions support collaboration in the public sector? And, what types of innovation are achieved by implementing AI in public service organizations?

We formulated a search string to answer the research questions by combining terms related to the topic. Tab. 3 shows the search terms. We tested several string combinations of the terms to assess the potential of the returned results. The searches were conducted in the Scopus database for dates after 2018.

Tab. 3 - Search String for Scopus database.

SUBJAREA (comp) TITLE-ABS-KEY (“Artificial Intelligence” OR “Machine Learning” OR “AI”) AND TITLE-ABS-KEY (“public services” OR “public sector” OR “government” OR “city”) AND TITLE-ABS-KEY (“collaborat*” OR “cooperat*”) AND PUBYEAR > 2018

We also formulated another string to collect public reports directly in the Google search engine, as shown in 4. It was necessary because many AI solutions adopted by the public sector are described only in the gray literature.

Tab. 4 - Search String for Google search.

(“Artificial Intelligence” OR “AI” OR “machine learning”) AND (“public services” OR ‘government“ OR “public sector” OR “city”) AND (“collaborate” OR “cooperate”)

3.2 Selection of Studies and Quality Assessment

Table 5 presents the exclusion criteria applied across the search engines throughout the search process. In the Scopus database, the first step involved using the search strings, which returned 658 publications. Then, duplicate publications were excluded, and all selected publications had their titles and abstracts analyzed according to the exclusion criteria, resulting in 156 publications. In the full reading step, we applied the exclusion criteria again and selected 54 publications, each with one AI use case. In Google, the first step involved using the search strings that yielded 33.800.000 results. Then, we went through the first 120 results on the list, evaluating titles and abstracts according to the exclusion criteria. This process resulted in 8 reports with a collection of AI use cases in the public sector. In the full reading step, we again applied the exclusion criteria and selected six reports with 49 AI use cases.

Tab. 5 - Exclusion Criteria.

Criterion	Scopus	Google
The study does NOT answer at least one research question from the RQs	✓	✓
The study does NOT present at least one developed application	✓	✓
The study is a literature review	✓	✓
The study is NOT a report with a collection of AI cases in the public sector		✓

3.3 Meta-characteristic and Ending Conditions

We started by defining a clear meta-characteristic as the base for all classifications. This meta-characteristic ensures that every category logically follows from it, avoiding arbitrary groupings and addressing the needs of scholars, practitioners, and public managers. These users are interested in high-level features that allow them to understand AI's various concepts and applications in public services and how the agents involved collaborate or do not collaborate with these systems. In this sense, these users are not interested in technical aspects of AIs, such as the algorithms used, the model training technique, or the strategies applied for data processing. By anchoring our taxonomy in this high-level meta-characteristic, we ensure each category is relevant and aligned to clarify AI’s essential properties and practical uses in the public sector. This method provides the taxonomy remains coherent

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and purposeful throughout its development.

Our taxonomy development process follows objective and subjective ending conditions as Nickerson et al. (2013) outlined. The objective conditions are met when the taxonomy is mutually exclusive and collectively exhaustive, meaning each element of AI in public services fits into one unique category without overlap, and all possible elements are covered. The subjective conditions require the taxonomy to be concise, robust, comprehensive, extensible, and explanatory. These conditions imply that the taxonomy should have a manageable number of well-differentiated categories, cover all relevant aspects of AI in public services, allow for future additions, and provide clear, valuable explanations. The development process concludes when these conditions are fully satisfied, ensuring the taxonomy is valid and useful for its intended users.

3.4 First Iteration: Conceptual-to-Empirical

In this iteration, we decided to use a conceptual-to-empirical approach because we already had a theoretical background that provided relevant conceptualizations for this study. From this background, we conceptualized the following dimensions: AI application (Wirtz et al., 2019), Problem-solving (Mehr, 2017), Innovation (Chen et al., 2020), and Government Function (COFOG) (OECD,2023).

Then, we randomly selected 60 of the 103 use cases collected in the literature review and examined them according to the conceptualized characteristics. We noticed that almost all the characteristics identified in the four dimensions corresponded in at least one of the observed cases. The only exception was the Government Function dimension, which had several unmatched characteristics across use cases. Despite this, we still decided to maintain these characteristics because, even if there are no AI applications for certain government functions, soon, this could be different.

Although we inserted four dimensions in this iteration, making it concise, extendable, and explanatory, we realized it could become more robust if we included one more dimension related to supporting collaboration. Because of this, we decided to carry out a second iteration.

3.5 Second Iteration: Empirical-to-Conceptual

In this iteration, we used an empirical-to-conceptual approach to include a new dimension related to collaboration support and discover its characteristics. To do this, we selected all 103 cases from the literature review so that common characteristics could be analyzed and identified.

However, before starting this analysis, defining the types of agents and their relevant interactions was necessary to characterize collaboration. To do this, we were inspired by the work used by Tsvetkova et al. (2017) and used a Human-Machine Networks approach to conduct this research stage. More specifically, we define a pattern language (Van Welie and Van der Veer, 2003) based on an arrangement of agents and interactions, as presented in Fig. **2**.

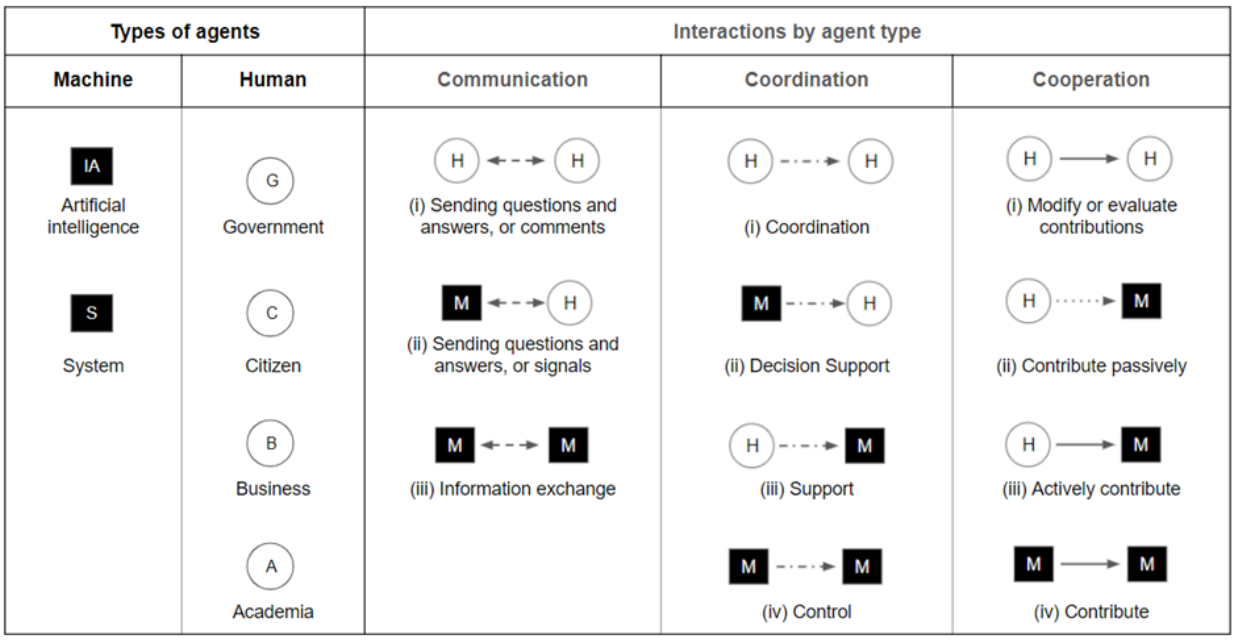


Fig. 2 - Pattern Language of Agents and Interaction in AI in the Public Sector.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In this arrangement, first, we define the types of agents, which can be machines or humans. The machines were identified as Systems or Artificial Intelligence. System refers to public or private systems that already exist and are in use, which can be traditional information systems or systems that include physical devices such as sensors, actuators, and signals (such as traffic systems and their traffic lights, for example). Artificial Intelligence refers to the AIs presented in the respective selected studies and is a new element within the specific government context in which it is applied. As for human agents, we identified from the theoretical background that Government, Citizens, Business (this term includes industry), and Academia are the main interested parties capable of interacting and collaborating.

Next, we define the types of interactions related to communication, coordination, and cooperation (Fuks et al., 2008). Communication involves exchanging questions, answers, comments, or signals between humans, between humans and machines, and between machines themselves. Coordination occurs when humans organize and manage others, machines support human decision-making, organizations or individuals maintain system functionality through resources and technical upkeep, and machines have command and control relationships with others. Cooperation involves humans modifying or evaluating the contributions of others, passive contributions from humans to machines usually collected automatically, active and voluntary contributions between humans and machines, and machines building upon the contributions of other machines.

We analyzed the 103 use cases identified in the literature from the constructed pattern language. The HMN arrangements represent how they incorporated AI in that government context. Therefore, it was possible to identify common characteristics and group objects according to the agents involved. Fig. **3** presents the primary arrangements already grouped according to the agents involved, which are the characteristics of this new dimension called collaboration support.

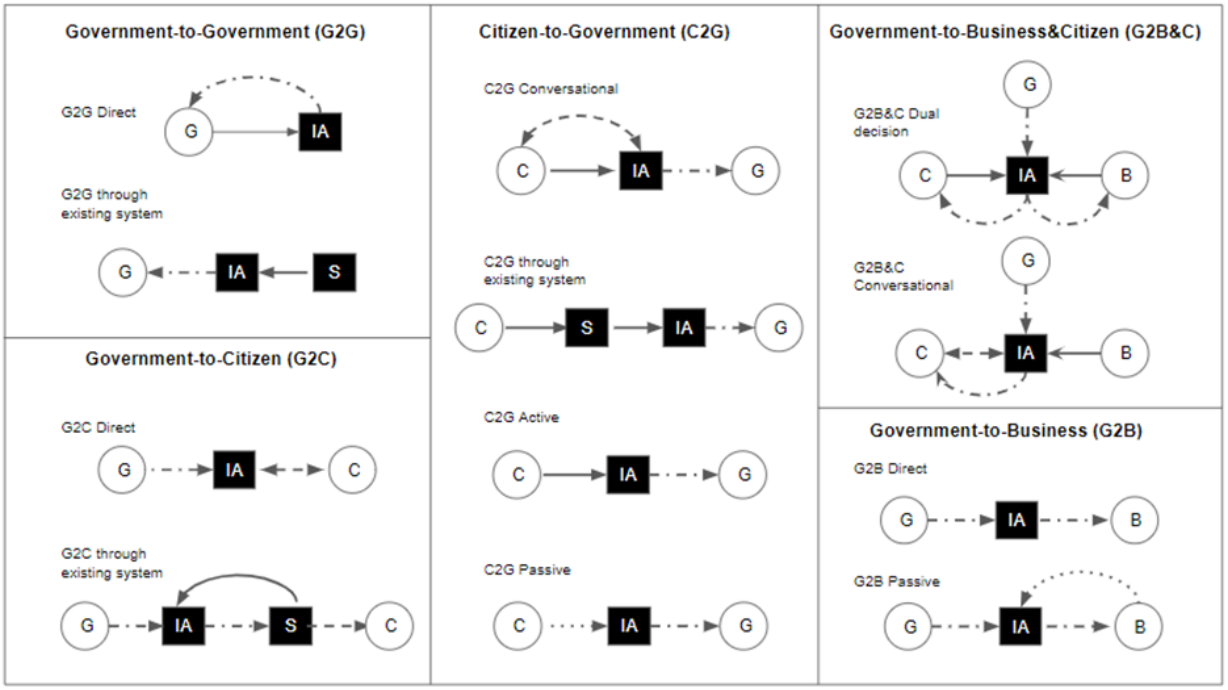


Fig. 3 - Collaboration Support grouped by the Agents involved.

Below, we summarize these main characteristics and sub-characteristics found and described in Fig. **3**:

Government-to-Government (G2G): The government uses AI to solve its own problem. It could be an internal approach for a particular agency or an inter-agency solution.

- Direct G2G: The government actively contributes to AI, providing the necessary data, and AI supports some decision-making directly.

- G2G through the existing system: There is another existing system, private or from the public sector itself, that provides data for the AI and supports some government decision-making.

Government-to-Citizen (G2C): The Government provides an AI capable of supporting citizens in some task type.

- G2C through the existing system: The government supports an AI that receives active contributions from another system and simultaneously controls it, with this system being responsible for sending signals to

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

citizens.

- Direct G2C: The government supports an AI that exchanges questions and answers or sends signals to citizens.

Citizen to Government (C2G): The government supports an AI that directly or indirectly interacts with citizens, obtains information, and supports government decision-making.

- Conversational C2G: Citizens advancing AI while exchanging questions and answers. The data obtained in this process supports government decisions.

- C2G through existing system: Citizens active with an existing system, who in turn actively contribute AI to support government decisions.

- Active C2G: Citizens advanced with AI, and the data obtained in this process supports government decisions.

- Passive C2G: Citizens invest passively with AI, and the data obtained from this process supports government decisions.

Government-to-Business&Citizen (G2B&C): The government leverages AI to support collaboration between citizens and businesses.

- G2B&C Dual Decision: The government supports an AI that receives active contributions from citizens and businesses while supporting the decision-making of these same agents.

- Conversational G2B&C: The government sustains an AI that receives active input from businesses, exchanges questions and answers with citizens, and supports the latter's decision-making.

Government-to-business (G2B): The government supports AI to support businesses.

- Direct G2B: The Government supports AI that supports companies' decision-making.

- Passive G2B: The Government supports an AI that supports companies' decision-making based on passive contributions from the last.

4. Results

4.1 Taxonomy for AI applications for public services

As presented previously, throughout the first iteration with a Conceptual-to-empirical approach, it was possible to conceptualize the taxonomy with the following dimensions: AI application, Problem Solved, Innovation, and Government Function (COFOG), which were already described. In the second iteration, we conceptualized a new dimension called collaboration support and its characteristics with an empirical-to-conceptual approach.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

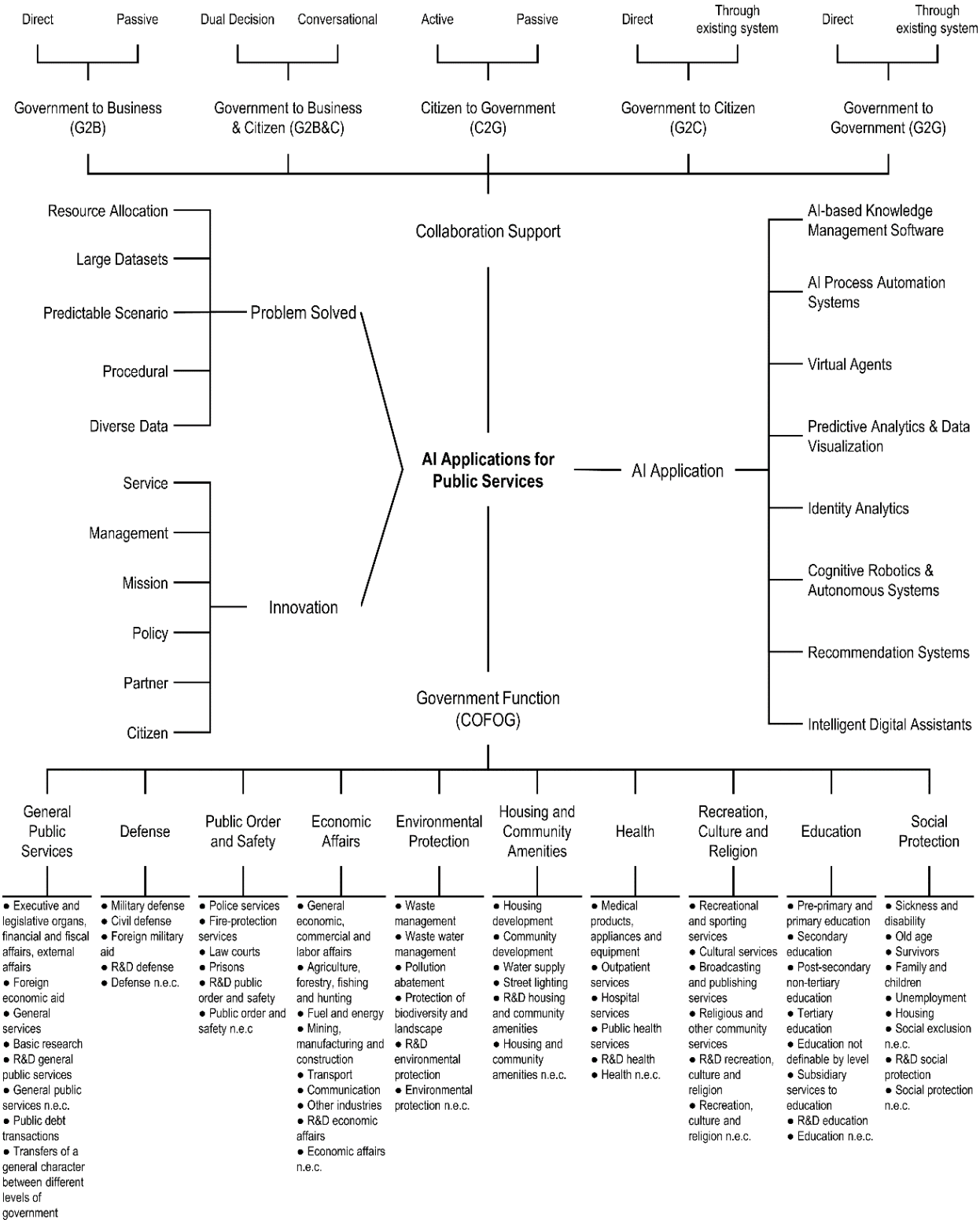


Fig. 4 - Taxonomy of AI applications in the Public Sector.

4.2 Answering the Research Questions

Once we conceptualized the taxonomy, we analyzed the documents identified during the review to demonstrate the usefulness and generalizability of the proposed taxonomy. In this way, we applied the taxonomy as an analytical framework to make it possible to answer the following questions below.

RQ 1: What are the types of AI solutions developed to support public services? And what problems do they solve?

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The primary type of AI solution identified, as seen in Fig. **5**, was Predictive Analysis & Data Visualization, followed by AI Process Automation Systems in 41.75% and 22.33% of cases, respectively. All other types were below 10% of occurrence each, with a greater emphasis on Intelligent Digital Assistants (IDA) and AI-Based Knowledge Management (KM) Software, identified in 9.71% and 6.80% of cases, respectively.

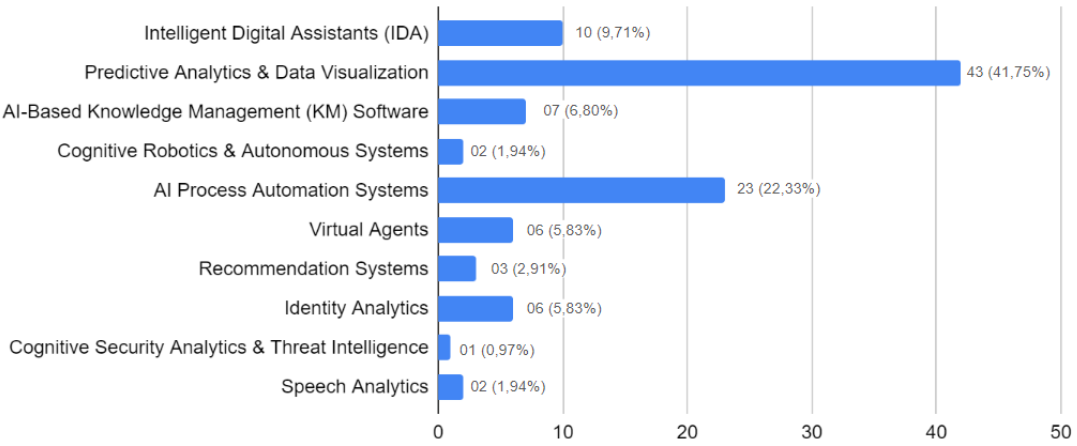


Fig. 5 - Distribution of types of AI applications in the publications analyzed.

As for the types of problems solved through AI, it is clear that the main problems addressed are the Diverse Data and Predictable Scenario problems, identified in 41.75% and 27.18% of cases, respectively. All other types were below 13% of occurrence each, with a greater emphasis on Resource Allocation, identified in 12.62% of cases, as seen in Fig. **6.**

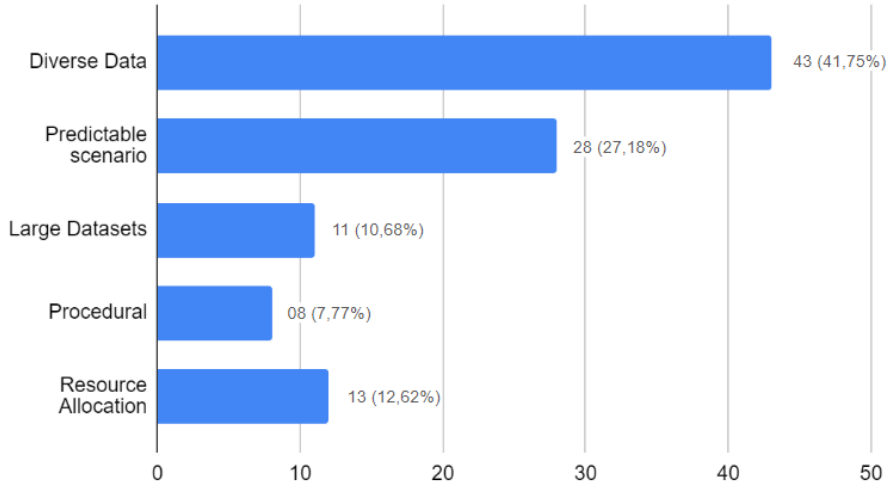


Fig. 6 - Distribution of types of problems in the publications analyzed.

Fig. **7** presents the correlation between the problems identified and the AI solutions employed. The same solution can be used to solve different problems, as in the case of Predictive Analysis & Data Visualization, which addresses four of the five types of problems encountered. The same problem can be solved through different solutions, as in the case of Diverse Data, which is addressed by nine of the ten types of solutions. Furthermore, somewhat obviously, the relationship between Predictive Analysis & Data Visualization solutions and Predictable Scenario problems stands out, with an occurrence of 24%. Next, the Predictive Analysis & Data Visualization solution stands out again, but now with the relationship with Diverse Data problems with an occurrence of 10.68%. Next, the relationships between the AI Process Automation Systems Solution and the Diverse and Procedural problems stand out, with 9.71% and 7.77% of the cases found.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

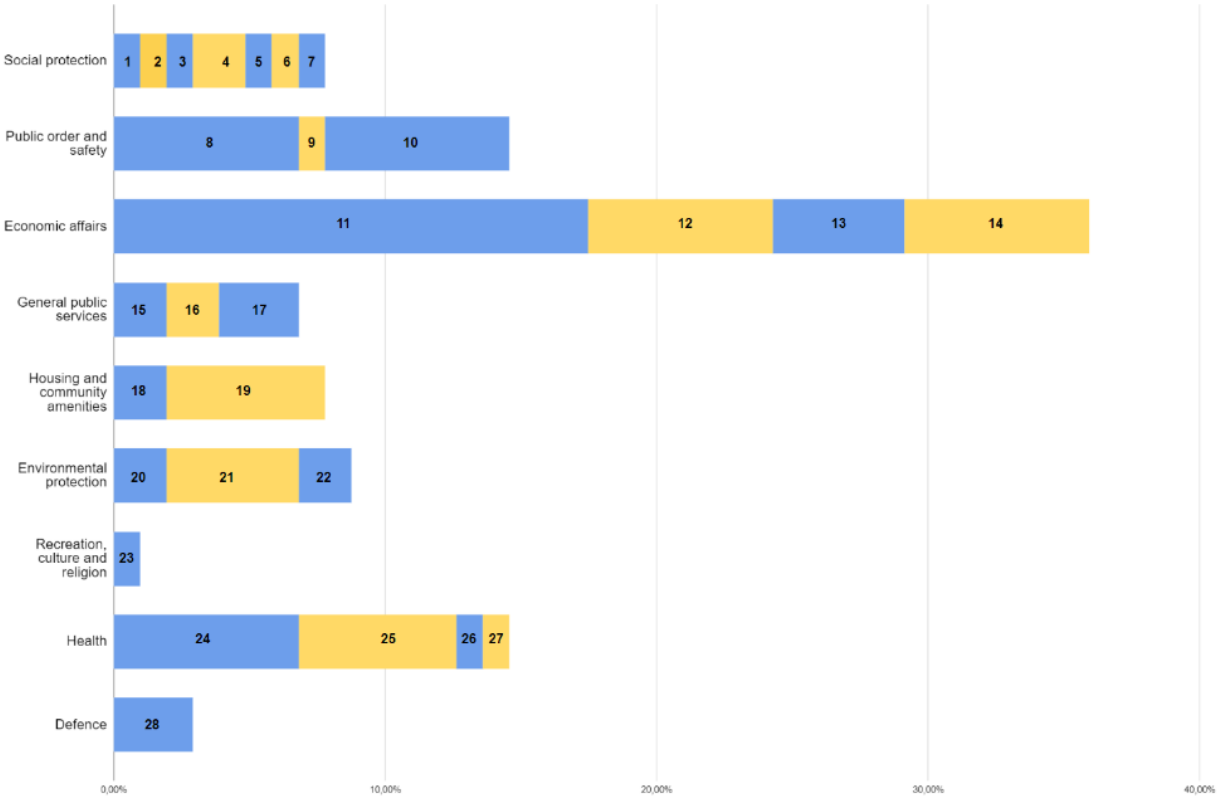
	Resource Allocation	Large Datasets	Predictable scenario	Procedural	Diverse Data
AI-Based Knowledge Management (KM) Software	0,00%	2,91%	0,00%	0,00%	3,88%
AI Process Automation Systems	2,91%	1,94%	0,00%	7,77%	9,71%
Virtual Agents	1,94%	0,00%	0,00%	0,00%	3,88%
Predictive Analytics & Data Visualization	2,91%	3,88%	24,27%	0,00%	10,68%
Identity Analytics	0,97%	0,97%	0,00%	0,00%	3,88%
Cognitive Robotics & Autonomous Systems	0,00%	0,00%	1,94%	0,00%	0,00%
Recommendation Systems	0,97%	0,00%	0,97%	0,00%	0,97%
Intelligent Digital Assistants (IDA)	1,94%	0,97%	0,00%	0,00%	6,80%
Speech Analytics	0,97%	0,00%	0,00%	0,00%	0,97%
Cognitive Security Analytics & Threat Intelligence	0,00%	0,00%	0,00%	0,00%	0,97%

Fig. 7 - Correlation heat map for problems and AI applications.

RQ 2: Which government functions are using artificial intelligence? And what is the extent of these government functions covered by AI?

The central government function category that stands out is Economic Affairs, followed by Public Order and Safety, and Health, with 35.92%, 14.56%, and 14.56%, respectively, as can be seen in Fig. **8**. All other government function categories individually do not reach 9% of occurrences; if totaled, they reach 34.96%. As for the most prominent government function subcategories, we have Transport (#11) within the Economic Affairs category with 17.48% and then tied with 6.80%. We have the subcategories of Law Courts (#10), Agriculture, Forestry, fishing and hunting (#12), General, economic, commercial and labor affairs (#14), and Hospital services (#24) from the categories of Public Order and Safety, Economic Affairs, Economic Affairs, and Health respectively. Of all 28 subcategories, 16 (57.14%) present up to 1.94% of occurrences and a total of 21.34% of occurrences.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



Social protection 7,77%		
1	Survivors	0,97%
2	Housing	0,97%
3	Family and children	0,97%
4	Social protection n.e.c	1,94%
5	Unemployment	0,97%
6	Old age	0,97%
7	R&D social protection	0,97%

Public order and safety 14,56%		
8	Police services	6,80%
9	Fire-protection services	0,97%
10	Law courts	6,80%

General public services 6,80%		
15	Executive and legislative organs, financial and fiscal affairs, external affairs	1,94%
16	R&D general public services	1,94%
17	General public services	2,91%

Environmental protection 8,74%		
20	R&D environmental protection	1,94%
21	Pollution abatement	4,85%
22	Environmental protection n.e.c.	1,94%

Health 14,56 %		
24	Hospital services	6,80%
25	Public health services	5,83%
26	Medical products, appliances and equipment	0,97%
27	Outpatient services	0,97%

Economic affairs 35,92%		
11	Transport	17,48%
12	Agriculture, forestry, fishing and hunting	6,80%
13	Fuel and energy	4,85%
14	General economic, commercial and labour affairs	6,80%

Housing and community amenities 7,77%		
18	Housing development	1,94%
19	Community development	5,83%

Recreation, culture and religion 0,97%		
23	Cultural services	0,97%

Defence 2,91%		
28	Civil defence	2,91%

Fig. 8 - Distribution of Government Functions in the publications analyzed.

On the other hand, as can be seen in Fig. **9**, it is worth mentioning that the fact that some categories, such as Education and Defense, still seem to be poorly supported by AI, which may be a reflection of a limitation of this research related to the search protocol used. More specifically, in the case of Defense, for example, it may be that AI research is being published in other forums that were not reached with the strings used in the database consulted (Scopus). The same goes for the Education category, which, despite having many new features related to well-publicized AI applications, was not mentioned in this work, probably because the published AI applications for educational purposes are developed with a focus on the private sector that sees AI as a solution capable of bringing competitive advantage. Regardless of the limitations of this research, it is possible to note that seven of the ten government function categories have at least 50% of subcategories not supported by AI.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

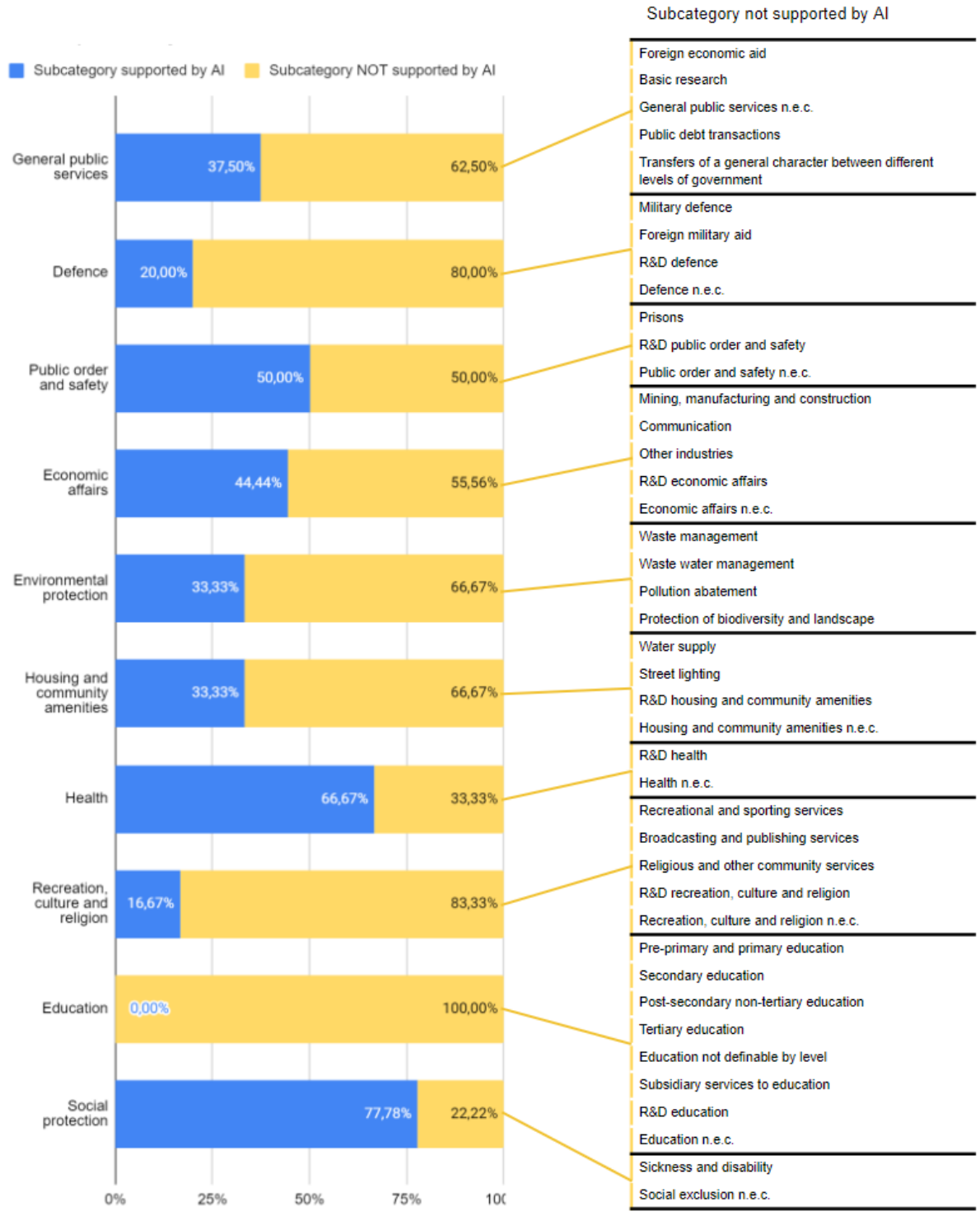


Fig. 9 - Distribution of the AI support in different Government Functions in the publications analyzed.

RQ 3: In what ways do AI solutions support collaboration in the public sector? And, what types of innovation are achieved through the implementation of AI in public service organizations?

The main collaboration category identified is Government-to-Government (G2G), followed by Citizen-to-Government (C2G), with 67.9% and 16.5% of occurrences, respectively, as seen in Fig. **10**. When we analyze the collaboration subcategories, we find that the G2G Direct subcategory is identified in 65% of cases, followed by C2g Active. All subcategories were identified individually, with a maximum of up to 4.9% of occurrences each.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

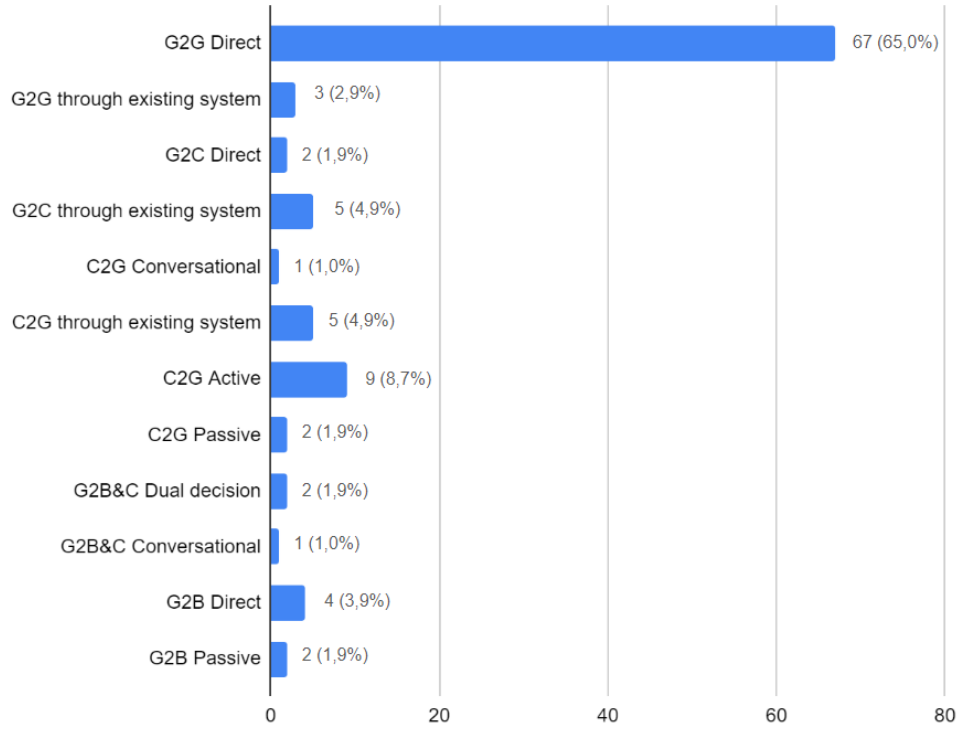


Fig. 10 - Distribution of types of Collaboration support in the publications analyzed.

As shown in Fig. **11**, regarding the type of innovation in organizations providing public services, innovations at the Management, Citizen, and Policy levels stand out mainly with 55.3%, 16.5%, and 11.6% of occurrences, respectively. The other types of innovation do not exceed 6.8% of occurrences each. It is also important to highlight that there is no direct relationship between the classification made regarding collaboration and the classification made regarding innovation. For example, the fact that collaboration involves citizens in some way does not imply that that innovation will necessarily be characterized as an innovation at the citizen level.

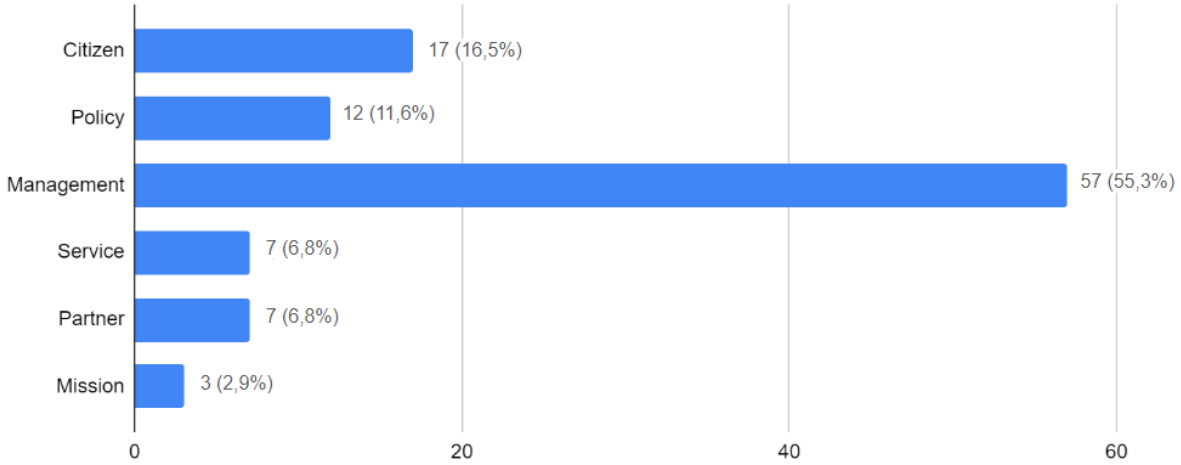


Fig. 11 - Distribution of types of Innovation in the organization in the publications analyzed.

5. Discussion

5.1 AI support beyond government administrative tasks

Based on the results of this research, AI in the public sector is primarily oriented towards addressing prediction problems and diverse datasets. Hence, the solutions often involve data visualization and predictive analysis, as well as the automation of repetitive processes. Furthermore, AI is predominantly applied in government functions such as Economic Affairs, Health, and Public Order. The reasons for the predominance of AI adoption in these areas are uncertain. One possible driver for acquiring these technologies may be the budget, as Economic affairs and Health are among the 4 COFOGs with the highest expenditure (Eurostat., 2024). However, this factor does not explain the high adoption of AI in the Public Order government function. The willingness to adopt AI technologies in

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

government depends on how officials perceive their positive and negative impacts on society in the long run and their familiarity with these technologies (Ahn and Chen, 2022). In this way, some of the impacts of AI have already been part of the collective social imagination for a long time, such as health and transport (inserted in economic affairs) as hopeful visions or the threat of surveillance, which denotes its power to be applied in the context of public order (Fast and Horvitz, 2017).

In terms of collaboration, it is evident that most of the collaboration achieved is within the government itself. The government tends to create technological solutions that it will utilize internally. When citizens are involved, they typically interact with AI systems to facilitate the production of information, knowledge, or decision support that the government needs. The government mainly develops AI solutions to its administrative and repetitive problems. These problems are often characterized by having extremely diverse, poorly structured, and fragmented datasets that require automation and predictive capabilities, particularly in sectors with large budgets.

While this focus on administrative efficiency is somewhat expected and natural, there is also a range of applications, problems, government functions, and innovative and collaborative efforts that, although currently in the minority, show significant potential for growth. For instance, government initiatives using AI applications can operate as platforms (O'Reilly, 2011) that impact citizens and businesses in crucial areas to enhance life quality and contribute to sustainable development goals (Singh et al., 2024). The concept of public services in this research is associated with Services of General Interest (SGIs), which are tasks and functions deemed essential for the quality of life of citizens, their well-being, and the overall functioning of society.

In this light, the diversity found in AI applications within the public sector offers alternative and innovative pathways for public services. These pathways differ from the traditional models we have seen and hold the potential for disruptive innovation, leading to new collaborative governance models. Such models could transcend the current dichotomy between market-based approaches focused on efficiency and those grounded in democratic values and the effectiveness of government work. This research underscores AI's potential to streamline administrative tasks and drive meaningful improvements in public service delivery, ultimately benefiting society.

5.2 How do Language Models and this Taxonomy connect?

When this research began, we had not yet experienced the boom of generative AI and the use of LLMs on a large scale. The rapid adoption of LLMs, which are machines with conversational and textual synthesis capabilities previously unfamiliar to much of the public, combined with extensive marketing from AI companies often backed by big tech, presents a vision of the future where LLMs are seen as a near step to Artificial General Intelligence (AGI). This AI hype already presents us with costs and threats that go opposite to what governments should pursue (Markelius et al., 2024). Furthermore, overestimating the ability to use LLMs in the public sector can generate a series of problems, and the risks of its use must be mitigated well (Analysis and Research Team, 2023).

In other words, AI lacks genuine understanding despite its ability to mimic human communication (Bishop, 2021). LLM does not indicate a direct pathway to AGI and its generalized problem-solving capabilities, but we can consider Biological and Quantum approaches to AGI (Mohammad et al., 2023). Therefore, we use Narrow AI (Berryhill et al., 2019), which refers to a machine with specific capabilities. In this context, the taxonomy presented in this work is especially valuable as it offers an analytical framework for classifying AI applications and types of problems, reminding us that LLM is not a panacea for the public sector challenges.

So, a question that might arise for those using the taxonomy is: how do LLMs fit into the dimension of AI application? First, it's important to understand how the specific LLM is primarily used to answer this question. Second, it's important to consider that a particular LLM could be part of a more robust architecture capable of presenting various capabilities. However, this is not unique to LLMs. Some solutions investigated in the review also pointed to certain multi-capabilities. Nonetheless, this is entirely different from claiming that LLMs, simply because they are LLMs, can perform all the diverse capabilities of various types of AI applications.

6. Conclusion

In this work, we investigated the support of AI-powered technologies in public services. Despite advancements in the field and academic efforts to understand the phenomenon, certain aspects related to the impact of AI adoption on innovation and collaboration in the public sector remain unresolved. A recognized need is also to create more robust classification structures for organizing knowledge about AI applications in public services. To address these gaps, we conducted a rapid review to identify how AI applications have been used, their impacts on innovation in the public sector, and the collaborative arrangements they have fostered among various stakeholders. Furthermore, we designed a taxonomy to classify AI applications in the public sector that was used as an analytical framework to answer the research questions.

The review results indicated that AI in the public sector is mainly used for prediction problems with diverse

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

datasets, involving data visualization, predictive analysis, and automating repetitive processes. These applications are primarily found in economic affairs, health, and public order. These are government functions with substantial budgets and where potential AI applications have been part of the collective imagination for a long time. Generally, governments develop AI solutions to their administrative and repetitive problems. However, fewer applications and collaborative arrangements were identified, suggesting potential growth for new AI adoption forms and possible public management disruptions, ultimately benefiting public service delivery and society.

Regarding the development of the taxonomy, two iterative cycles led to a result encompassing five dimensions along with a new conceptualization of collaborative arrangements based on a language of patterns of agents and interactions. Ultimately, these contributions are expected to support researchers, public managers, and tech companies in understanding and analyzing the complex domain of AI in public services to create and responsibly adopt new AI solutions in the future.

The main limitation of this study lies in the search protocol. Our search strings did not include broader terms such as "algorithm", nor did they draw from curated repositories like the OECD AI Observatory. Consequently, we may have overlooked relevant cases, especially AI applications in health, education, and defence that, although developed in predominantly private settings, are already being adopted by public organisations. Moreover, our collaboration framework (G2G, G2C, C2G, G2B..) aggregates interactions at a macro level and therefore does not adequately reflect public-private partnerships, citizen co-creation initiatives, or decentralised governance arrangements. Finally, ethical risks and challenges, algorithmic bias, transparency, accountability, and citizen trust, receive only limited attention.

Future work will address these gaps by (i) expanding the search strategy with additional descriptors and specialised databases to capture a more diverse set of cases; (ii) developing an extended version of this article that includes detailed case studies, demonstrating the taxonomy's applicability and refining it to accommodate intergovernmental and multi-stakeholder collaborations; and (iii) deepening the discussion on ethics and AI governance in the public sector by integrating systematic risk assessments and models of organisational, social, and environmental impact. These efforts aim to guide both the development of more responsible, explainable AI solutions and the formulation of evidence-based public policies.

Acknowledgement

- **Funding or Grant:** Coordenação de Aperfeiçoamento de Pessoal de Nível Supe-rior,001,001,
- **Data/Software Access Statement** : The data supporting this paper's findings is available upon request.
- **Contributor Statement**: Ramon Chaves: Conceptualization, Investigation, Methodology, Visualization, Writing – Original Draft; Gustavo Araujo de Oliveira: Investigation, Software, Writing – Original Draft; Carlos Eduardo Barbosa: Methodology, Validation, Writing – Review & Editing; Jano Moreira de Souza: Resources, Supervision.
- **Use of AI**: During the preparation of this work, the authors used ChatGPT in order to support text processing tasks such as translation and rewriting to improve clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Ahn, M. J., & Chen, Y.-C. (2022). Digital transformation toward AI-augmented public administration: The perception of government employees and the willingness to use AI in government. Government Information Quarterly, 39(2), 101664. https://doi.org/10.1016/j.giq.2021.101664

Analysis and Research Team (ART). (2023). ChatGPT in the public sector – overhyped or overlooked? Council of the European Union. https://www.consilium.europa.eu/media/63818/art-paper-chatgpt-in-the-public-sector-overhyped-or-overlooked-24-april-2023_ext.pdf

Berryhill, J., Heang, K. K., Clogher, R., & McBride, K. (2019). Hello, World: Artificial intelligence and its use in the public sector (OECD Working Papers). OECD. https://doi.org/10.1787/726fd39d-en

Bishop, J. M. (2021). Artificial intelligence is stupid and causal reasoning will not fix it. Frontiers in Psychology, 11, Article 513474. https://doi.org/10.3389/fpsyg.2020.513474

Bjørnsen, H. M., Foss, O., & Johansen, S. (2015). The concept and definition of services of general interest. In Services of General Interest and Territorial Cohesion: European Perspectives and National Insights (p. 275). V&R Unipress.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Chen, J., Walker, R. M., & Sawhney, M. (2020). Public service innovation: A typology. Public Management Review, 22(11), 1674–1695. https://doi.org/10.1080/14719037.2019.1645874

Denhardt, R. B., & Denhardt, J. V. (2000). The new public service: Serving rather than steering. Public Administration Review, 60(6), 549–559. https://doi.org/10.1111/0033-3352.00117

Desouza, K. C., Dawson, G. S., & Chenok, D. (2020). Designing, developing, and deploying artificial intelligence systems: Lessons from and for the public sector. Business Horizons, 63(2), 205–213. https://doi.org/10.1016/j.bushor.2019.11.004

Eurostat. (2024). Government expenditure by function – COFOG. Eurostat - Statistics Explained. Retrieved July 4, 2024, from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Government_expenditure_by_function_%E2%80%93_COFOG

Fast, E., & Horvitz, E. (2017). Long-term trends in the public perception of artificial intelligence. Proceedings of the AAAI Conference on Artificial Intelligence, 31(1). https://doi.org/10.1609/aaai.v31i1.10635

Fuks, H., Raposo, A., & Gerosa, M. A. (2008). The 3C collaboration model. In S. Kelsey & K. St. Amant (Eds.), Encyclopedia of E-collaboration (pp. 637–644). IGI Global.

Hartley, J., Sørensen, E., & Torfing, J. (2013). Collaborative innovation: A viable alternative to market competition and organizational entrepreneurship. Public Administration Review, 73(6), 821–830. https://doi.org/10.1111/puar.12136

Iivari, J. (2007). A paradigmatic analysis of information systems as a design science. Scandinavian Journal of Information Systems, 19(2), Article 26.

Kattel, R., Lember, V., & Tõnurist, P. (2020). Collaborative innovation and human-machine networks. Public Management Review, 22(11), 1652–1673. https://doi.org/10.1080/14719037.2019.1645873

Kuziemski, M., & Misuraca, G. (2020). AI governance in the public sector: Three tales from the frontiers of automated decision-making in democratic settings. Telecommunications Policy, 44(6), 101976. https://doi.org/10.1016/j.telpol.2020.101976

Leydesdorff, L., & Etzkowitz, H. (1998). Triple helix of innovation: Introduction. Science and Public Policy, 25(6), 358–364. https://doi.org/10.1093/spp/25.6.358

Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. Government Information Quarterly, 29(4), 446–454. https://doi.org/10.1016/j.giq.2012.06.003

Luusua, A., Ylipulli, J., Foth, M., & Aurigi, A. (2023). Urban AI: Understanding the emerging role of artificial intelligence in smart cities. AI & Society, 38(3), 1039–1044. https://doi.org/10.1007/s00146-022-01537-5

Markelius, A., Wright, C., Kuiper, J., Delille, N., & Kuo, Y.-T. (2024). The mechanisms of AI hype and its planetary and social costs. AI Ethics. Advance online publication. https://doi.org/10.1007/s43681-024-00461-2

Mehr, H. (2017). Artificial intelligence for citizen services and government (Ash Center for Democratic Governance and Innovation). Harvard Kennedy School. Retrieved from https://ash.harvard.edu/files/ash/files/artificial_intelligence_for_citizen_services.pdf

Mohammad, A. F., Clark, B., Agarwal, R., & Summers, S. (2023). LLM/GPT generative AI and artificial general intelligence (AGI): The next frontier. In 2023 Congress in Computer Science, Computer Engineering, & Applied Computing (CSCE) (pp. 413–417). IEEE. https://doi.org/10.1109/CSCE60160.2023.00073

Nickerson, R. C., Varshney, U., & Muntermann, J. (2013). A method for taxonomy development and its application in information systems. European Journal of Information Systems, 22(3), 336–359. https://doi.org/10.1057/ejis.2012.26

O'Reilly, T. (2011). Government as a platform. Innovations: Technology, Governance, Globalization, 6(1), 13–40. https://doi.org/10.1162/INOV_a_00056

OECD. (2023). Government at a glance 2023. Organisation for Economic Co-operation and Development. https://www.oecd-ilibrary.org/governance/government-at-a-glance-2023_3d5c5d31-en

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Singh, A., Kanaujia, A., Singh, V. K., & Vinuesa, R. (2024). Artificial intelligence for Sustainable Development Goals: Bibliometric patterns and concept evolution trajectories. Sustainable Development, 32(1), 724–754. https://doi.org/10.1002/sd.2706

Sousa, W. G. de, Melo, E. R. P. de, Bermejo, P. H. D. S., Farias, R. A. S., & Gomes, A. O. (2019). How and where is artificial intelligence in the public sector going? A literature review and research agenda. Government Information Quarterly, 36(4), 101392. https://doi.org/10.1016/j.giq.2019.07.004

Straub, V. J., Morgan, D., Bright, J., & Margetts, H. (2023). Artificial intelligence in government: Concepts, standards, and a unified framework. Government Information Quarterly, 40(4), 101881. https://doi.org/10.1016/j.giq.2023.101881

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., … Straus, S. E. (2015). A scoping review of rapid review methods. BMC Medicine, 13(1), 224. https://doi.org/10.1186/s12916-015-0465-6

Tsvetkova, M., Garcia, D., Menges, J.,… & Schweitzer, F. (2017). Understanding human-machine networks: A cross-disciplinary survey. ACM Computing Surveys, 50(1), Article 12. https://doi.org/10.1145/3039868

Valle-Cruz, D., Ruvalcaba-Gomez, E. A., Sandoval-Almazan, R., & Criado, J. I. (2019). A review of artificial intelligence in government and its potential from a public policy perspective. In Proceedings of the 20th Annual International Conference on Digital Government Research (dg.o '19) (pp. 91–99). Association for Computing Machinery. https://doi.org/10.1145/3325112.3325242

Van Welie, M., & Van der Veer, G. C. (2003). Pattern languages in interaction design: Structure and organization. In Proceedings of the Human-Computer Interaction INTERACT '03. Zurich, Switzerland.

Wirtz, B. W., Weyerer, J. C., & Geyer, C. (2019). Artificial intelligence and the public sector—Applications and challenges. International Journal of Public Administration, 42(7), 596–615. https://doi.org/10.1080/01900692.2018.1498103

Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. Government Information Quarterly, 38(3), 101577. https://doi.org/10.1016/j.giq.2021.101577

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

AI-driven public consultation platforms: Transforming civic engagement in local governments.

Meredith Dedema [a*], *Loni* Hagen [b].

[a] Department of Information and Library Science, School of Informatics, Computing and Engineering, Indiana University Bloomington, USA, fndedema@iu.edu, 0000-0003-0203-8945.

[b] School of Information, University of South Florida, USA, lonihagen@usf.edu, 0000-0002-6532-0852

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. The integration of artificial intelligence (AI) in local governments has gained increasing attention as a means to enhance civic engagement and streamline public participation. This study examines how local governments utilize AI-powered platforms for civic engagement, exploring the perspectives of public servants and developers on the implementation of AI, its benefits, challenges, and ethical considerations. With a qualitative approach, semi-structured interviews were conducted with developers, product designers, public servants, and decision-makers involved in developing and using the AI-powered platform for civic engagement initiatives. Thematic analysis was employed to identify key themes related to AI functionalities, user experiences, and governance challenges. The preliminary results reveal that four distinct types of AI applications have been employed, including AI-powered optical character recognition (OCR), AI-based content moderation, AI sensemaking, and AI-driven translation. These AI tools facilitate efficiency in data processing, enhance accessibility, and support decision-making. However, concerns regarding AI transparency, data privacy, and public trust remain significantly challenging. Additionally, public servants emphasized the need for AI literacy training and the development of ethical guidelines to ensure the responsible use of AI in local governance. This study contributes to the growing discourse on AI in civic engagement by offering insights into the practical and ethical dimensions of AI adoption in local governments. The findings underscore the need for policy frameworks, digital inclusivity measures, and ongoing capacity-building efforts to enhance AI-driven public participation.

Keywords. Artificial Intelligence, Local governments, Civic engagement, Technology adoption.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.953

1. Introduction

As public sector organizations worldwide embark on digital transformation initiatives, the integration of Artificial Intelligence (AI) technologies has emerged as a distinctive force. At its core, AI refers to the development of computer systems capable of performing tasks that typically require human intelligence. In today's rapidly evolving technology landscape, AI has increasingly become integral to the functioning of the public sector, playing a pivotal role in optimizing government processes, decision-making, and service delivery (van Noordt & Misuraca, 2022). Such technologies are deployed in the public sector to support the smart allocation of public resources, assist citizens with chatbots, identify patterns, develop predictive analytics models, and enable sensor-based detection and prevention (Medaglia & Tangi, 2022). However, limited research has been conducted in this area compared to the research on AI adoption in the private sector. The public sector's slower pace of AI adoption, combined with the need for regulations and ethical oversight, makes it challenging to implement and study AI technologies on a large scale. Yet, it is critical to learn about AI adoption in a social and organizational context like

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the public sector, where the performance value (e.g., reducing the cost and increasing the efficiency) does not always have the priority it has in the private sector; there is also public value (e.g., fairness and accountability) that needs to be considered (Sousa et al., 2019).

Civic engagement, in general, is defined as individual or collective forms of action designed to identify and address matters of public concern (Axelsson et al., 2010). It encompasses a wide range of activities through which individuals or groups seek to influence public policy, improve their communities, and ensure that their voices are heard in the decision-making processes. Examples of civic engagement include voting, attending town hall meetings, participating in local boards or committees, volunteering for community projects, petitioning (Dumas et al., 2015), and engaging in public advocacy (Uslaner & Brown, 2005). Since the last decade, digital participatory platforms have enabled governments to engage citizens more effectively, promote transparency, and foster collaboration in decision-making processes (Falco & Kleinhans, 2018). While digital government research has examined e-participation tools, AI-driven engagement remains underexplored. It is essential to explore how digital participatory platforms harness AI technologies to further advance democratic participation.

To address this gap, this research endeavors to investigate the use of an AI-based platform for civic engagement in local governments when delivering public services. We adopted a socio-technical perspective to examine the intricate interplay between a specific social system (i.e., local governments) and the technological infrastructures (i.e., AI). This approach posits that technological artifacts and social dynamics are mutually constitutive, meaning that technologies are designed, implemented, and used within specific social contexts, and, in turn, they shape social practices, organizational structures, and human behaviors (Kling, 2007). We aim to provide a comprehensive understanding of the socio-technical dynamics surrounding the implementation and use of AI in local governments, facilitating more informed decision-making and promoting responsible AI deployment for the public good.

In this study, the GoVocal platform was selected for its AI features, which are designed for civic engagement in public services. The local governments in the US that are using the GoVocal platform were exhaustively sampled for an interview study. To gather data about practices and perceptions of AI for civic engagement, we talked to 1) the developers, product designers, and customer support specialists from the GoVocal platform on the development side, and 2) the public servants who work with GoVocal's AI features in local governments on the implementation side to triangulate the investigated phenomenon from different perspectives. Compared to prior studies that investigate how citizens as users at the front end respond to digital participatory platforms, this study focuses on public servants who are users of the GoVocal platform at the back end.

The research questions we seek to address in this study are: **RQ1:** What AI features have been developed and used to enhance civic engagement in local governments? **RQ2:** What are the benefits, challenges, risks, and ethical considerations of AI adoption for civic engagement in local governments?

2. Literature review

The adoption and use of AI in governments worldwide are growing rapidly. Governmental agencies at local, regional, and national levels have begun to pay close attention to AI applications being developed in commercial settings and envision utilizing AI to support administrative processes and deliver public services (Ahn & Chen, 2022).

2.1 AI capabilities in governments

AI capability, derived from the concept of IT capabilities, suggests that organizations need to leverage AI, as well as other complementary resources, to realize value rather than solely identifying degrees of AI adoption (Mikalef & Gupta, 2021). AI capability consists of complementary AI-related tangible, human, and intangible resources. Such conceptualizations of an organization's ability to leverage technology provide more accurate representations of the value that can be expected, as they encompass the intangible aspects that enable technological innovations to be implemented (Mikalef et al., 2022). Therefore, AI capability builds on the necessary technical and organizational elements required to effectively deploy AI resources to achieve prioritized objectives. Mikalef and Gupta (2021) define AI capabilities as "the ability of a firm to select, orchestrate, and leverage its AI-specific resources." (p.4) This definition denotes that an AI capability goes beyond just selecting, or else adopting AI, and includes the capacity to bring AI-related projects to fruition.

When investigating AI capabilities in governments, Medaglia and Tangi (2022) found that requirements indicated as important by public managers involved in public service in European AI projects largely overlap with classic drivers known from well-established research in e-government, which include both internal factors, such as middle and top management commitment and external factors, such as the availability of IT resources, government support at different levels, citizen support, and business support. Yigitcanlar et al. (2023) investigated how the adoption of AI would impact local governments' abilities to enhance services and establish user expectations, using semi-structured interviews with city managers from Australia and the United States. On the one hand, the adoption

of AI may lead governments to learn from and cultivate their own AI systems, particularly those governments that are at the forefront of experimenting with AI and have the necessary leadership and funding support. On the other hand, some governments that cannot afford or are unprepared to adopt these systems, prioritize them, and train to use them will be left behind. This suggests that the disruptive impacts of AI adoption are predicted to create a widening knowledge and skill gap between local governments, with those that cannot adopt it likely to lag behind.

Moreover, prior literature has highlighted the importance of having a robust technical infrastructure in place to support the deployment of AI (Zuiderwijk et al., 2021). This technical infrastructure is necessary to obtain, manage, and store the various data required to train AI. AI is typically integrated into existing IT systems and is never used in isolation, which requires organizations to have a basic IT infrastructure with suitable hardware and software. Local governments should, therefore, have access to an infrastructure with high connectivity and enough bandwidth, processing power, server hardware, networks, and database management technologies to facilitate the storage and analysis of the large datasets needed to develop AI. Alternatively, in the case of cooperating with a third party for AI services, local governments should initiate the guidelines and set up the principles before employing external AI services.

Additionally, utilizing AI in local governments requires that public servants and citizens possess a certain level of digital literacy. Hence, local governments in some countries provide training to citizens of all ages and public servants on the basics of computer use, navigating the Internet, and searching for information. Increasingly, some also provide specialized knowledge on AI. These initiatives enhance computer literacy and support individuals' ability to leverage existing work on AI for their own personal and professional purposes. For instance, the French Institute for Public Management and Economic Development (IGPDE), which forms part of the French Ministry of Economy and Finance, offers many different training courses, including short, one-day sessions such as "Digital Transformation of the State and Data" and "Artificial Intelligence, Data Science: New Economic Challenges." These aim to equip public servants with a basic understanding of AI and its opportunities and challenges. One more example is the government of Singapore, which offers AI workshops open to public officers and middle to senior managers. It aims to increase digital literacy and provide foundational knowledge about the potential of AI for public work and public organizations.

2.2 The benefits and challenges of AI in governments

The use of AI in government could bring a range of benefits. Three primary ones can be summarized as **1) Improving internal efficiency:** AI applications have the capabilities to perform specified tasks (e.g., extracting structured data from relevant documents) and consequently free up precious cognitive resources of public workers, which can then be allocated to tasks of higher added value (Loi & Spielkamp, 2021). This reallocation enables the government to concentrate its scarce resources on tasks where human workers excel, such as problem-solving activities that require empathy, creativity, and innovation. **2) Enhancing the capacity of decision-makers:** A natural benefit of applying AI techniques to public decision-making is the ability of AI algorithms to consider a greater number of variables, as well as the increased granularity and accuracy of the actions that AI systems can recommend. In cases where citizens' opinions are important, AI-powered simulations can model policies and their effects, and these simulations can be used to support discussions among citizens (Charles et al., 2022). In addition, the potential benefits could be perceived as impartiality, which decisions delegated to AI-powered algorithms can provide. For instance, AI may be perceived as not having the same biases as humans do. Local-level bureaucrats in public sector organizations face the possibility that various factors, such as corruption, organizational politics, and personal biases of any type (e.g., gender, race, and socio-economic status), may influence their decisions (Alon-Barkat & Busuioc, 2023). **3) Promoting citizen-government interaction:** On the one hand, AI can enhance existing service interfaces or create new ones with more usable and human-centered applications. For example, implementing chatbots to collect citizens' opinions and facilitate deliberative interaction with natural language processing and text analysis (Henk & Nilssen, 2021). On the other hand, AI can potentially increase citizens' trust and participation in public sector activities. For instance, AI functions as a nudging device, prompting humans to consider the value implications of their decisions or to reflect on when to make decisions that are perceived as more equitable, fair, and legitimate, thereby increasing trust (Aoki, 2020). Scholars have also pointed out that the adoption of AI within government institutions supports organizations in becoming more transparent and open to citizens, as well as more participatory with other sectors (van Noordt & Misuraca, 2020).

While the benefits of AI in government are significant, there are also potential risks to consider when seeking to minimize the unintended consequences, which include: **1) Algorithmic bias**: While the ability of AI applications to recognize patterns can be beneficial when segmenting populations, for example, in welfare service provision or when addressing anti-social behavior, it can also amplify discriminatory biases already present in human-led assessments (Gualdi & Cordella, 2021). Predictive algorithms can favor groups that are better represented in the data used to train algorithms. As algorithms can play a role in the propagation of existing social biases across gender, race, sexuality, and ethnicity, AI could thus participate in and potentially increase systematic and unfair treatment of citizens based on social biases (Zuiderwijk et al., 2021)—an outcome that is in direct conflict with the mission of governments to provide unbiased and equitable treatment of citizens under the rule of law. **2)**

Algorithm opacity: The increasing complexity of AI systems, especially deep learning solutions with more and more layers and parameters, reduces the capability of human operators to trace outputs back to specific inputs, making it potentially impossible to account for specific AI-driven outcomes clearly, and to correct actions with unintended consequences (Morley et al., 2020). The broader consequences of this phenomenon have been referred to as creating a "black box society" (Wirtz et al., 2020) and have profound implications for governments, which, by definition, are bound to citizens' expectations of transparency and accountability. On the other hand, AI systems can shift public servants' responsibility for accountability, posing challenges in the legal and political liability dimensions (e.g., who is responsible for damage to a citizen stakeholder if the decision has been outsourced to an AI application?) (Wihlborg et al., 2016). **3) Invasion of privacy:** The harvesting of large volumes of personal data required to fuel AI solutions poses a risk of infringing on the privacy of citizen users (Zhang et al., 2021). Any AI algorithm, regardless of its area of application, can produce relevant outputs only if trained with an appropriate amount of data. Such data might be personal, sensitive, or inappropriately collected or managed. Additionally, the use of AI in governments may entail the risk of extensive surveillance (Valle-Cruz et al., 2019). Addressing these risks requires a comprehensive and ethical approach to the development, deployment, and governance of AI systems in governments.

2.3 Public servants' and developers' perceptions of AI in governments

Public servants play a critical role in governments' adoption and use of new technologies, and their attitude and willingness to utilize them are crucial in creating a sustainable and meaningful digital transformation. Based on survey results from current government employees in the U.S., Ahn and Chen's (2022) analysis reveals that the willingness to implement and use AI technologies in governments is contingent upon a series of positive and negative perceptions about the new technologies, the long-term outlook on the role of AI technologies in society, and their familiarity and experience with using some form of AI applications in the past. Specifically, Ahn and Chen (2022) found that when asked if the government should consider using AI to improve public service, a vast majority (77%) agreed or strongly agreed, while 10% disagreed, and 11% remained neutral. When asked to choose one area of their work that they perceived that AI would improve, the majority of the respondents said that its use would increase the efficiency of their work (55%), improve service quality and effectiveness (21%), and relieve them of mundane and repetitive tasks (19%). The results also indicated that government employees were mildly concerned with AI taking discretionary authority away from their work (55%), while 45% were not concerned or were uncertain about AI's role in their discretionary authority. Also, a correlation was found between exposure to AI and the degree of support for AI in governments, where the employees who had used AI were likely to show a greater degree of support for implementing AI in their agencies.

However, government employees' perceptions of the transformative potential of AI for improving government transparency reduced their willingness to adopt AI in government, reflecting resistance to opening governmental processes to the public. Among the perceived concerns, the concern over AI's ability to make sound ethical and moral judgments had a statistically significant influence on the willingness to use AI in government (Ahn & Chen, 2022). Regarding the perception of the role of AI in society, its ability to surpass human intellectual abilities, its role as a competitor to humans, and the perception of its eventual benefit to humanity had statistically significant impacts on respondents' willingness to use it. Among the types of government work and the demographic characteristics of public servants, party affiliation with the Democratic Party was negatively associated with the willingness to adopt, while working in state government had a positive impact. Middle managers were less willing to support AI technologies in government, while male respondents were more likely to support them than female respondents (Ahn & Chen, 2022).

Henk and Nilssen's (2021) empirical findings on the use of AI in Scandinavian public services showed that implementing AI-based chatbots in day-to-day activities alters rather than completely replaces the existing jobs of frontline service workers. For example, implementing AI results in the need to improve the empathic and intuitive skills of service workers. This may occur because public servants may need to respond to personalized inquiries that require close human interaction, rather than handling routine requests that can be automated. Additionally, the organizational culture has not undergone significant changes due to the implementation of AI. Employees perceived the chatbot as an assisting "new colleague" rather than a breakthrough technology that disrupted everyday activities. The findings suggest that instead of creating a new culture, managers created an understanding of the chatbot's limitations and integrated it into the existing culture. Moreover, the participative leadership style of managers facilitated the uninterrupted implementation of the application by promoting cross-departmental cooperation and fostering a positive attitude toward the change.

Figueras et al. (2022) examined how AI developers perceive ethical issues concerning AI design and how they interpret and put them into practice by conducting interviews with AI practitioners working in or for public organizations in Sweden and found four different kinds of tensions: 1) tensions in respondents' ranking of the ethical principles, which means that practitioners valued ethical principles differently; 2) tensions in the interpretation of ethical principles, which means practitioners interpret ethical principles in different ways; 3) tensions in enacting ethical principles, which means practitioners embedded ethical principles in design in

different ways; 4) tensions between national and professional practice, which means national governance may clash with the AI design practice and ethical principles on certain occasions. Interviews with chatbot designers revealed that they prioritize specific value dimensions for public services (Makasi et al., 2022). The first level comprises six dimensions, which are discussed as high priorities for both basic and advanced chatbots in the public sector: efficiency, effectiveness, user orientation, professionalism, adaptability, and trust in government. The second level consists of five value dimensions cited as critical to public services, particularly in relation to chatbots that retain user profiles, which is typically the advanced type of chatbot. These are privacy, legitimacy, accountability, acceptability, and social license. Finally, the third level consists of four dimensions acknowledged as highly important in the overall performance management of all chatbot initiatives in the public sector: openness, sustainability, fairness, and collaborative intelligence. These value dimensions shed light on the ethical design of AI.

3. Methods

3.1 Research subject

When examining the use of AI in local governments, we identified a specific platform (i.e., GoVocal, see Figure 1) that incorporates AI features adopted by multiple local governments in the US. The investigated phenomenon in this research is the use of this platform, particularly its AI features, in local governments for civic engagement initiatives when delivering public services. GoVocal is a digital platform designed to empower citizens and enhance civic engagement by fostering meaningful dialogue and facilitating constructive interaction. It serves as a digital town hall where residents can voice their opinions and contribute ideas to a wide range of civic projects, including urban planning, environmental sustainability, and social initiatives. With its technological affordances and AI-based features, such as online surveys, idea generation, interactive mapping, and discussion forums, the platform supports diverse forms of citizen participation.

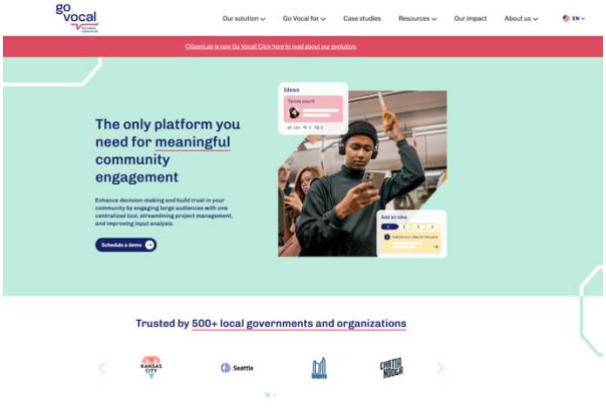


Fig. 1 - Homepage of the GoVocal (formerly CitizenLab) website (https://www.govocal.com/).

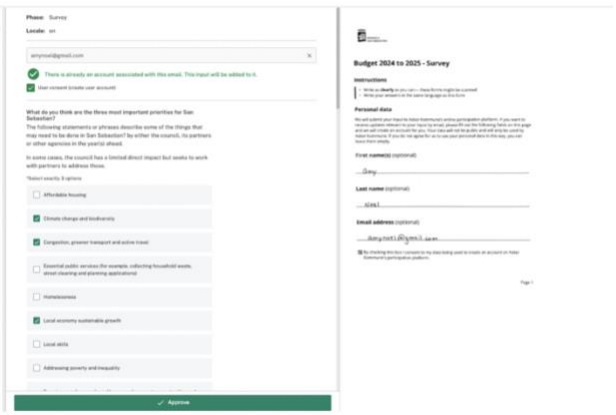


Fig. 2 - The user interface for the AI-powered OCR.

AI features developed and provided by GoVocal include:

1. AI-powered optical character recognition (OCR) is used to scan and digitize the uploaded paper participation at scale by handling a wide variety of document layouts and handwriting with minimal manual intervention (see Figure 2).

2. AI-based content moderation automatically assesses and filters online content by identifying abusive, toxic, harmful, or other inappropriate expressions from user-generated posts, proposals, and comments on the platform.

3. AI sensemaking is an AI-driven tool that analyzes, interprets, and derives meaningful insights more quickly across vast amounts of textual and quantitative data collected during engagement projects, identifying patterns and contextualizing results (see Figure 3).

4. AI-driven translation leverages large datasets and sophisticated algorithms to learn linguistic patterns, content, and nuances across multiple languages, enabling the automatic conversion of text from one language into another.

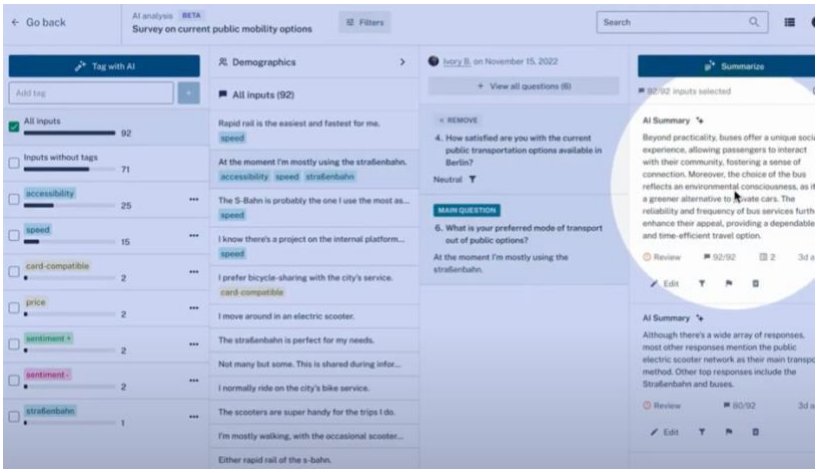


Fig. 3 - The user interface for the AI sensemaking tool.

3.2 Data collection

According to GoVocal's website, the platform has been used in a wide range of countries in Europe and North America. In this study, all the local governments in the US that were using the platform by the time the interview study was conducted have been exhaustively sampled and contacted (see Table 2). Interviews are particularly helpful when aiming to explore the use of AI for civic engagement in local government as a complex yet novel social phenomenon, and to gather in-depth information to understand participants' lived experiences, perspectives, and opinions (Gubrium et al., 2012).

Tab. 1 - Local governments in the US that use the GoVocal platform and their population size based on 2023 census data.

Location	Population size	text
Carlisle, PA	22K	https://carlisle.govocal.com/en/
Lancaster, PA	57K	https://engage.cityoflancasterpa.gov/en/
Norwich, CT	40K	https://envisionnorwich360.com/en/
Seattle, WA	749K	https://engage.oneseattleplan.com/en/
Struthers, OH	44K	https://discover.cityofstruthers.com/en/
Benicia, CA	26K	https://engagebenicia.com/en/
St. Louis, MO	281K	https://stlouis.govocal.com/en/
Allen, TX	111K	https://engage.cityofallen.org/en/
Cincinnati, OH	311K	https://cincinnati.govocal.com/en/
Hyattsville, MD	20K	https://hellohyattsville.com/en/
Kansas, MO	510K	https://speakeasy.kcmo.gov/en/

We conducted a series of semi-structured interviews with two groups of stakeholders: 1) developers, product designers, and customer support specialists from the GoVocal platform, and 2) public servants and decision-makers in local governments who work with the GoVocal platform and its AI features for civic engagement. The interviews aim to gain contextualized information about the actual design and implementation of the AI features provided for civic engagement. Additionally, the perceptions of benefits, challenges, and ethical considerations associated with using AI in local governments will be investigated (please see the interview questions in the Appendix). In this preliminary finding, we report the results of our interviews. We interviewed three GoVocal developers, product designers, and customer support specialists, as well as seven public servants (one to two from each local government, based on their availability).

3.3 Data analysis

The audio-recorded interviews were transcribed, and a thematic analysis was conducted with a grounded theory approach (Glaser & Strauss, 1967). This method involves analyzing patterns or themes by closely examining the data line by line to identify concepts or ideas, which will then be labeled with descriptive codes. The grounded theory approach avoids reliance on preconceived theories or hypotheses, allowing for the exploration of the

complexity and richness of the phenomena under study. The NVivo application was used for the analysis. First, we conducted an open coding guided by the research questions on 10-20% of the corpus to start developing the codebook. After that, each author separately coded the same sample using a well-defined codebook and then calculated the intercoder reliability. The percentage of agreement exceeds 90% when comparing our coding results, and disagreements were resolved through discussions and re-coding. We didn't use Cronbach's alpha because the unit of coding is not consistent, as it is not always on the sentence level, and many codings were conducted on the paragraph level, which made the calculation of Cronbach's alpha a bit difficult. The codebook was ready when one of the authors completed the coding for the rest of the corpus. The identified codes for the thematic analysis are shown in Table 2.

Tab. 2 - Codebook for the thematic analysis of interview transcriptions.

Codes	Descriptions
AI features	The features provided by the platform, designed with AI technologies by developers and utilized by public servants in local governments for civic engagement, include existing ones that have been developed and implemented, as well as future ones that are being envisioned and anticipated.
Civic engagement	The understanding of civic engagement in local governments from the perspectives of developers and public servants, such as the objectives and goals.
Evaluation	The evaluation of AI features' performance from the perspectives of developers or public servants, for example, their effectiveness, usability, and potential public value in creating civic engagement in local governments.
Benefits/Challenges/ Risks	Benefits, challenges, or risks of developing, implementing, and using AI features for civic engagement in local governments.
Ethical consideration	Considerations of ethical issues like fairness, bias, transparency, accountability, data privacy, and security and how they are addressed in the development, implementation, and actual use of AI features for civic engagement in local governments.

4. Findings

4.1 What and how are the features developed and used for enhancing civic engagement?

Platform developers and public servants described how various AI features were designed and utilized to enhance civic engagement in local governments, including AI-powered OCR, AI-based content moderation, AI sensemaking, and AI-driven translation.

First, platform developers explained the motivation for developing AI-powered OCR was that when talking to public servants to learn about their needs for a digital platform enhancing civic engagement, public servants complained that it was quite time-consuming to transcribe all ideas after collecting surveys offline while "*offline consultation is important to engage senior citizens or people who have lower digital literacy and have difficulties with accessing digital surveys online*." (P5) Hence, the platform provided the AI-powered OCR to help with speeding up the transcription by extracting data from scanned PDF/Excel documents to generate structured input. This feature utilized AI technology to make engagement more inclusive by enabling public servants to efficiently synchronize offline insights and input. While traditional OCR is a rule-based technology suitable for basic text recognition, developers have noted that "*AI-powered OCR leverages advanced machine learning techniques to deliver higher accuracy, contextual understanding, and adaptability in complex scenarios*" (P8). AI-powered OCR can learn and adapt to different fonts, languages, and writing styles. It also handles low-quality or distorted images more effectively and recognizes text from complex layouts, such as tables or multi-column documents.

Second, AI-based content moderation automatically reviews and manages citizens' inputs on the platform by unpublishing content that is non-compliant with established community guidelines. The developers (P7) mentioned that they have built "*profanity blockers that contain lists of offensive words for governments across Europe, the US, and Latin America*." With AI technologies, content moderation seeks to foster civic engagement by creating a more respectful online environment that encourages public participation. One of the public servants (P1) mentioned, "*What I always tell people is I was amazed at the depth of thought and quality of the answers. It was not like a Facebook forum where everyone just said and argued nasty things. Of course, at the back end, we see email notifications about the red-flagged posts removed by the AI moderation, but at least people who go to the platform for a civilized discussion don't have to build their opinions on that.*"

Third, the AI sensemaking tool automatically extracts useful insights from large volumes of citizens' input and generates summaries for public servants. The developers pointed out that government agencies spend far more time analyzing, communicating, and acting on data than gathering it; however, they often lack sufficient time to analyze the data, which ultimately motivated the platform to develop this AI sensemaking tool. For example, one of the developers (P6) mentioned, "*Our platforms get like thousands of comments and inputs from residents. It's really hard for local administrations to make sense of them. So we even had people saying that 'I just can't process it at all, and sometimes I only process 20% of the input.'*" Another developer (P7) added, "*It's not only sad, but as a city, you have a responsibility towards your constituents, and you are only reading 20% because you don't have time. So that's why we started developing AI sensemaking that helps summarize communities' input topically, sentiment-wise, and controversy-wise*." When talking to the public servants, one of them (P2) described this time-consuming process for analysis and lack of skills in dealing with vast amounts of qualitative data as "*we are surrounded by data, but too often starved for insights*." The AI sensemaking tool offers functionalities such as auto-tagging keywords, generating summaries, and providing references to original inputs for human validation. Public servants can filter responses based on specific answers and ask follow-up questions to gain a deeper understanding of the data. Moreover, this tool analyzes the most popular keywords or concepts discussed within the community, and then visualizes the most popular keywords on a map relative to their importance, clustering them together with keywords that appear together repeatedly. The visual representation, in addition, helps public servants quickly understand what people are discussing and then "*find out what the trends, changes, and gaps are in the current project and decide whether a detailed analysis is necessary for the next steps*" (P4).

Fourth, like AI-powered OCR helps maintain offline accessibility, a public servant emphasized the importance of language accessibility, particularly in cities serving communities with diverse cultural and linguistic backgrounds. P4 explained, "*As a city, as we communicate with citizens, we don't want to spend extra money to translate everything, so it's not useful for us unless the translations are built into the platform that makes everything accessible to people in different languages*." The AI-driven translation was very important as the GoVocal platform is a company based in and serving many European countries. One of the developers (P8) said, "*We serve, I think, around 17 different languages on our platform today. We also sometimes have platforms that are using multiple languages. We initially struggled with limited algorithmic resources for translation, but now we are utilizing a combination of ChatGPT 4 and Clouds, which are becoming increasingly proficient in multilingual tasks. So, as developers, we need to make sure that the platform generates their answers in the right language by specific prompt engineering to make it happen*."

4.2 The benefits and challenges of adopting an AI-based platform for civic engagement in local governments.

While using the AI features embedded in the platform, public servants expressed positive feedback, highlighting the user interface, effectiveness, and interaction design. For example, they noted improvements in efficiency, extended capacity, and the ability to accomplish more with limited resources, which they viewed as key factors in justifying the implementation of AI to government stakeholders. "*Because we are a quasi-governmental organization of two to six people, efficiency is the drive. That's how we convinced the local governments that we need to implement, utilize, and leverage AI tools, as we require greater efficiency and increased capacity for investment. I would simply say the investment is 100% worth it here with this platform. We were able to do more with less.*" P9 from the same institute added, "*In terms of convincing the stakeholders, it's very important for them to see the actual product and understand how it works. It gives them a clear picture of what results this product can bring to the organization*." (P3)

Furthermore, public servants appreciated the referencing functionality of the AI sensemaking tool, noting that its interaction design saves time, facilitates the verification of information sources, and enhances the reliability of the generated summaries. One of the public servants (P4) mentioned, "*Let's imagine a summary of 2,000 inputs that we've received. We will see a little bubble, sometimes with 20 bubbles or 30 bubbles, and by clicking on each bubble, we can actually see where that little insight or sentence originates from. Then we go back to the original source of the input for human verification.*" (see Figure 4)

Besides its summarization functionality, the AI sensemaking tool enables public servants to pose specific questions regarding residents' input using various prompts. One of the public servants (P10) reflected on this design and said, "*Most people's experience, like at least their greatest exposure to AI, is ChatGPT, so you get used to this chat box and just type in your questions. I'm surprised to see we can also ask questions based on how this AI tool understands the residents' input.*" This chatbot-like design for interaction lowered the entry barrier for individual public servants to effectively leverage AI capabilities. Overall, with the various tools and AI features provided by the platform, public servants feel more empowered when analyzing data, as some may lack the skills or expertise to handle large volumes of qualitative data or interpret survey results. This is especially beneficial for smaller local governments with limited human resources dedicated to civic engagement initiatives. P2 elaborated, "*It's useful when going through all the data because I'm not a statistician, I'm not whatever. It saves time when pulling out keywords and recurring themes, which I previously had to do manually by reading everything. So that kind of thing makes the handling of the data a little easier, especially being a one-person team for all the public engagement stuff*."

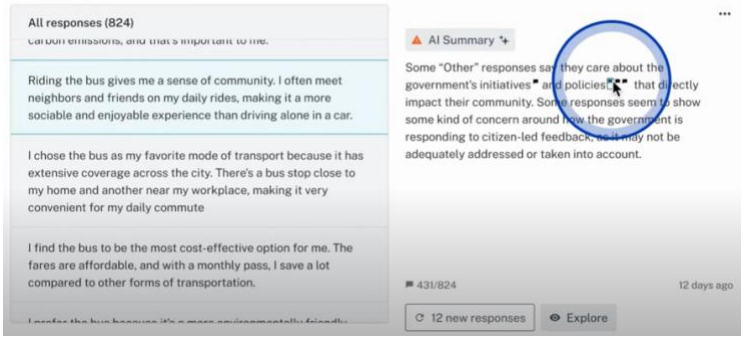


Fig. 4 - AI summarization enables users to verify the source of the input.

The first challenge identified by public servants is the accuracy of AI-generated summaries, which highlights the need for careful consideration of which projects are suitable for analysis using AI tools and which require alternative approaches. According to the interviews, public servants believe that AI performs effectively in projects where its primary role is to extract information and keywords from citizen input. However, they prefer manual analysis for projects that demand deeper contextual understanding or when capturing the sentiment of the input, which is particularly important. For instance, P5 described their strategy utilizing AI summarization, "*What I'm worried about with AI is that they're going to give me the information, but because this is such a contentious issue with people holding polarized opinions, what I really want to understand is the context and people's feeling when they're typing things out. I want to know if they are really against it. Are they pissed off? Do they feel heard?*" P9 also expressed concerns over the quality of data being produced by AI summarizations and emphasized that human verification is essential: "*It's a great tool, but it still needs a human to review it. Make sure that it is, in fact, correct and accurate. And I think people rely too heavily on just saying, 'Oh, well, the tool did it.' That would be my concern that people would forget that it still needs oversight and fix things before it goes out into the world*."

The second challenge pertains to public servants' AI literacy, which is crucial for ensuring the effective and ethical application of AI features in civic engagement within local governments. One of the public servants (P10) said, "*There were elements about it that were not as user-friendly as it could be*." In addition, public servants may resist using AI features due to a lack of understanding, as "*AI algorithms function as so-called black boxes,*" according to one of the developers (P8). Therefore, the platform provided onboard training for public servants when they first adopted the AI features and they found it "*very helpful to get a basic idea about what's going on and how to process citizens' input*." (P4) One of the developers (P6) added that, "*The training sessions don't mean to tell public servants how we developed the platform and how we're using AI models to make everything happen. They only need to learn how to analyze the data with all AI features, and we emphasized many times about human moderation so that they also know how to double-check with original inputs and summaries generated by AI*."

Challenges related to the digital divide, fairness, and inclusiveness also emerge as significant concerns. Although the platform was designed to enhance civic engagement, public servants noted difficulties in ensuring that it serves all members of the community. Limited access to the internet or digital devices among certain groups restricts their ability to participate, thereby hindering the platform's inclusivity. P1 commented, "*Obviously, the only limitation is if you're going to be in an area where there may be questionable internet access, how do you reach those residents? When you're talking about rural parts of the United States, due to the cost barriers, people might not have access to the internet, or they don't even have the infrastructure*." Therefore, public servants also adhere to their offline engagement strategies. As P2 stated, "*When we do major projects, we've also had either face-to-face meetings, or mailers, or door hangers, especially targeting those areas that we know are low tech and not okay with online show-ups*." To further raise public awareness about the online platform for civic engagement, public servants shared their methods of directing people from traditional engagement channels to the platform. For example, P9 said, "*We are simultaneously using old-school posters that point people through a QR code back to that platform. We will issue a press release to the local newspaper. We'll put it on our social media*."

4.3 The ethical considerations of AI adoption for civic engagement in local governments.

The application of AI for collecting and analyzing civic engagement data introduces potential risks related to the use, storage, and sharing of personal information. When asked about data security and privacy issues, public servants shared different perspectives. For example, one public servant highlighted the importance of data ownership and the ability to export and retain data after the contract expires. As P1 said, "*There were very few platforms that would allow the municipality to keep the data or to export the data when the contract with the platform expired. But this platform allowed us to export all the data and keep it, even if the municipality chooses not to use the platform any longer*."

Regarding the risk of data breaches, where unauthorized parties may access sensitive or confidential information,

most public servants did not express significant concern. This was primarily because sensitive data were not stored or shared online, or due to the perception that the platform operates similarly to other commonly used platforms. P10 explained, "*Not in the sense that we were asking any questions that would ask for social security numbers, bank account information, or healthcare data. Nothing felt where the residents, at least through the platform, were providing a lot of information that would put them at a data breach type of problem*." P5 added, "*Since anything online is going to have the possibility for a data breach, we weren't worried about this any more than you'd be worried about residents using any type of platforms that are exposed to hackers. I think it's a fair assessment*."

Furthermore, developers outlined the measures implemented to safeguard user data on the back end and explained that, when utilizing APIs from large AI models, they establish contractual agreements with the respective companies to ensure the data is not used as training material. P8 said, "*We also have clear data processing agreements where we explicitly make sure that they do not use any of this data from the platform for other purposes. That's how we protect the input from citizens being used as further training material*." P7 added, "*So today, when a resident on our platform typically posts an idea or submits a survey response or contributes another mechanism that we have, they leave their name, they leave their email address, they leave potentially some demographic information. We don't send those things to the AI. AI is only about summarizing the content that they have written*."

Additionally, transparency and trust are highly voiced as ethical considerations by both developers and public servants. Developers emphasized the importance of referencing functionality in promoting transparency, explaining that it enables public servants to trace the connection between original inputs from residents and the generated summaries. P6 described, "*So we kind of create that transparency to make sure public servants can easily find back what is based on when AI makes a statement. The machine is there, but let's try to use design to make it as easy as possible for humans to understand what the machine does and verify its actions. And that's not as much rocket science AI, but it's a really better user interface that allows for a good user experience*."

Public servants underscored the necessity of being transparent about AI use and making methodologies accessible to the public to facilitate understanding and encourage further participation. P4 commented, "*There are so many disclaimers and so much information about how we are actively using AI. It's not about not telling people. I feel it is important to be upfront about the use of these tools so people feel empowered to use them as well. Our office employs specialized tools, including maps, Excel, and Python, which are used to understand and produce meaningful insights. However, those tools are not accessible to the general public. So, I think we should be transparent about how these tools helped us to understand things. And our methodology should be accessible to everyone else to encourage a more communal, participatory model of data sharing*."

5. Discussions

5.1 Embracing AI tools: The cultural transformation has happened.

The findings indicate that public servants have increasingly embraced AI tools as integral components to streamline administrative tasks and enhance efficiency. More importantly, the efficiency gained from AI-powered tools appears to differ from that achieved through traditional IT adoption: AI tools expedite the collection and processing of citizen input data and extract insights of higher added value (Loi & Spielkamp, 2021). It is about *revolutionizing the process of generating insights from citizen input*. In addition, AI-driven tools have enabled small organizations to expand their capacity, allowing them to "*do more with less*." As a result, AI tools are seen as a potential solution to the resource constraints faced by local governments (Charles et al., 2022).

The integration of these AI technologies reflects a broader cultural transformation within local governments. Traditionally, public service institutions have been characterized by bureaucratic inertia and resistance to change (Savoldelli et al., 2014). However, the current trend of AI adoption suggests a significant departure from these longstanding practices. Public servants are now more inclined to explore and utilize technological innovations that not only enhance operational efficiency but also foster a more participatory form of governance. This shift is indicative of a cultural reorientation toward openness, agility, and a willingness to experiment with novel approaches to citizen engagement (Henk & Nilssen, 2021).

The cultural shift toward embracing AI tools has significant implications for civic engagement initiatives. By automating routine tasks and providing advanced analytical capabilities, these technologies enable public servants to devote more time and resources to strategic decision-making and policy development. This reallocation of efforts has the potential to foster more meaningful and responsive interactions between local governments and their constituents (Androutsopoulou et al., 2019). Furthermore, the adoption of AI tools helps mitigate some of the challenges associated with managing large-scale digital civic engagement, such as information overload and the need for rapid response to public concerns.

5.2 Keep humans in the loop: Human moderation and AI literacy.

The integration of AI tools into civic engagement initiatives within local governments offers remarkable advantages in terms of efficiency, scalability, and data-driven decision-making. However, the findings of this study underscore that the full potential of these technologies can only be realized when human oversight is maintained—a principle encapsulated in the mantra "*keep humans in the loop*" (Alon-Barkat & Busuioc, 2023). This approach not only compensates for the limitations inherent in automated systems but also fosters the development of AI literacy among public servants, ensuring responsible and ethical deployment of technology. According to the interview results, public servants have expressed concerns about the accuracy and accountability of AI tools. While AI sensemaking adeptly analyzes and synthesizes large, complex datasets into actionable insights, the interpretation of these insights within the intricate socio-political landscape of civic engagement requires a depth of contextual understanding that only public servants can provide.

Interview results highlight a concern about a lack of oversight when governments rely on insights created by AI-based tools. Before the development of more recent AI technologies, technical experts still had a greater ability to scrutinize outcomes to some extent (Hagen, 2018). However, the latest AI technology, such as large language models, makes scrutinizing the AI outcomes nearly impossible. Notably, (1) AI outcomes lack logical paths that humans can trace, and (2) AI development involves complex training data and multiple layers of probabilistic sampling—just two of many challenges in evaluating their results (Zhao et al., 2024). Public servants, through their expertise and familiarity with local contexts, can identify potential biases, challenge erroneous conclusions, and ensure that AI-derived insights align with broader governance goals. Thus, keeping humans in the loop transforms AI sensemaking from a purely computational exercise into a collaborative process that enhances both the reliability and relevance of the outcomes (Wang et al., 2020).

Central to this human-AI collaboration is the need for robust AI literacy among public servants. As local governments increasingly adopt sophisticated digital tools, it becomes imperative that those responsible for managing these systems possess a deep understanding of their operational mechanisms and limitations. AI literacy empowers public servants to critically assess the outputs of AI systems, make informed decisions about when and how to intervene, and continuously refine these technologies based on practical, context-specific feedback (Long & Magerko, 2020). This proficiency not only enhances operational efficiency but also promotes a culture of innovation and ethical accountability within local government institutions.

6. Conclusion

This study examined AI features successfully adopted by local governments for civic engagement practice. Those AI features include automatic formatting and summarization, data analysis, and intelligence generation. Our findings suggest that AI tools have enhanced the capacity of small organizations and contributed to cultural shifts in civic engagement by promoting respectful discussion and improving efficiency. However, public servants also highlighted key challenges, such as concerns about the accuracy of AI-generated outcomes, the need for greater AI literacy, and the lack of accountability in AI decision-making.

This study will make several contributions and holds significant potential for advancing both technological innovation and democratic governance. First, exploring the use of AI-enabled civic engagement tools will significantly contribute to the design and improvement of such systems by enhancing AI-driven interactions and addressing ethical concerns. Second, by examining how AI is utilized to deliver public services and engage with citizens and communities, researchers can identify best practices and innovative approaches that enhance the quality, efficiency, and effectiveness of government services. Third, by studying the impact of AI on community participation and decision-making processes, researchers can determine whether these technologies are effectively reaching marginalized populations and amplifying their voices in the policymaking process. Ultimately, investigating the application of AI in local governments for civic engagement can also help identify and mitigate potential risks and challenges associated with these technologies. This includes concerns related to data privacy, algorithmic bias, digital divides, and the erosion of trust in government institutions. In the meantime, by focusing on the organizational level's adoption of AI in delivering public services, this study would make theoretical contributions toward social informatics in terms of social structures, civic engagement, and ethical considerations.

While this interview study served as an exploratory analysis of the understudied phenomenon of AI use in local governments for civic engagement, there are many directions for future work to expand upon the presented findings. For example, future studies can investigate the use of AI in local governments across various regions, countries, or cultural contexts to understand how variations in governance, resources, and public needs influence the adoption of AI. Additionally, it would be beneficial to conduct studies that focus on citizens' experiences and perceptions of AI-based platforms to gain a deeper understanding of trust, accessibility, and usability issues. Based on the ethical considerations in the findings, we suggest that scholars develop ethical frameworks to ensure transparency, trust, and fairness in AI decision-making processes and study the role of policy and governance frameworks in guiding the ethical use of AI in local governments.

The primary limitation of this study is the limited access to relevant and reliable data in local governments. The

interviews were conducted with one or two representatives from each organization due to concerns about low availability and confidentiality. Also, the lack of background information on each organization and the absence of standardized datasets across these local governments make comparative analysis difficult. This study focused on governments that adopted this specific platform, leading to limited generalizability, which may also result in skewed results due to the overrepresentation of more technologically advanced or resource-rich local governments. Moreover, the research only captured a snapshot in time, missing the long-term evolution of AI adoption in local governments and its impacts on civic engagement.

References

Ahmad, T., Zhang, D., Huang, C., Zhang, H., Dai, N., Song, Y., & Chen, H. (2021). Artificial intelligence in sustainable energy industry: Status Quo, challenges and opportunities. *Journal of Cleaner Production*, *289*, 125834. https://doi.org/10.1016/j.jclepro.2021.125834

Ahn, M. J., & Chen, Y. C. (2020). Artificial intelligence in government: Potentials, challenges, and the future. *The 21st Annual International Conference on Digital Government Research*, 243–252. https://doi.org/10.1145/3396956.3398260

Ahn, M. J., & Chen, Y. C. (2022). Digital transformation toward AI-augmented public administration: The perception of government employees and the willingness to use AI in government. *Government Information Quarterly*, *39*(2), 101664. https://doi.org/10.1016/j.giq.2021.101664

Alon-Barkat, S., & Busuioc, M. (2023). Human–AI interactions in public sector decision making: "Automation bias" and "selective adherence" to algorithmic advice. *Journal of Public Administration Research and Theory*, *33*(1), 153–169. https://doi.org/10.1093/jopart/muac007

Androutsopoulou, A., Karacapilidis, N., Loukis, E., & Charalabidis, Y. (2019). Transforming the communication between citizens and government through AI-guided chatbots. *Government Information Quarterly*, *36*(2), 358–367. https://doi.org/10.1016/j.giq.2018.10.001

Aoki, N. (2020). An experimental study of public trust in AI chatbots in the public sector. *Government Information Quarterly*, *37*(4), 101490. https://doi.org/10.1016/j.giq.2020.101490

Axelsson, K., Melin, U., & Lindgren, I. (2010). Exploring the importance of citizen participation and involvement in e-government projects: Practice, incentives, and organization. *Transforming Government: People, Process and Policy*, *4*(4), 299–321. https://doi.org/10.1108/17506161011081309

Bonsón, E., Royo, S., & Ratkai, M. (2015). Citizens' engagement on local governments' Facebook sites. An empirical analysis: The impact of different media and content types in Western Europe. *Government Information Quarterly*, *32*(1), 52–62. https://doi.org/10.1016/j.giq.2014.11.001

Charles, V., Rana, N. P., & Carter, L. (2022). Artificial Intelligence for data-driven decision-making and governance in public affairs. *Government Information Quarterly*, *39*(4), 101742. https://doi.org/10.1016/j.giq.2022.101742

Dhieb, N., Ghazzai, H., Besbes, H., & Massoud, Y. (2020). A secure ai-driven architecture for automated insurance systems: Fraud detection and risk measurement. *IEEE Access*, *8*, 58546-58558. https://doi.org/10.1109/ACCESS.2020.2983300

Dumas, C. L., LaManna, D., Harrison, T. M., Ravi, S., Kotfila, C., Gervais, N., Hagen, L., & Chen, F. (2015). Examining political mobilization of online communities through e-petitioning behavior in We the People. *Big Data & Society*, *2*(2), 2053951715598170. https://doi.org/10.1177/2053951715598170

Glaser, B., & Strauss, A. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Aldine Transaction.

Gualdi, F., & Cordella, A. (2021). Artificial Intelligence and decision-making: The question of accountability. In *Proceedings of the 54th Hawaii International Conference on System Sciences*, 2297–2306. https://doi.org/10.24251/HICSS.2021.281

Hagen, L. (2018). Content analysis of e-petitions with topic modeling: How to train and evaluate LDA models? *Information Processing & Management*, *54*(6), 1292–1307. https://doi.org/10.1016/j.ipm.2018.05.006

Henk, A., & Nilssen, F. (2021). Can AI become a state servant? A case study of an intelligent chatbot implementation in a Scandinavian public service. In *Proceedings of the 54th Hawaii International Conference on System Sciences (HICSS)*. http://hdl.handle.net/10125/71290

Hood, C., & Margetts, H. (2007). *The Tools of Government in the Digital Age*. Bloomsbury Publishing.

Kuziemski, M., & Misuraca, G. (2020). AI governance in the public sector: Three tales from the frontiers of automated decision-making in democratic settings. *Telecommunications Policy*, *44*(6), 101976. https://doi.org/10.1016/j.telpol.2020.101976

Loi, M., & Spielkamp, M. (2021). Towards accountability in the use of Artificial Intelligence for public administrations. *Proceedings of the 2021 AAAI/ACM Conference on AI, Ethics, and Society*, 757–766. https://doi.org/10.1145/3461702.3462631

Long, D., & Magerko, B. (2020). What is AI Literacy? Competencies and Design Considerations. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–16. https://doi.org/10.1145/3313831.3376727

Maragno, G., Tangi, L., Gastaldi, L., & Benedetti, M. (2021). The spread of Artificial Intelligence in the public sector: A worldwide overview. *14th International Conference on Theory and Practice of Electronic Governance*, 1–9. https://doi.org/10.1145/3494193.3494194

Medaglia, R., & Tangi, L. (2022). The adoption of Artificial Intelligence in the public sector in Europe: Drivers, features, and impacts. *15th International Conference on Theory and Practice of Electronic Governance*, 10–18. https://doi.org/10.1145/3560107.3560110

Morley, J., Floridi, L., Kinsey, L., & Elhalal, A. (2020). From what to how: An initial review of publicly available AI ethics tools, methods and research to translate principles into practices. *Science and Engineering Ethics*, *26*(4), 2141–2168. https://doi.org/10.1007/s11948-019-00165-5

OECD (2019). Recommendation of the Council on Artificial Intelligence. Retrieved from https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449

Savoldelli, A., Codagnone, C., & Misuraca, G. (2014). Understanding the e-government paradox: Learning from literature and practice on barriers to adoption. *Government Information Quarterly*, *31*, S63–S71. https://doi.org/10.1016/j.giq.2014.01.008

Sharma, S. K., Al-Badi, A., Rana, N. P., & Al-Azizi, L. (2018). Mobile applications in government services (mG-App) from user's perspectives: A predictive modeling approach. *Government Information Quarterly*, *35*(4), 557–568. https://doi.org/10.1016/j.giq.2018.07.002

Sousa, W. G. D., Melo, E. R. P. D., Bermejo, P. H. D. S., Farias, R. A. S., & Gomes, A. O. (2019). How and where is artificial intelligence in the public sector going? A literature review and research agenda. *Government Information Quarterly*, *36*(4), 101392. https://doi.org/10.1016/j.giq.2019.07.004

Tangi, L., van Noordt, C., & Rodriguez Müller, A. P. (2023). The challenges of AI implementation in the public sector. An in-depth case studies analysis. *Proceedings of the 24th Annual International Conference on Digital Government Research*, 414–422. https://doi.org/10.1145/3598469.3598516

Uslaner, E. M., & Brown, M. (2005). Inequality, trust, and civic Engagement. *American Politics Research*, *33*(6), 868–894. https://doi.org/10.1177/1532673X04271903

Valle-Cruz, D., Alejandro Ruvalcaba-Gomez, E., Sandoval-Almazan, R., & Ignacio Criado, J. (2019). A review of artificial intelligence in government and its potential from a public policy perspective. *Proceedings of the 20th Annual International Conference on Digital Government Research*, 91–99. https://doi.org/10.1145/3325112.3325242

van Noordt, C., & Misuraca, G. (2020). Evaluating the impact of artificial intelligence technologies in public services: Towards an assessment framework. *Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance*, 8–16. https://doi.org/10.1145/3428502.3428504

van Noordt, C., & Misuraca, G. (2022). Artificial intelligence for the public sector: Results of landscaping the use of AI in government across the European Union. *Government Information Quarterly*, *39*(3), 101714. https://doi.org/10.1016/j.giq.2022.101714

Wang, D., Churchill, E., Maes, P., Fan, X., Shneiderman, B., Shi, Y., & Wang, Q. (2020). From Human-Human Collaboration to Human-AI Collaboration: Designing AI Systems That Can Work Together with People. *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–6. https://doi.org/10.1145/3334480.3381069

Wihlborg, E., Larsson, H., & Hedström, K. (2016). "The computer says no!" — A case study on automated decision-making in public authorities. In *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 2903–2912. https://doi.org/10.1109/HICSS.2016.364

Wirtz, B. W., Weyerer, J. C., & Sturm, B. J. (2020). The dark sides of Artificial Intelligence: An integrated AI governance framework for public administration. *International Journal of Public Administration*, *43*(9), 818–829. https://doi.org/10.1080/01900692.2020.1749851

Yigitcanlar, T., Agdas, D., & Degirmenci, K. (2023). Artificial intelligence in local governments: Perceptions of city managers on prospects, constraints and choices. *AI & SOCIETY*, *38*(3), 1135–1150. https://doi.org/10.1007/s00146-022-01450-x

Zhang, W., Zuo, N., He, W., Li, S., & Yu, L. (2021). Factors influencing the use of artificial intelligence in government: Evidence from China. *Technology in Society*, *66*, 101675. https://doi.org/10.1016/j.techsoc.2021.101675

Zhao, W. X., Zhou, K., Li, J., Tang, T., Wang, X., Hou, Y., Min, Y., Zhang, B., Zhang, J., Dong, Z., Du, Y., Yang, C., Chen, Y., Chen, Z., Jiang, J., Ren, R., Li, Y., Tang, X., Liu, Z., … Wen, J.-R. (2024). *A Survey of Large Language Models* (arXiv:2303.18223). arXiv. https://doi.org/10.48550/arXiv.2303.18223

Zuiderwijk, A., Chen, Y. C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly*, *38*(3), 101577. https://doi.org/10.1016/j.giq.2021.101577

It is important that all references used in the text are listed in the references list at the end of the paper. Please make sure that the items listed are as accurate and complete as possible. For this conference we will be using the APA referening style (see: https://apastyle.apa.org/style-grammar-guidelines/references/examples).

Appendix

Interview questions for platform designers

Background information

- Can you tell me a little about your positions and work at GoVocal? How long have you been with the company? What are your main responsibilities?
- What inspired GoVocal to focus on developing an AI-based platform for public service and community engagement? What do you think about the use of technology for public service? What do you think about community engagement?

Design and development

- Could you describe the process of designing an AI-based platform for public service and community engagement? What stages are involved? How do you initiate the project?
- What specific challenges do you encounter when developing these platforms? How do you address issues related to data privacy, user trust, and inclusivity?
- How do you ensure that the AI-based platform is user-friendly and accessible to a diverse range of users? What considerations are taken into account for different user demographics?

Technical aspects

- What technologies and tools do you typically use in developing these AI platforms? Are there any specific programming languages, frameworks, or software that are particularly important?
- How do you train and test the AI models to ensure they perform effectively in real-world public service scenarios?
- How do you evaluate the performance? How do you handle misinformation, trolling, and other kinds of manipulative language in the design?

Civic engagement

- How do you understand civic engagement in public services? What are the objectives of community engagement for local government? How do you design for those goals and objectives?
- How do you involve other stakeholders in the design and development process (e.g., public servants and citizens)? What methods do you use to gather feedback from those stakeholders?
- How do you design for different communities, especially for those who have immigrants from other countries or people with other linguistic and cultural backgrounds?

Impact and outcomes

- Can you provide examples of successful implementations of GoVocal's AI platforms in public service and community engagement? What were the key factors that contributed to their success?
- How do you evaluate the impact of your AI platforms on the communities they serve? What metrics or indicators do you use?

Ethical considerations

- What ethical considerations do you take into account when designing AI platforms for public service? How do you address potential bias and discrimination in the AI models?
- How does GoVocal ensure fairness, explainability, security, transparency, and accountability in its AI platforms?

Future directions

- What are GoVocal's future plans for developing AI platforms for public service and community engagement? Are there any upcoming projects or new features you are excited about?
- What advancements in AI do you believe will most significantly impact public service and community

engagement in the next five years?

Interview questions for public servants

Background information

- Can you tell me a little about your role within the local government? How long have you been in this position? What are your main responsibilities?
- How long has your government been using GoVocal?
- What's the size of your population in the community?

Adoption and implementation

- What are the motivations for your governments to adopt the GoVocal platform? How did you make the decision? What are the things that you considered in the adoption?
- Can you describe how GoVocal's AI features are integrated into your public service and community engagement efforts? What specific services or initiatives are you using GoVocal for?
- What was the process of implementing GoVocal Like? What steps did you take? Were there any challenges during the implementation?
- How do you train your staff to use GoVocal's AI features? What kind of training or support does GoVocal provide?

Impact on public service and community engagement

- What improvements or changes have you observed in public service delivery since implementing GoVocal? How do you measure the effectiveness of GoVocal in enhancing public services? Can you provide specific examples or metrics?
- How do you understand community engagement in public services? What are the objectives of community engagement for local government? How has GoVocal impacted community engagement in your areas? Are there any notable success stories or positive outcomes? Or what metrics or indicators do you use?
- How do you involve other stakeholders in the decision-making process (e.g., public servants and citizens) about the implementation of GoVocal in local governments? What methods do you use to gather feedback from those stakeholders?

Impact on work and public service

- How has the use of GoVocal's AI features transformed your work as a public servant? Can you provide specific examples of how it has changed your daily tasks or responsibilities?
- What improvements or efficiencies have you noticed since using GoVocal? How has it affected the way you deliver public services?
- How has GoVocal impacted your interactions with the community? Are there any specific instances where GoVocal improved community engagement?

Challenges and solutions

- What challenges have you encountered while using GoVocal's AI features? How have you addressed or overcome these challenges?
- Are there any limitations of the GoVocal platform that you have identified? How do you work around these limitations?
- Have you needed to adapt your work processes to accommodate GoVocal? What changes did you make to your workflow?

User experience and feedback

- How do the residents and community members respond to the AI features of GoVocal? What feedback have you received from the public?
- How do you collect and incorporate feedback from the community about GoVocal's features? Can you give examples of how community feedback has led to changes or improvements?

Ethical and privacy considerations

- What measures do you take to ensure the ethical use of AI in your work? How do you address issues related to data privacy and security?
- How transparent are you with the community about the use of AI in public services? What steps do you take to maintain transparency and build trust?

Future directions

- What future plans do you have for using GoVocal and its AI features in your local government? Are there any new projects or expansions you are considering?
- What advancements or features would you like to see in GoVocal to better serve your needs?

Algorithmic fairness as sociotechnical system: A typology of the information construct.

Mortaza S. Bargh[a*], *Sunil* Choenni[b], *Floris* ter Braak[c]

[a]Research and Data Centre, Ministry of Justice and Security, The Hague, The Netherlands, email address m.shoae.bargh@wodc.nl, ORCID number 0000-0001-5395-456X.

[b]Affiliation 1: Research and Data Centre, Ministry of Justice and Security, The Hague, The Netherlands, email address r.choenni@wodc.nl, Affiliation 2: Creating 010 Research Centre, Rotterdam Univeristy of Applied Sciences, Rotterdam, The Netherlands, email address r.choenni@hr.nl, ORCID number 0000-0003-2772-6330.

[c]Research and Data Centre, Ministry of Justice and Security, The Hague, The Netherlands, email address f.ter.braak@wodc.nl, ORCID number 0000-0001-9966-3514.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Organizations and enterprises search for ways to exploit the vast amount of data that is produced by citizens, sensors, devices and administrative processes. Capitalizing on the produced data should be done responsibly by preventing, mitigating and managing undesired side effects such as violation of rules and regulations, human rights, ethical principles as well as privacy and security requirements. A key challenge in employing data, algorithms and data-driven systems is to adhere to the principle of fairness and justice. In this contribution we focus on the issue of algorithmic fairness, which itself can be framed as a sociotechnical system with interacting social and technical/formal subsystems. Information is a key construct of any sociotechnical system, where information creation and exchange can ease the opacity of interactions between the social and formal subsystems, and of interactions between the subsystems and the environment in which they operate. Based on literature, we categorize the types and flows of the information construct within the sociotechnical systems of algorithmic fairness in 7 categories. As such, the presented insights about the 7 categories of the information construct can form a common mental model whereby social and technical disciplines can inform each other systematically and align their views on algorithmic fairness.

Keywords. Algorithmic fairness, fairness, information construct, justice, sociotechnical systems.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.952

1. Introduction

Data are currently being generated, collected, analyzed, and distributed at a fast-growing pace. This growth is due to proliferation of connected devices (such as cameras, smartphones, sensors, and smart household appliances), widespread and intensive use of social networks, and fast-paced digitalization of business and organizational processes/services, among others. Public organizations and private enterprises collect a vast amount of data directly as a necessary input for provisioning their services or as a byproduct of their services. As a result of this growth, there is a rising interest (and demand) to harvest the available data by using Artificial Intelligence (AI) and Machine Learning (ML) algorithms to develop advanced data-driven systems, like decision-support systems, that ease our daily lives, create additional value for businesses, provide insight into societal phenomena, and guide policymaking processes. These data-driven systems are applied to various domains of society like justice, healthcare, education, public safety and security, public administration, transportation and logistics. Specifically within public organizations, AI and ML have gained a foothold in daily

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

practice for policy making (e.g., to detect social issues quickly, improve policy decisions, and monitor policy implementation), for provisioning public services (e.g., to improve service delivery and develop innovative services), and for managing internal affairs (e.g., to develop management innovations, human resources, procurement and finances), to name a few (Leeuw, 2025). All these have presently resulted in various forms of smart environment paradigms like smart cities, smart healthcare, smart logistics, and smart government.

The current trend of digitization, digitalization and digital transformation worldwide, which relies on digital technology and data-driven systems, has a huge impact on several aspects of our lives. In addition to its potentials, this trend inflicts a wide range of disorders and problems, ranging from sustainability-oriented ones to efficiency-oriented ones (Toli & Murtagh, 2020). Sustainability-oriented problems are related to social values (e.g., equity, community autonomy, citizen well-being, quality of life and gratification of fundamental human needs), economy vitality and diversity, and environment conservation (e.g., flora, fauna, and natural resources). Efficiency-oriented problems are related to efficient management of public and commercial services in various domains of society.

However, as data and data-driven systems are transforming our society on every scale, the so-called smart systems that capitalize on data should not be perceived as pure technological systems. The way that data are collected, which are often blended with sensitive and stigmatizing information about individuals, groups, and businesses, and the way that algorithms and data-driven smart systems are devised, designed, implemented, deployed, and (mis)used (are going to) impact us deeply at individual, group and societal levels. As such, all societal, environmental, technological transformations affected by or derived from data-driven systems must be attentive and respectful of legal, ethical and human rights principles.

Despite the success that data-driven smart systems are experiencing, there are still many key stumbling blocks in their large-scale and real-life deployments. Realizing smart systems, on the one hand, entails several technological challenges like establishing efficient mechanisms for integration, storage, and retrieval of (large volumes of) data, and processing (different types of) data in almost real-time. On the other hand, there are many non-functional challenges for using data and algorithms in practice, also known as soft challenges. Some examples of these challenges are mitigating the security issues of largely distributed data-reliant systems, managing the quality issues of loosely coupled data sources, and dealing with biased and/or wrongful discrimination of individuals and groups (i.e., unfairness) as embedded in collected data or induced due to inattentive design or use of algorithms. Not handling these soft challenges appropriately and adequately would harm individuals, groups and society, adversely affecting basic human rights like privacy, liberty, autonomy and dignity.

In this contribution, we consider decision-support systems, which are a specific case of data-driven smart systems. Often in such systems, AI and ML algorithms are used to train classification models, the trained models are used to predict some outcomes, and the predicted outcomes are used as (partial) evidence for making decisions about individuals (e.g., in credit granting) and/or groups (e.g., in policy-making). A publication by the European Union (EU) office (see Misuraca & van Noordt, 2020) has extensively analyzed the landscape of AI usage in public services across Europe. During the period of May 2019 – February 2020, the report gives an account of 230 initiatives for using AI in public services across Europe. Of these 230 initiatives, there are 29 initiatives (about 13%) categorized as "Expert and Rule-based Systems, Algorithmic Decision Making", which can give a good estimate of the mentioned AI/ML based-decision support-systems for public services. A well known example of such systems in the justice domain is the Correctional Offender Management Profiling for Alternative Sanctions (COMPAS) tool. The tool was used for measuring the risk of a defender to recommit crime, i.e., recidivism. Although the tool was designed to be fair from some perspective (Dieterich et al., 2016), a follow up study showed that the COMPAS tool was unfair from another perspective (Larson et al., 2016). Specifically, African American defendants were more likely than Caucasian defendants to be incorrectly flagged as higher risk of recidivism (false positive rate), while Caucasian defendants were more likely than African American defendants to be incorrectly flagged as low risk of recidivism (false negative rate). Note the results of this paper can be applied to other usage areas of algorithms.

As the outcome of such decision-support systems can be biased against social groups and individuals unjustifiably (Choenni et al., 2018; Dolata et al., 2022; Netten et al., 2018; Starke et al., 2022), we aim at addressing the soft-challenge of social biases and wrongful discrimination (i.e., unfairness) when realizing and using data-driven decision-support systems. This unfairness stems from, for example, the biased data used for training algorithms, the bias introduced in such algorithms, and/or the way that the outcomes are interpreted and applied to the practice (Choenni et al., 2021). In other words, we focus on the field of *algorithmic fairness* which

aims at addressing these biases and discrimination when the outcomes of an AI/ML algorithm is used within (i.e., as a part of) social service provisioning. Not only are decision-support systems used within social services sociotechnical systems, but also their algorithmic fairness component can be regarded as a sociotechnical system with two interacting subsystems: a formal/technical subsystem and a social subsystem (Dolata et al., 2022). Sociotechnical systems are generally characterized by some generic constructs in literature. Information is one of these constructs that shapes and is shaped by how the components of a sociotechnical systems interact and it paves the way to achieve the desired goals of a system by providing some sort of order (i.e., by reducing uncertainty/entropy via imparting dialog, meaning, and utility to sociotechnical interactions) (Chatterjee et al., 2021). Towards the research objective described above, we deliver the following contributions in this paper.

- We present a model of the sociotechnical systems corresponding to algorithmic fairness, which conceptualizes the development stages of these systems. The model encompasses fairness conceptualization, design, and operation stages, where each of these stages has footholds in both technical and social subsystems.
- We delve into the information construct of sociotechnical systems and, based on literature, identify and specify 7 information artifacts that may arise due to interactions among the components of the sociotechnical systems associated with algorithmic fairness.

For this study we have conducted extensive content analysis of the literature to derive the insights and the model presented. The conducted literature review can be characterized as a theoretical review that "draws on existing conceptual and empirical studies to provide a context for identifying, describing, and transforming into a higher order of theoretical structure and various concepts, constructs or relationships" (Paré et al., 2015). Our primary goal was to develop a conceptual model that explains the existing structure and the information construct of algorithmic fairness. To this end, we studied and analyzed a number of selected papers that have been published in leading journals and conferences in fields of data science, law, and ethics. The analysis is performed through the lens of applying AI/ML classification outcomes to social context where, due to uncertainty, the impact on individuals and social groups can be unfair and can thus lead to (social) injustice.

The outline of the paper is follows. In Section 2 we provide some background information about algorithmic fairness and present our conceptual model of algorithmic fairness sociotechnical systems. In Section 3 we review the related literature. In Section 4, we present our typology of the information construct for algorithmic fairness, supported by evidences from the literature. Finally, in Section 5 we discuss the results, draw our conclusions, and mention several directions for future research.

2. Algorithmic fairness as a sociotechnical system

In this section we provide some background information and present our first contribution. We start with explaining relevant concepts in Section 2.1. In Section 2.2 we explain the social and formal views on fairness and algorithmic fairness, as well as their pitfalls. Subsequently, in Sections 2.3 and 2.4 we explain the need for adopting a sociotechnical viewpoint and approach, respectively, to address the issues of algorithmic fairness in complex social settings. In Section 2.5, we summarize the outcome of the section.

2.1. Fairness and algorithmic fairness

Fairness in the context of decision-making refers to the "absence of any prejudice or favoritism toward an individual or group based on their inherent or acquired characteristics" (Mehrabi et al., 2021). Two sources of unfairness (lack of fairness) are bias and wrongful discrimination. (NB., from this point on we will use the term discrimination instead of wrongful discrimination for brevity as well as for conformity to the literature.) In data-driven decision support systems bias can exist in data, algorithms, and/or the way that the outcomes of algorithms are applied to practice (i.e., in interaction between algorithms and users), see (Mehrabi et al., 2021). Some forms of bias can lead to unfairness in different down-stream systems that use the outcomes of data-driven decision support systems. Discrimination is attributed to human prejudice and stereotyping that is based on the sensitive attributes (like gender, race and religion).

Algorithmic fairness refers to those technological solutions that are devised for detecting and preventing systematic harms or benefits to different subgroups and individuals in data-driven decision-making (Dolata et al.,

2022). In other words, algorithmic fairness aims at (a) mathematically quantifying biases in AI and ML based systems using various metrics (or indicators) and (b) devising measures (i.e., solutions) to mitigate unjustified biases and discrimination. We note that protecting both individuals and subgroups is at the focus of such solutions. Further, as will be explained in the following sections, the scope of algorithmic fairness spans beyond technical solutions and intertwines with social solutions (i.e., social measures or interventions) for mitigating undesired biases and discrimination in AI and ML based systems. Therefore, we use *algorithmic-based fairness* to refer to those technical and non-technical solutions in data-driven decision-making processes that can be devised for preventing systematic harms or benefits to individuals or different subgroups (one may refer to this holistic view as algorithmic justice).

Note that algorithmic fairness together with algorithmic transparency (and the related concepts of explainability and interpretability) and cybersecurity (which includes privacy protection) constitute the core components of the field of responsible AI (Chorąś et al., 2020).

2.2. Social and formal views on (algorithmic) fairness

Figure 1 shows our model of the sociotechnical systems corresponding to algorithmic fairness. It actually conceptualizes the development stages of these systems vertically; and the technical and social subsystems of sociotechnical systems horizontally. Conceptually, as shown by conceptualization space in Figure 1, there are two main views on fairness that originate from the social discourse and formal discourse on fairness (see Starke et al., 2022 and Dolata et al., 2022). The social view on fairness can be traced back to disciplines like philosophy, political science, legal science, organization science, criminology, sociology, anthropology, neuroscience, and psychology. The formal view on fairness encompasses attempts to model (aspects of) the social concepts of fairness, especially those borrowed from anthropological and organizational viewpoints. To this end, based on the derived models, one builds formal (i.e., technical) fairness measures and mechanisms in Information System (ISs). While the social discourse inspires the formal discourse (see the link drawn in Figure 1) – thus resulting in mathematical or formal definitions of fairness or the so-called fairness metrics – the formal discourse lays down the ground for the formal aspects of algorithmic fairness.

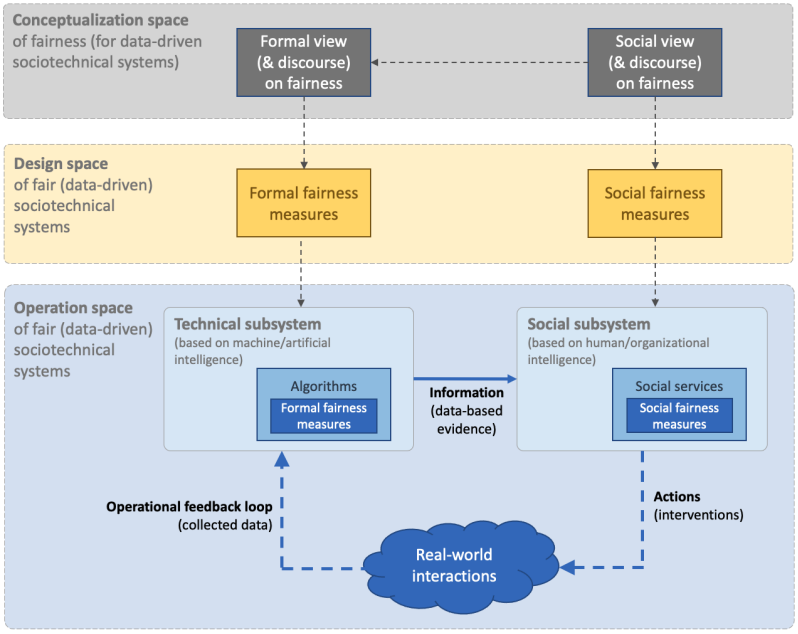


Fig. 1 – An illustration of social and formal aspects of algorithmic fairness in three system development spaces.

In practice, the design space of algorithmic fairness encompasses technical metrics as well as both formal and social measures (solutions), as indicated in the middle of Figure 1. Through design, the formal and social measures of fairness should be combined appropriately to deliver algorithmic-based fairness in a given context. In the operation phase of a data-driven decision support system, as indicated by operation space in Figure 1, the formal and social subsystems, which include formal and social fairness measures, are applied into practice to operationalize the intended intervention. Depending on the operation context, the operation space may encompass group related actions (e.g., making policies) and/or individual related actions (making decisions

about someone). Through interacting with the real-world phenomena and environment, the interaction between technical and social subsystems may lead to emerging behaviors that were not foreseen in the design phase.

2.3. Algorithmic fairness as a sociotechnical system

Investigating algorithmic fairness solutions from the literature, the authors of (Dolata et al., 2022) identify several wrong assumptions that are typically made about algorithmic fairness within the social and formal discourses. For example, in the social discourse one may ignore the differences among various formal fairness measures and treat them equally and/or assume that only human reasoning yields fair decision making (i.e., the so-called black box and purity assumptions). Similarly, in the formal discourse one may assume that there is a technical solution that captures all complex notions of fairness completely (i.e., the so-called equivalence and translation assumptions). Although these assumptions might be stereotypical to some degrees, we think reviewing them is useful for informing about and preventing the possible pitfalls of algorithmic fairness. We argue that system designers may cause harm if they either totally ignore or naively adopt the existing formal solutions.

Each of the social and formal views on fairness puts forward several, to some degree, valid points about algorithm fairness. Nevertheless, there are also interactions between social and formal aspects (and both with environment) that should be considered. In other words, not only is the data driven decision support system a sociotechnical system, so is the algorithmic fairness (aspect of the) system (Dolata et al., 2022). One can characterize algorithmic fairness as a sociotechnical phenomenon because, as illustrated in Figure 1, the process of algorithm design and development is a social practice, since the outcomes of algorithms impact individuals, groups, and society; and algorithms and algorithmic fairness are a matter of public debate (Dolata et al., 2022). As such, the social and formal aspects of algorithmic fairness interact directly or indirectly (i.e., via feedback loops as shown in Figure 1). Further, we note that the nature of these interactions is dynamic and changes in time due to gradual impacts of the interventions triggered by the models, which are a result of the algorithms. Part of this dynamicity can be attributed to the changes that occur in the environment in which the algorithms are deployed due to, for example, introducing new policies, laws, and technologies.

2.4. Adopting a sociotechnical approach

Looking at formal and social aspects individually and optimizing fairness in the formal or social domain separately does not consider the existing interactions and inter-dependencies between them nor does it account for the emerging interactions among social, formal and environmental factors. These interactions and inter-dependencies could be noticed and dealt with if one would consider them together. As the overall outcome of the sociotechnical system should be fair, unfairness threats must be sought in the combined system (like undesired emerging behavior when the formal and social subsystems interact with each other and with the environment). A careful consideration, analysis, or design of machine and human collaborations and engagements in a sociotechnical system relies on the following constructs (Chatterjee et al., 2021; Lee, 2004; Sarker et al., 2019):

- having social and formal subsystems,
- having reciprocal interactions between the social and formal subsystems (and the environment), and
- information arising from the interaction between social and formal subsystems.

In this paper, as to be explained in the following section, we contribute to the basic construct of information within the sociotechnical system of algorithmic fairness (i.e., the last construct mentioned above). The *information* construct is not a subsystem but an emergent property of the overall system that shapes and is shaped by how its social and technical subsystems interact (Chatterjee et al., 2021). "[T]he role of information is to help realize the path (by being well-formed and meaningful) of achieving the desired goals of a system. In other words, information provides some sort of order to a goal-seeking system in its effort to realize those goals, thus reducing entropy" via imparting dialog, meaning, and utility to sociotechnical interactions (Chatterjee et al., 2021). Thus, creating and exchanging information in a well-formed, meaningful, and order-giving way, is a key element/construct of sociotechnical systems. Through contributing to the basic construct of information exchange for the sociotechnical system of algorithmic fairness, we intend to move one step away from the traditional formal notion of algorithmic fairness toward the *sociotechnical* notion of fairness (or *algorithmic based fairness* as we defined in Section 2.1).

2.5. Recapturing on the proposed (mental) model

The model shown in Figure 1 is the a conceptual mental model of the sociotechnical systems associated with algorithmic fairness that we introduce in this contribution. The model aims at conceptualizing the development stages of these systems in three layers (or spaces) of fairness conceptualization, fairness design, and fair algorithm operation. The proposed model of the sociotechnical system of algorithmic fairness captures also the footholds of these stages in both technical and social subsystems.

3. Related work

Algorithmic fairness is complex as it encompasses social and formal components as well as interactions between them and the environment. There is a lot of literature describing the complex landscape of algorithmic fairness from various perspectives. Although there are valuable contributions to various aspects of algorithmic fairness, there is still room to provide more in depth understanding about how these aspects influence each other and how the disciplines involved can inform each other about the characteristics (e.g., capabilities and limitations) of fairness concepts and notions in their fields. In brief, an overarching and unifying framework for algorithmic fairness that streamlines the different perspectives and disciplines is missing.

A lot of the literature emphasizes the need for adopting a cross-disciplinary approach, particularly from a sociotechnical perspective. The authors of (Altman et al., 2018) argue that for algorithmic fairness one should consider the foreseeable effects or harms that algorithmic design, implementation, and use have on the well-being of individuals. They propose a harm-reduction framework for algorithmic fairness, which aims at identifying and mitigating harms during all stages of data lifecycle. Based on a systematic literature review, Starke et al. (Starke et al., 2022) argue about the necessity of a human-centric approach that takes individuals' perceptions on fairness into account when designing and implementing algorithmic decision-making systems. They advocate for more interdisciplinary research that adopts a society-in-the-loop framework. Dolata et al. (Dolata et al., 2022) argue that since fairness is an inherently social concept, using algorithmic fairness technologies should be based on a sociotechnical approach. They aim at embedding algorithmic fairness in the sociotechnical view of ISs and call for undertaking a holistic approach to algorithmic fairness. We build on these ideas behind the sociotechnical approach for algorithmic fairness and aim at providing a systemic view on algorithmic fairness and an informative overview of the main information flows within that systemic view.

4. A typology of the information construct for algorithmic fairness

Realizing an effective sociotechnical approach to algorithmic fairness requires, among others, information harvesting and exchange across the formal and social disciplines involved. In addition to creating transparency, the basic construct of information for sociotechnical systems, as mentioned in Section 2.2, can impart meaning and utility to sociotechnical interactions, can ensure alignment of the social and formal subsystems, and thereby can play a major role in realizing the overall goals of the system. Providing appropriate information about, for example, system components, their dynamic interactions, and the emerging behaviors, can reduce randomness and uncertainty when realizing and operationalizing the system. According to (Beynon-Davies & Wang, 2019), reducing entropy (or in other words uncertainty) is a unifying conception of information that can be related to environmental structures, organization of signals, coding and decoding of signals, shared intentionality of actors, and coordination of joint actions.

Based on literature we distinguish several flows and types of the information construct that may arise due to the interactions between the components of the sociotechnical system of algorithmic fairness shown in Figure 1. The resulting information types and flows are shown in Figure 2, which are inspired by various papers that contribute to each or a subset of therein identified elements. Without intending to be exhaustive, we motivate these information flows/types by reviewing a couple of example works per flow/type shortly in the following.

4.1. Informing about social justice norms

As illustrated by link (a) in Figure 2, the social view informs the formal discourse about social justice and fairness norms. As a result, social view inspires formal view on (aspects of) fairness. The social definitions of fairness originate from various disciplines like philosophy, political science, legal science, criminology, sociology, anthropology, neuroscience, and psychology (Dolata et al., 2022). In (Binns, 2018) the author explains

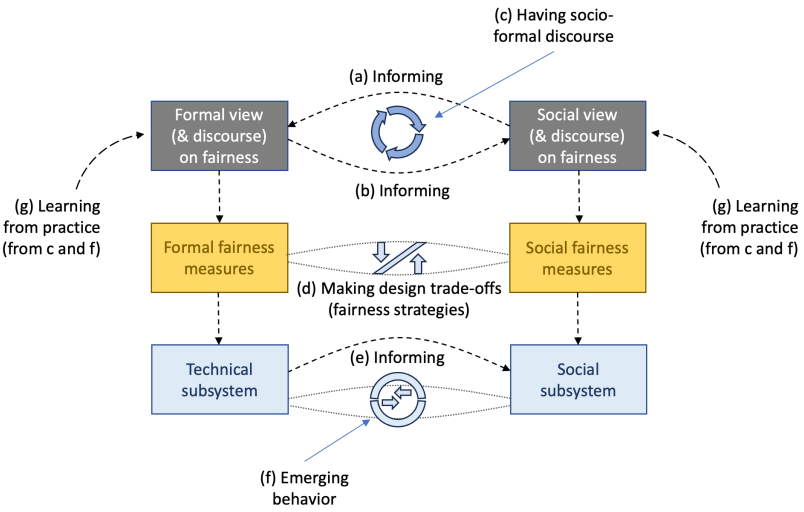


Fig. 2 – An illustration of the informational interactions between social and formal aspects of algorithmic fairness at three levels, which forms the information construct.

the terms fairness and non-discrimination as have been laid down by moral and political philosophers. Binns aims at providing a rigorous understanding about these concepts from political philosophy and elucidating the emerging debates about fair algorithms. This work can be regarded as a typical example of information link (a) shown in Figure 2.

It appears that there are inherent trade-offs between some formal metrics that quantify group and individual fairness. In (Dwork et al., 2012) the authors raise the concern that simple statistical parity metrics between protected groups could be intuitively unfair at the individual level. (In several examples they show the outcome is blatantly unfair for individuals, while statistical parity is maintained for the group the individuals belong.) The work marks another example for information link (a) in Figure 2.

4.2. Informing about algorithmic fairness measures

As illustrated by link (b) in Figure 2, the formal view uses data, simulation and formalism to quantitatively inform the social discourse about some aspects of social fairness (and justice) norms. Often inspired by social definitions of social biases, IS developers define and realize technical measures, i.e., the so-called algorithmic fairness solutions, to deal with the biases, especially when using algorithms in social domains. Existing technical definitions or measures of social bias are of four types: statistical-based, similarity-based, performance-based, and causal reasoning-based (Starke et al., 2022). In practice, there are often discrepancies between the fairness definition(s) as realized in the technical domain, i.e., those offered by algorithmic fairness solutions, and the fairness definition(s) as desired in non-technical domains. In addition to discrepancies between technical and non-technical definitions of fairness, there are discrepancies between the ways that algorithmic fairness solutions are viewed in the technical domain and in non-technical domains. Both sorts of discrepancies (i.e., those between fairness definitions and between views on algorithmic fairness) can contribute to unjustified discrimination of social groups and individuals, especially when applying the outcomes of decision-support systems into practice in social contexts (i.e., where humans, social groups and society are affected directly or indirectly).

To elaborate further on information flow (b), we explain a well-known inconsistency issue among three statistical measures, which is identified in the literature using formal and analytical methods. Specifically, the inconsistency is concerned with statistical measures, on the one hand, the Positive Predictive Value (PPV) and, on the other hand, the False Negative Ratio (FNR) and False Positive Ratio (FPR). Chouldechova (Chouldechova, 2017) gives an analysis of the relation between the PPV, FNR and FPR, assuming that the base rate for protected and unprotected groups differ. Base rate, also called prevalence or prior probability, is the percentage of a social group (like men or women) in a dataset used for training a ML model. Assuming that the base rates for the protected group and the unprotected group are different implies that it is impossible to make both PPV and FNR/FPR the same for both sensitive groups (Chouldechova, 2017). This inconsistency necessitates making trade-offs if and when applying them together into practice is required.

These achievability conditions are also derived in (Kleinberg et al., 2016) in a different and more generic

setting. Both results of (Chouldechova, 2017) and (Kleinberg et al., 2016) show the need for making trade-offs between false positive (idem, false negative) ratios vs predicted parity (or well-calibration in the generic case of Kleinberg et al., 2016). The arguments of (Chouldechova, 2017) and (Kleinberg et al., 2016) are important in investigating the famous COMPAS like cases, where the critique focused on the violation of the false positive (idem, false negative) ratios and the counterarguments established the satisfaction of predictive parity (and well-calibration) condition, see (Corbett-Davies et al., 2016; Flores et al., 2016).

It is important to realize that these results, which are derived with formal methods (and data analytics), hold for all decision-makings; including those made by human decision makers who carry out structured decision rules (Corbett-Davies et al., 2016).

4.3. Information derived from socio-formal discourse

As illustrated by link (c) in Figure 2, the exchange of information flows (a) and (b) paves the way for a socio-formal discourse, which leads to enriching the social and/or formal concepts of fairness.

In (Binns, 2020), the author reconsiders the conflict or inconsistency between group and individual fairness metrics as was already raised in (Dwork et al., 2012). This conflict exists in cases where two similar individuals who belong to different social groups (i.e., they are otherwise similar but differ in a protected characteristic) are assigned different outcomes in order to satisfy group fairness. In this case group fairness leads to individual unfairness. The authors of (Binns, 2020) argue that the conflict is a misconception based on theoretical discussions from formal and social discourses. As a result, the paper concludes that individual and group fairness are not fundamentally in conflict and that "the apparent conflict ... is more of an artefact of the blunt application of fairness measures, rather than a matter of conflicting principles". Similarly, in (Hellman, 2020) the author reconsiders the legal and philosophical rationale behind the fairness metrics that are shown to be in conflict in the case of the COMPAS tool. Both papers (Binns, 2020) and (Hellman, 2020) can be seen as a testimony of the information creation shown by link (c) in Figure 2.

4.4. Information about design trade-offs

The link (d) in Figure 2 represents the information (e.g., the design guidelines) needed for dealing with the inconsistencies that might exist among formal (and social) fairness metrics and/or measures. In the design space, this information is needed for making trade offs within and between contending social and formal fairness measures (i.e., among the partial solutions of the algorithmic-based fairness).

Both results of (Chouldechova, 2017) and (Kleinberg et al., 2016) show the need for making trade-offs between the contending statistical measures of PPV, FNR and FPR, as mentioned for link (b). The author in (Chouldechova, 2017) propose three strategies for making such trade-offs namely:

- "Allow unequal false negative rates to retain equal PPV's and achieve equal false positive rates,
- Allow unequal false positive rates to retain equal PPV's and achieve equal false negative rates,
- Allow unequal PPV's to achieve equal false positive and false negative rates".

Other options that in theory might work would be making perfect prediction (i.e., making FPR and FNR) zero (or negligible) for both protected and unprotected groups) or making the base rates for social groups equal. Although the last two options are impractical, but they could be seen as a justification of striving for perfect solutions (like eradication of social inequalities).

The trade-offs can not only be made between technical algorithmic measures as mentioned above, but also between technical and social and/or less technical ones. For the latter category one can think of trending solutions of algorithmic recourse (Karimi et al., 2022) and algorithmic contestability (Alfrink et al., 2023). Algorithmic recourse is concerned with providing explanations and recommendations to individuals who have received unfavorable outcomes from automatic decision-making systems. The explanations and recommendations should provide end-users with actionable measures whereby the outcome of an AI system can be changed to the favorable one. Making AI systems contestable by design is another way to mitigate these concerns. Via algorithmic contestability one aims at making AI systems responsive to human intervention throughout the system lifecycle. Such a human intervention can ask an AI system, for example, to explain and

interpret how outcomes are derived (including, from which input and training data). Unlike in algorithmic recourse, in algorithmic contestability the objective is not to change the algorithm outcome, but to change the outcome of the whole process from which the algorithm is part of (i.e., the term algorithmic-based fairness we introduced above). Answering these questions in both algorithmic recourse and algorithmic contestability can be facilitated by having data lineage in place (Bargh, 2024).

These works can be seen as examples for link (d) in Figure 2, representing the information (or guidelines) needed for making design trade offs among various formal metrics and social interventions.

4.5. Information about the applied fairness measures

As illustrated by link (e) in Figure 2, during system operation phase, there is a need for the AI/ML system to explain and inform social domain about the meaning and certainty of the outcomes of the technical subsystem. This information may help social domain practitioners to interpret the outcomes appropriately within the operation context.

Several works give overviews about the formal (i.e., technical) metrics and measures to algorithmic fairness from different perspectives, which can be characterized as examples of information flows and types denoted by link (e) - and to some degree of types (a) and (b) - in Figure 2. In (Verma & Rubin, 2018; Zafar et al., 2017) the authors present statistical fairness metrics according to three fairness notions of disparate treatment, disparate impact and disparate mistreatment. (Note that the scope of technical solutions covered in Verma & Rubin, 2018 is broader than statistical fairness metrics.) Carey and Wu (Carey & Wu, 2023) survey statistical fairness metrics and explain the philosophical views on fairness (like equality of opportunity and luck-egalitarian) that support or inspire those metrics.

Similarly, Verma and Rubin (Verma & Rubin, 2018) provide an overview of the most prominent formal metrics and measures of fairness which can be applicable for the algorithmic classification problem. Further, they elaborate on inconsistencies among these definitions. Balayn et al. (Balayn et al., 2021) and Mehrabi et al. (Mehrabi et al., 2021) survey the literature about bias and unfairness, the metrics and methods to identify these biases, and the measures to deal with these biases. While the former focuses on bias in training data (thus on fairness metrics, fairness identification, and unfairness mitigation methods in the field of data management), the latter considers these aspects also within algorithms and at the interaction point between end-users and algorithms.

4.6. Information about unforeseen behavior

As illustrated by link (f) in Figure 2, due to interactions of the technical and social subsystems in the operation phase, a new behavior may emerge that was not known beforehand (i.e., during the conceptualization and design phases). This emerging behavior should be accounted for and documented for further use.

Considering the feedback loops shown in Figure 1, context dependency, and the growing use of AI algorithms, algorithmic fairness sociotechnical systems can be perceived as complex systems. Scholars consider the notion of complex systems versus simple systems, although the boundary between them cannot be identified precisely (Manning & Ravi, 2013). In narrative terms, complex systems encompass, among others, contextuality, reflexivity, temporal sensitivity; allowing for reproduction, self-organization, and adaptation. In such systems, interaction among localized mechanisms within sybsystems may cause undesired emergent (mis)behaviors at a more aggregated scale (Manning & Ravi, 2013; Mogul, 2006).

When an algorithmic fairness solution is designed and implemented, there might arise new insights that were not foreseen beforehand during conceptualization or design phases. A testimonial example for this is the COMPAS tool. As mentioned in the previous sections, the tool was designed to be fair from the viewpoint of some formal fairness metrics (Dieterich et al., 2016) but, as shown by a follow up study (Larson et al., 2016), the tool was unfair according to another metric. This case can be seen as an example of link (f) shown in Figure 2.

4.7. Informing formal and social definitions

As illustrated by link (g) in Figure 2, the emerging behavior can be used for enriching social and formal views and their discourse. Current research communities are predominantly reactive in addressing the emerging "issues" from the growing use of algorithms in society. Therefore, there is an urgent need for the unity of intellectual frameworks beyond disciplinary perspectives and research practices, to offer holistic thought leadership in this space (Engin et al., 2024). A key aspect of this holistic approach is to learn from and adopt to the emerging (mis)behaviors from the practice. To this end, a realistic (impact) evaluation of such systems, which is lacking nowadays, is needed before, during and after their operation (Leeuw, 2025). The outcomes of such learning can be used to enrich the conceptualization and design of algorithmic fairness.

One of the concepts close to fairness that has changed during the time is privacy (Bargh, 2019). As the early principled discussion of privacy, Aristotle made distinction between public and private spheres of life (Nissim & Wood, 2018). Afterwards, there have been many definitions for privacy introduced, particularly within legal regimes like the right to be let alone by Warren and Brandeis in 1890, limited access to the self by Godkin in 1880, and control over personal information by Westin (Westin, 1968). An interesting point within the evolution of privacy concept is the role or rise of certain technological developments. The definition of Warren and Brandeis, i.e., the right to be let alone, brought up as a reaction to Kodak's new snap cameras and widespread newspaper circulation in 1890's. Later on, we notice ICT developments which made it possible to transfer data between remote servers (like development of the DARPANET in the 1970's), coincides with Westin's definition in 1968.

5. Conclusion

Despite the success that data-driven decision making systems offer, there are still many obstacles in their large-scale and real-life deployments like mitigating the security issues of largely distributed data-reliant systems, managing the quality issues of loosely coupled data sources, and dealing with social biases and wrongful discrimination of individuals and groups (i.e., unfairness) as embedded in collected data or induced due to inattentive data processing. Not handling these soft challenges appropriately and adequately would harm individuals, groups, and society, adversely affecting basic human rights like privacy, liberty, autonomy, and dignity.

Inspired by non-technical definitions of social biases and discrimination, IS developers define and realize algorithmic fairness solutions to deal with these issues, especially when using AI/ML based algorithms. In practice, there are discrepancies between the ways that algorithmic fairness solutions are viewed in formal and social domains. Such discrepancies can contribute to an inefficient system design, which may lead to to unjustified biases and discrimination of social groups and individuals. Such a practice becomes highly risky, especially when applying the outcomes of decision-support systems in social contexts (i.e., where humans, social groups and society are affected directly or indirectly).

In this contribution we focused on the issue of algorithmic fairness, which, in itself, can be framed as a sociotechnical system with interacting social and formal components. The information construct is considered as a key element of sociotechnical systems. It is concerned with creating and exchanging information in a well-formed, meaningful, and order-giving way. As part of the information construct, we presented a conceptual (mental) model of the sociotechnical systems associated with algorithmic fairness. The model conceptualizes the development stages of these systems for both formal and social views. As such, it can serve as a mental model for both formal and social stakeholders. Having such a common view on the complex algorithmic fairness sociotechnical systems can facilitate information exchange among the multi-disciplinary stakeholders involved and thus help bridging the gap between the formal and social views. In addition, from the literature, we noted that providing information eases the opacity of the components of the algorithmic fairness sociotechnical system. As another contribution, we identified 7 types of the information types and flows, which can collectively constitute the information construct of the sociotechnical system of algorithmic fairness.

In our future research, we will elaborate on the existing inconsistencies among some statistical fairness metrics from the literature, which ask for making tradeoffs among contending values. Further, we will sketch and discuss several strategies to deal with some aspects of algorithmic fairness (like making trade-offs). Despite being developed within or inspired by the formal perspective, we foresee that these strategies can inform the design of integrated formal and social solutions that aim at adhering to fairness principles and ideals.

Contributor Statement

The authors confirm sole responsibility for study conception and design, data collection, analysis and interpretation of results, and manuscript preparation. The first author's roles are Writing – original draft, Visualization, Investigation, Conceptualization. The second and third authors' roles are Writing – review & editing, Conceptualization, Investigation.

Use of AI

There is no use of AI in this work.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Alfrink, K., Keller, I., Kortuem, G., & Doorn, N. (2023). Contestable ai by design: Towards a framework. *Minds and Machines*, *33*(4), 613–639.

Altman, M., Wood, A., & Vayena, E. (2018). A harm-reduction framework for algorithmic fairness. *IEEE Security & Privacy*, *16*(3), 34–45.

Balayn, A., Lofi, C., & Houben, G.-J. (2021). Managing bias and unfairness in data for decision support: A survey of machine learning and data engineering approaches to identify and mitigate bias and unfairness within data management and analytics systems. *The VLDB Journal*, *30*(5), 739–768.

Bargh, M. S. (2019). *Realizing secure and privacy-protecting information systems: Bridging the gaps*. Hogeschool Rotterdam.

Bargh, M. S. (2024). Data lineage for the justice system: Scope, potentials, and directions. http://hdl.handle.net/20.500.12832/3443

Beynon-Davies, P., & Wang, Y. (2019). Deconstructing information sharing. *Journal of the association for information systems*, *20*(4), 1.

Binns, R. (2018). What can political philosophy teach us about algorithmic fairness? *IEEE Security & Privacy*, *16*(3), 73–80.

Binns, R. (2020). On the apparent conflict between individual and group fairness. *Proceedings of the 2020 conference on fairness, accountability, and transparency*, 514–524.

Carey, A. N., & Wu, X. (2023). The statistical fairness field guide: Perspectives from social and formal sciences. *AI and Ethics*, *3*(1), 1–23.

Chatterjee, S., Sarker, S., Lee, M. J., Xiao, X., & Elbanna, A. (2021). A possible conceptualization of the information systems (is) artifact: A general systems theory perspective 1. *Information Systems Journal*, *31*(4), 550–578.

Choenni, S., Netten, N., Bargh, M. S., & van den Braak, S. (2021). Exploiting big data for smart government: Facing the challenges. In J. C. Augusto (Ed.), *Handbook of smart cities* (pp. 1035–1057). Springer International Publishing. DOI: https://doi.org/10.1007/978-3-030-69698-6_82.

Choenni, S., Netten, N., Shoae-Bargh, M., & Choenni, R. (2018). On the usability of big (social) data. *2018 IEEE Intl Conf on Parallel & Distributed Processing with Applications, Ubiquitous Computing & Communications, Big Data & Cloud Computing, Social Computing & Networking, Sustainable Computing & Communications (ISPA/IUCC/BDCloud/SocialCom/SustainCom)*, 1167–1174. DOI: https://doi.org/10.1109/BDCloud.2018.00172.

Choraś, M., Pawlicki, M., Puchalski, D., & Kozik, R. (2020). Machine learning–the results are not the only thing that matters! what about security, explainability and fairness? *Computational Science–ICCS 2020: 20th International Conference, Amsterdam, The Netherlands, June 3–5, 2020, Proceedings, Part IV 20*, 615–628.

Chouldechova, A. (2017). Fair prediction with disparate impact: A study of bias in recidivism prediction instruments. *Big data*, *5*(2), 153–163. DOI: https://doi.org/10.1089/big.2016.0047.

Corbett-Davies, S., Pierson, E., Feller, A., & Goel, S. (2016). A computer program used for bail and sentencing decisions was labeled biased against blacks. it's actually not that clear. *Washington Post*, *17*.

Dieterich, W., Mendoza, C., & Brennan, T. (2016). Compas risk scales: Demonstrating accuracy equity and predictive parity. *Northpointe Inc*, *7*(4), 1–36.

Dolata, M., Feuerriegel, S., & Schwabe, G. (2022). A sociotechnical view of algorithmic fairness. *Information Systems Journal*, *32*(4), 754–818.

Dwork, C., Hardt, M., Pitassi, T., Reingold, O., & Zemel, R. (2012). Fairness through awareness. *Proceedings of the 3rd innovations in theoretical computer science conference*, 214–226.

Engin, Z., Gardner, E., Hyde, A., Verhulst, S., & Crowcroft, J. (2024). Unleashing collective intelligence for public decision-making: The data for policy community. *Data & Policy*, *6*, e23.

Flores, A. W., Bechtel, K., & Lowenkamp, C. T. (2016). False positives, false negatives, and false analyses: A rejoinder to machine bias: There's software used across the country to predict future criminals. and it's biased against blacks. *Fed. Probation*, *80*, 38.

Hellman, D. (2020). Measuring algorithmic fairness. *Virginia Law Review*, *106*(4), 811–866.

Karimi, A.-H., Barthe, G., Schölkopf, B., & Valera, I. (2022). A survey of algorithmic recourse: Contrastive explanations and consequential recommendations. *ACM Computing Surveys*, *55*(5), 1–29.

Kleinberg, J. M., Mullainathan, S., & Raghavan, M. (2016). Inherent trade-offs in the fair determination of risk scores. *Information Technology Convergence and Services*. https://api.semanticscholar.org/CorpusID:12845273

Larson, J., Mattu, S., Kirchner, L., & Angwin, J. (2016). How we analyzed the compas recidivism algorithm [Retrieved on 14 October 2024 from https://www.propublica.org/article/how-we-analyzed-the-compas-recidivism-algorithm].

Lee, A. S. (2004). Thinking about social theory and philosophy for information systems. *Social theory and philosophy for information systems*, *1*, 26.

Leeuw, F. L. (2025). The algorithmization of policy and society: The need for a realist evaluation approach. In *Artificial intelligence and evaluation* (pp. 242–265). Routledge.

Manning, P., & Ravi, S. (2013). Cross-disciplinary theory in construction of a world-historical archive. *Journal of World-Historical Information*, *1*(1), 15–39.

Mehrabi, N., Morstatter, F., Saxena, N., Lerman, K., & Galstyan, A. (2021). A survey on bias and fairness in machine learning. *ACM computing surveys (CSUR)*, *54*(6), 1–35.

Misuraca, G., & van Noordt, C. (2020). Overview of the use and impact of ai in public services in the eu. *Publications Office of the European Union: Luxembourg*.

Mogul, J. C. (2006). Emergent (mis) behavior vs. complex software systems. *ACM SIGOPS Operating Systems Review*, *40*(4), 293–304.

Netten, N., Bargh, M. S., & Choenni, S. (2018). Exploiting data analytics for social services: On searching for profiles of unlawful use of social benefits. *Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance*, 550–559.

Nissim, K., & Wood, A. (2018). Is privacy privacy? *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *376*(2128), 20170358.

Paré, G., Trudel, M.-C., Jaana, M., & Kitsiou, S. (2015). Synthesizing information systems knowledge: A typology of literature reviews. *Information & management*, *52*(2), 183–199.

Sarker, S., Chatterjee, S., Xiao, X., & Elbanna, A. (2019). The sociotechnical axis of cohesion for the is discipline: Its historical legacy and its continued relevance. *MIS quarterly*, *43*(3), 695–720.

Starke, C., Baleis, J., Keller, B., & Marcinkowski, F. (2022). Fairness perceptions of algorithmic decision-making: A systematic review of the empirical literature. *Big Data & Society*, *9*(2). DOI: https://doi.org/10.1177/20539517221115189.

Toli, A. M., & Murtagh, N. (2020). The concept of sustainability in smart city definitions. *Frontiers in Built Environment*, *6*, 77. DOI: https://doi.org/10.3389/fbuil.2020.00077.

Verma, S., & Rubin, J. (2018). Fairness definitions explained. *Proceedings of the international workshop on software fairness*, 1–7.

Westin, A. F. (1968). Privacy and freedom. *Washington and Lee Law Review*, *25*(1), 166.

Zafar, M. B., Valera, I., Gomez Rodriguez, M., & Gummadi, K. P. (2017). Fairness beyond disparate treatment & disparate impact: Learning classification without disparate mistreatment. *Proceedings of the 26th international conference on world wide web*, 1171–1180.

Developing competences for Artificial Intelligence in the Public Sector: The AI4Gov Canvas

Gianluca Carlo Misuraca [a*], *Rony* Medaglia [b], *Claudio* Feijoo [c], *Marzia* Mortati [d], *Colin* van Noordt [e]

[a] Department of Design, Polytechnic University of Milan, Milan, Italy, gianlucacarlo.misuraca@polimi.it

[b] Department of Digitalization, Copenhagen Business School, Frederiksberg, Denmark

[c] Technical University of Madrid, Madrid, Spain

[d] Department of Design, Polytechnic University of Milan, Milan, Italy

[e] KU Leuven, Leuven, Belgium

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 3 June 2025

Abstract. This article introduces the AI4Gov Canvas, an evidence-based framework designed to identify and develop the competences needed by individuals working with artificial intelligence (AI) in the public sector. Recognising the need for functional specialist profiles in AI management, use and implementation within public administrations, we address the challenge of combining a variety of domains, such as technology, management and design, and policy, ethical and legal expertise.

The AI4Gov Canvas was developed through a three-step process of competence identification, clustering, and validation, involving a review of research and grey literature, expert interviews (N=5), and an online survey (N=54). It is structured around three dimensions: technology, management and design, and policy/legal/ethical, with each dimension further categorized into three levels of abstraction: meta-competences, governance competences, and operational competences.

The Canvas serves as a practical tool for mapping existing competences, identifying training needs, and designing functional specialist profiles that balance competence importance with the difficulty of obtaining them. We provide concrete examples of how the Canvas can be used to create personas, such as the "TechnoSteward" and the "Policy Sentinel", which highlight the framework's ability to guide the development of realistic and multi-disciplinary competence profiles. We conclude by outlining lessons learnt and future steps.

Keywords. Artificial intelligence, public sector, competences, governance.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.951

1. Introduction

Artificial intelligence (AI) is becoming an increasingly vital technology for tackling social challenges and improving policymaking and public services. However, to successfully utilise these technologies, public administrations need to have the competences in their workforce to develop AI solutions, manage such initiatives, and ensure that they are used effectively.

The lack of a skilled workforce in AI is one of the critical challenges public administrations face: public managers often have limited expertise and lack competent figures to harness the benefits of AI technologies (Ahn & Chen, 2022; Neumann et al., 2022). While the lack of competencies in public administration plagues the effective deployment of other technologies as well (Zhang & Kimathi, 2022), they become crucial in avoiding irresponsible use of AI that may lead to harm. For instance, working with ethical frameworks requires different ways of working

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

than merely having these frameworks (Fest et al., 2022). Public organisations are in need for functional specialist profiles on AI development and implementation with relevant competences.

Competences encompass key skills, expertise, and knowledge that are essential for various facets of developing and utilizing AI within the public sector. The European Centre for the Development of Vocational Training's defines competences as 'The ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development)' (European Centre for the Development of Vocational Training, 2008, p. 47). This definition also specifies that 'competence is not limited to cognitive elements (involving the use of theory, concepts or tacit knowledge); it also encompasses functional aspects (involving technical skills) as well as interpersonal attributes (e.g. social or organisational skills) and ethical values' (European Centre for the Development of Vocational Training, 2008, p. 47).

Some existing frameworks on competences in a digital society have tackled the need to identify and categorize competences for relevant stakeholders. The Digital competence Framework (DigComp) (Vuorikari et al., 2022), for European citizens, and the Entrepreneurship competence Framework (EntreComp) (Bacigalupo et al., 2016), for enterprises, include general competences needed for personal development, social inclusion, active citizenship and employment, and transversal skills, such as entrepreneurship. While neither specifically focused on the public sector, nor on AI, they have paved the way for the global discourse on the need for identifying, building, and disseminating competences in the workforce of the future.

Researching competences for artificial intelligence (AI) in the public sector differs significantly from studying general digital competences due to the unique challenges and requirements associated with AI adoption in government contexts. AI competences in the public sector extend beyond technical skills, reflecting the need for compliance with regulatory frameworks like the EU AI Act and the broader societal impacts of AI implementation. These competences are also closely tied to governance practices that ensure effective deployment and continuous improvement of AI solutions, which are often hindered by rigid organizational structures and limited resources in public institutions. In contrast, research on general digital competences typically focuses on foundational skills for using digital tools and technologies, which are relevant across sectors but lack the specialized focus on governance, ethics, and public accountability required for AI in government settings (Hofmann & Ogonek, 2018).

The notable framework by the European Commission's Study on the development of a European framework for interoperability skills and competences in the public sector (EIFISC) (European Commission, 2021) is an example of zooming in on general competences related to digital transformation in the public sector. Scholarly studies so far have provided numerous empirical studies on general digitalization competences in the public sector (Edelmann et al., 2023; Hunnius & Schuppan, 2013; Mankevich et al., 2022; Ogonek et al., 2016), for example in relation to public middle managers (Roehl & Crompvoets, 2024), on digital leadership (Roman et al., 2018), and the context of smart cities (Tsoutsa & Lampropoulos, 2022) or developing countries (Hooda & Singla, 2020)

Only recently, the need for a specific framework on AI-related competences in the public sector has started to be discussed. The UNESCO framework "*Artificial Intelligence and Digital Transformation: Competences for Civil Servants* (Broadband Commission, 2022) has built the foundations for an in-depth understanding of the competence profiles of public servants that public organizations need when dealing with AI and is echoed in recent calls for further development of a comprehensive framework with the same focus (Misuraca et al., 2024).

However, key challenges emerge in the definition of an evidence-based framework that can be used as a practical tool for public managers engaged in AI projects. A first challenge rests in combining a large variety of domains that the adoption of AI in the public sector encompasses. These domains include technology expertise, such as software programming and Information Technology (IT) architecture designing; but also include managerial expertise, for example in leading AI teams; domain expertise, for example in combining AI and policy formulation; and ethical and legal expertise, for example in complying with national and supra-national regulatory guidelines (see, for instance, Mergel et al., 2024; Selten & Klievink, 2024; Medaglia et al. 2024).

A second challenge is that a single individual cannot realistically master all needed competences with equal proficiency (Misuraca & Rossel, 2023). The ideal competence profiles needed for individuals dealing with the opportunities and challenges of AI in the public sector are by necessity multi-disciplinary. On the one hand, in fact, public servants that are only knowledgeable on legal compliance practices, policymaking, and project management, for example, are ill-prepared to deal with AI initiatives, because they lack an understanding of the technical inner workings of AI systems and of their affordances. On the other hand, pure technologists who master "hard" skills in system design and programming, for example, lack the necessary insights to capture the value of such technologies in a public service context. While each competence domain is in high demand and essential to avoid common public AI project failures, it is not feasible for a single individual to have equally in-depth knowledge of the many relevant domains simultaneously.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

To address these challenges, in this article we present the AI4Gov Canvas, an evidence-based framework to identify the competences required for a functional specialist in the management, implementation, and use of AI in public sector organizations.

The Canvas stems from the experience of the AI4Gov Master on AI for public services, a training programme co-funded by the European Union (EU) under the Connecting Europe Facility (CEF), designed and implemented to equip public managers with the competences needed to manage AI in the public sector. The Master was first offered in 2021-2022 and was awarded the European Digital Skills Award in the area of Upskilling in 2023.

2. Methodology

To develop a comprehensive framework of competences for the design, implementation, management, and use of AI in the public sector, we employed a three-step approach: competence identification, clustering, and validation. These steps build upon one another to generate a robust framework.

The first step, *competence identification*, aimed to gather relevant competences from existing knowledge on AI in the public sector. This involved a) a review of academic literature identified with a combination of a keyword search in research databases, and of a meta-review of published literature reviews on AI in the public sector (Reis et al., 2019; Sharma et al., 2020; Sousa et al., 2019; Wirtz et al., 2021, 2022; Zuiderwijk et al., 2021), to map competences highlighted in empirical studies (N=15); b) a review of policy and "grey" literature from think tanks, consultancy organizations, and public institutions, carried out through a snowball approach (N=5); and interviews with experts on AI in the public sector (N=5), recruited via the AI4Gov network. The outcome was a list of competences categorized into three dimensions: technology, managerial and design, and policy/legal/ethical competences.

The second step, *competence clustering*, focused on classifying these competences according to different levels of abstraction. Competences in fact range from abstract concepts such as attitudes (e.g., risk proclivity, user centricity) and general knowledge (e.g., foundational AI knowledge), to practical skills like data collection and budgeting. To systematically incorporate this range, the competences were classified into three levels: *meta-competences* (the most abstract), *governance competences*, and *operational competences* (the most practical). To validate and integrate this classification, a workshop with 20 public servants experienced in AI and digitalization in the public sector recruited through the AI4Gov network was held.

The final step, *competence validation*, assessed the relevance and difficulty of obtaining each competence. This step addressed the reality that not all competences are equally important or easy to acquire in practice, nor they are equally difficult to obtain. An online survey of experts among public sector organizations (N=54) was conducted, where participants ranked each competence in terms of perceived relevance and difficulty, using a constant-sum allocation method (Desarbo et al., 1995). The constant-sum allocation method nudged respondents to make mindful choices between survey items, thus avoiding the possibility that all competences are marked as equally important and/or equally difficult to obtain. The method has been fruitfully used in research literature to support the creation of competence frameworks, such as non-technical competences in business degrees and business graduates (Jackson & Chapman, 2012a; 2012b) and the value of smart manufacturing competences (Böhm et al., 2023). Using the Qualtrics software for online surveys, we designed items so that the respondents had to use sliders to allocate a limited number of points across each group of competences, to evaluate each of them in terms of importance, and of difficulty to obtain. The number of points for each group of competences equalled 100 points, times the number of competences in the group that the competence belongs to.

Figure 1 provides an example of how the constant-sum allocation method was presented in the online survey.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

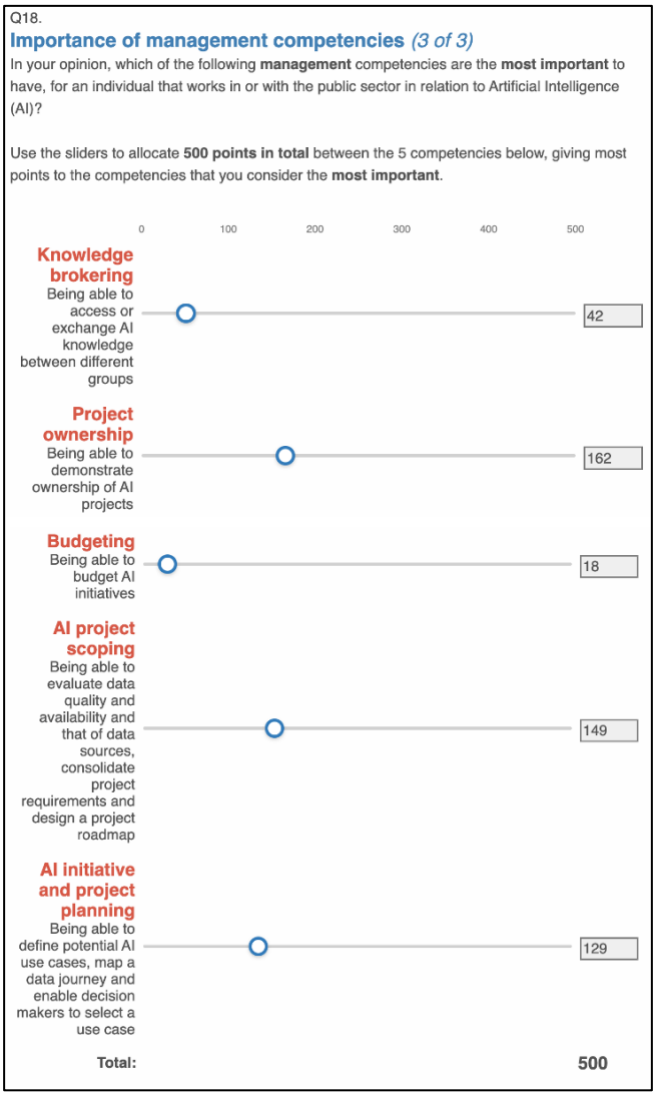


Fig. 1 – Constant-sum allocation method: example of a survey item.

The resulting data allowed us to define trade-offs when designing competence profiles that balance relevance and difficulty. This process ensures that the resulting competence framework reflects the practical constraints and priorities faced by public organizations in developing AI-related skills. As the outcome of this process, we created a comprehensive framework called the *AI4Gov Canvas*. This operational tool can be used by stakeholders to guide the development of AI competences in the public sector.

3. Results

The Annex to this article presents the list of all competences mapped, including a) the groupings in the three dimensions (management and design, technological, and policy, legal, and ethical) and in the three levels of abstraction (meta-competences, governance competences, and operational competences); b) the description of each competence; c) the coefficient of importance and coefficient of difficulty to obtain (μ) of each competence, derived from averaging the results of the online survey.

Results from the technology meta-competence group show that the most important competences are considered the foundational knowledge of AI (average score: 129) and data governance (average score: 124). This highlights the necessity for public sector professionals to have a solid understanding of AI principles and technologies to make informed decisions regarding AI integration. Coincidentally, these two competences are also considered the most difficult to obtain in the group (μ=116 and μ=169, respectively).

On the other hand, "awareness of fairness challenges" garnered an average score of 83, indicating that while respondents recognize the importance of fairness and bias mitigation in AI, they considered this technical competence not as important.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In comparing these values, it becomes evident that data-related skills and foundational AI knowledge are of paramount importance. While other competences, such as awareness of fairness challenges, technical design, technology inquisitiveness, and cultivating a data-oriented culture, are also valuable, their ranking provides a ground for prioritizing competences in building competence profiles.

It is noteworthy that some competences are considered highly relevant, yet they are also considered relatively easy to obtain. This is the case of "positive attitude towards AI" (μ=44) and "basic data literacy" (μ=78). Such competences are to be kept in mind, as they can be considered relatively "low-hanging fruits" when devising competence profiles for a Functional Specialist of AI in the public sector.

Results from the technology governance competence group show that competences in this group are considered easier to obtain. The most important competence, technical fairness risk mitigation, in fact, features a coefficient of difficulty to obtain very close to the baseline of 100. Other important competences that are considered relatively easy to obtain are "choice of machine learning techniques" (μ=95), and "choice of AI architecture" (μ=105).

Results from the technology operational competence group show that competences related to data collection and data quality assessment are considered the most important ones. Similarly to technology governance competences, these operational competences are also considered relatively easy to obtain. Understanding the fundamentals of machine learning, for instance, features a μ coefficient of 91, while being the third most importance technology operational competence.

Results from the management and design meta-competence group show that problem identification and framing, foresight, and user-centricity are not only the most important competences, but are also considered the hardest to obtain. These competences at a high level of abstraction represent the foundation of this cluster of competences for engaging with AI for public services.

Results from the management and design governance competence group also show that the most important competences are also the ones that are hardest to obtain. Change leadership (μ=118) and risk anticipation and mitigation (μ=116), in fact, feature a coefficient of difficulty to obtain that is well above the baseline. This pattern is also confirmed in the responses on the group of management and design operational competences. Competences that are considered the most important are also the ones that are considered the hardest to obtain. The competence of AI project scoping, for example, is very highly scored in terms of importance (153), and features one of the highest coefficients of difficulty to obtain of the entire list of competences (μ=143). On the other hand, the least important operational management competences of budgeting (μ=90) and of project ownership (μ=73) feature a much lower coefficient.

Results from the policy, legal and ethical meta-competence group show that critical technology assessment is considered the most important (133) and most difficult to obtain (μ=121) of this group of competences at a high level of abstraction. In general, all competences in this group feature a relatively high difficulty to obtain, except for the competence related to dissemination (μ=60).

The policy, legal and ethical governance group includes only four competences. Survey results show that AI procurement literacy is considered the most important competence of this group (108), while AI-compatible formulation is the hardest to obtain (μ=113).

Results from operational competence group in the policy, legal and ethical dimension show that understanding legal and ethical frameworks is considered the most important competence (115). On the other hand, the competence among these operational ones that is most difficult to obtain is specialized legal expertise (μ=121).

The diversity in importance ranking and difficulty in obtaining of each of these competences belonging to different dimensions and different levels of abstraction forms the basis for building a Functional Specialist Canvas. We present this framework in the next section.

4. The AI4Gov Canvas

The AI4Gov Canvas frames all competences identified and refined through the previous steps, clustered in the three dimensions of technology, management and design, and policy / legal / ethical. Each competence is also layered according to a level of abstraction, which increases as one gets closer to the centre: operational, governance, and meta-competence. The Canvas can be used as a spatial device to position each of the competences within the two dimensions of type of competence, and level of abstraction. Additionally, competences can be selected based on the degree of importance, and the coefficient of difficulty to obtain, derived from the results of the survey study. We illustrate an example of a possible use of the Canvas in Figure 2.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

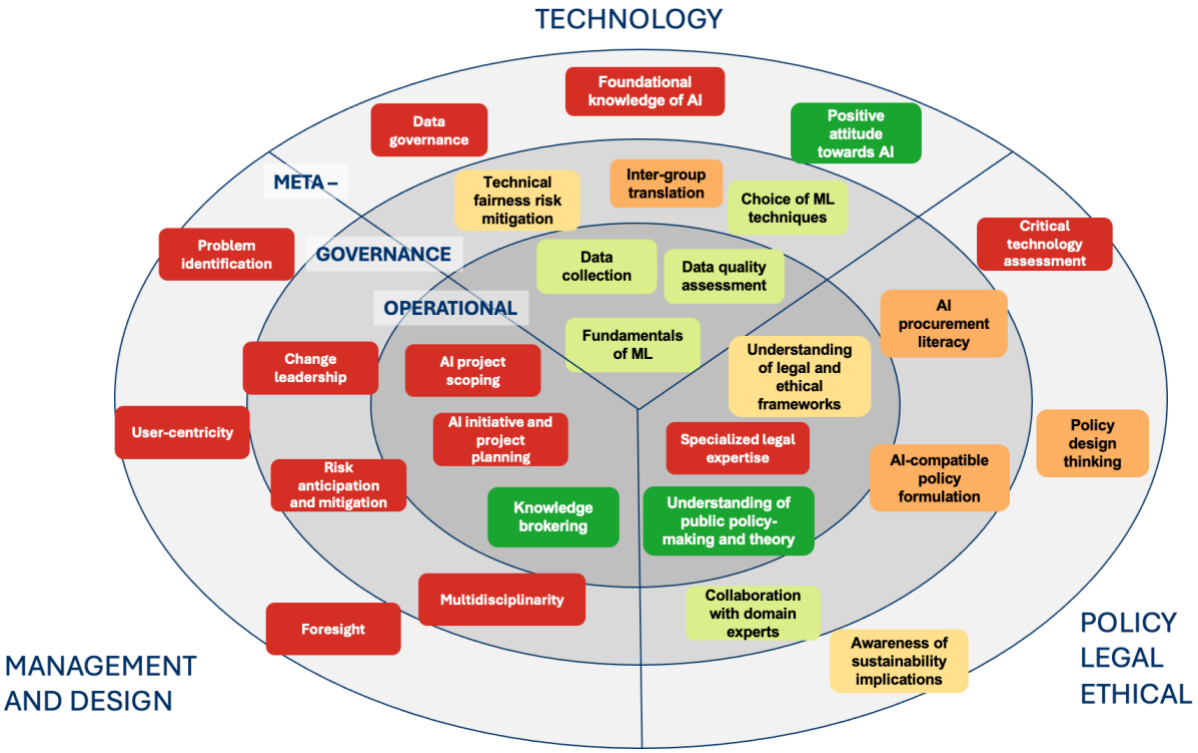


Fig. 2 - An illustration of the use of the AI4Gov Canvas.

In this example, we have mapped the three most important competences for each dimension and for each level of abstraction according to the average relevance score provided in the survey. Moreover, each competence is color-coded according to the average μ coefficient of difficulty obtained from the survey data, from vivid red (most difficult to obtain), to vivid green (least difficult to obtain).

Beyond the provided example, the canvas is developed to serve as a visual, flexible, and generative framework, rather than only a fixed assessment grid. Inspired by design research and public sector innovation practices, the use of the word *canvas* is deliberate and refers to a visual and structured co-design tool that facilitates reflection, discussion, and strategic alignment across stakeholders. The AI4Gov Canvas is not merely a static competence map; it is a generative framework that supports interactive and iterative dialogue about the conditions and capabilities necessary for a public sector organization to meaningfully engage with and govern AI. While existing tools may focus on business models or value creation, the AI4Gov Canvas is unique in its orientation toward public governance and its function as a reflective support for public sector institutions to explore their readiness and responsibilities when engaging with AI. The canvas format serves not only as an evidence-based mapping tool to assess competencies, but to stimulate critical discussion about the type of competence (technology, management and design, and policy /legal / ethical), its level of abstraction, its importance, and its difficulty to obtain. This in turn helps address the socio-technical, organizational, and political dimensions that shape AI governance. The AI4Gov Canvas is thus best understood as a sense-making tool: one that helps public sector teams explore the evolving capabilities they need to responsibly and strategically engage with AI, rather than providing prescriptive answers or benchmarking maturity levels. In this sense, it also provides a handy heuristic for tackling practical challenges in the governance of AI in the public sector.

For instance, the Canvas can be used to map the competences of a public manager, in order to precisely identify their area of strength and weaknesses against multiple dimensions (type of competences, level of abstraction, relevance, and difficulty to obtain). Such assessment can be used for purposes of benchmarking, both at individual and at organizational level of analysis; for rewarding public administration personnel; and for identifying training needs. Moreover, the Canvas can also be used to assess prospective public managers. This is the case of the use of the Canvas as a support tool in hiring processes. Candidates for a position in a public organization dealing with AI projects can be more objectively assessed against the multiple dimensions mentioned above.

Lastly, the Canvas lends itself to a *prescriptive* use. This goes beyond the *descriptive* approach that underpins the use of the Canvas for mapping competences, to include the use of the Canvas as a device to generate desired combinations of competences across multiple dimensions. This use of the Canvas allows for building of Functional Specialist profiles.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5. Designing functional specialist personas

The structure of the Canvas enables the bounded creation of Functional Specialist profiles. It does so by drawing on both the multiplicity of the dimensions it encompasses (type of competences, and levels of abstraction, relevance, and difficulty to obtain) but also, and most importantly, on the constraints provided by the coefficients associated to each competence.

These constraints are the feature that makes the AI4Gov Canvas stand out, when compared to existing similar competence frameworks – regardless of whether they are focused specifically on AI, or on general digital competences.

By setting a maximum value of both the score of importance and of the coefficient of difficulty to obtain that each competence has, users of the AI4Gov Canvas can better avoid devising lists of competences as mere "wish lists", or "dream profiles" that are not realistic. The AI4Gov Canvas, in fact, forces its users to make the necessary trade-offs between competences, even when devising profiles that are multi-disciplinary.

These trade-offs concern each of the dimensions that form the Canvas. With regards to the dimension of the *type* of competence: even for a functional specialist that is meant to possess competences across the technical, the management and design, and the policy / legal / ethical dimension, in which ones of these should they be stronger? With regards to the dimension of the level of abstraction of competence: should a desired functional specialist have mostly operational, governance, or meta-competences? With regards to the level of importance of each competence: should a desired functional specialist possess one very important competence, and multiple competences of much less importance? Or should they possess the largest possible number of averagely important competences? Finally, with regards to the difficulty of each competence: should a desired functional specialist possess one competence that is very difficult to obtain, and multiple competences that are much easier to obtain? Or should they possess the largest possible number of averagely difficult-to-obtain competences?

The AI4Gov Canvas allows to make informed decisions in devising functional specialist profiles for AI in the public sector. We will now turn to providing some concrete examples of how the Canvas can be used to create Functional Specialist personas.

5.1 Example 1: the TechnoSteward

Table 1 provides the details of an example of a competence profile created using the constraints of the AI4Gov Canvas. This example represents a Functional Specialist persona that features nine competences. In the Table, the competences are distributed across the three dimensions of type of competence (technology, management and design, and policy / legal / ethical) and the three levels of abstraction (operational, governance, and meta-competences) of the Canvas.

	Technology			**Management and design**			**Policy / legal / ethical**			**Total**	
		Imp.	*μ*		*Imp.*	*μ*		*Imp.*	*μ*	*Imp.*	*μ*
Operational	**AI-related software programming**	87	114	Knowledge brokering	89	72	Understanding of public policymaking and theory	97	77	273	263
Governance	**Inter-group translation**	120	113	Cross-team collaboration	101	97	Collaboration with domain experts	98	95	319	305
Meta-	**Data governance**	124	169	Data-supported decision-making	96	76	Dissemination	79	60	299	305
		331	396		286	245		274	232	**891**	**873**

Tab. 1 - Competences of the "TechnoSteward" functional specialist persona.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In this example, building a Functional Specialist profile corresponds to selecting nine competences that maximise the sum value of the level of importance of all competences combined (indicated as "Imp." in Table 1). Any competence can thus be chosen, with the constraint that the sum of the coefficient of difficulty to obtain (μ) of all the nine competences should not exceed the baseline difficulty to obtain of each competence (μ=100) multiplied by the number of competences in the profile (9 * μ100 = μ900).

The competences for this example profile have been selected within this constraint to include a particular focus on the technology dimension. Therefore, all three competences in the technology dimension have been chosen to have a very high coefficient of difficulty to obtain. These are (highlighted in bold type in Table 1): AI-related software programming (μ=114), inter-group translation (μ=120), and data governance (μ=124).

Conversely, in the other two dimensions (management and design, and policy / legal / ethical dimension), competences with low coefficients of difficulty have necessarily been selected. The three least difficult competences (highlighted in red in Table 9) are, in fact, knowledge brokering, in the management and design dimension (μ=72), and understanding of public policymaking and theory (μ=77) and dissemination (μ=60), in the policy / legal / ethical dimension.

For the rest of the competences, this technology-focused profile provides for selecting desired competences whose sum of the coefficients of difficulty is as close as possible to 900, but without exceeding it (μ=873); and for racking up as much value of importance as possible: in this case, Imp.=891.

Looking at the characteristics of this Functional Specialist competence profile, we label it as the persona of a "TechnoSteward". The TechnoSteward profile combines the technical prowess and the responsible stewardship needed for AI in the public sector. The TechnoSteward possesses a deep understanding of technology, including the hands-on competence of software programming related to AI, but also the ability to translate concepts from a bureaucratic language to a language that is understandable by users of AI public services, and to apply data governance practices. At the same time, the TechnoSteward can access or exchange AI knowledge between different groups, establish collaboration between teams, and make decisions based on data.

This persona embodies a technologist mindset, which is however also able to consider, to some extent, the implications of public policymaking and theory, to engage in dissemination, and to collaborate with experts from other domains. This combination of competences is not only cross-disciplinary but also, and most importantly, likely to be realistic, because it comprises of competences that are not all equally difficult to obtain. Figure 3 illustrates the competence profile of the TechnoSteward using the AI4Gov Canvas.

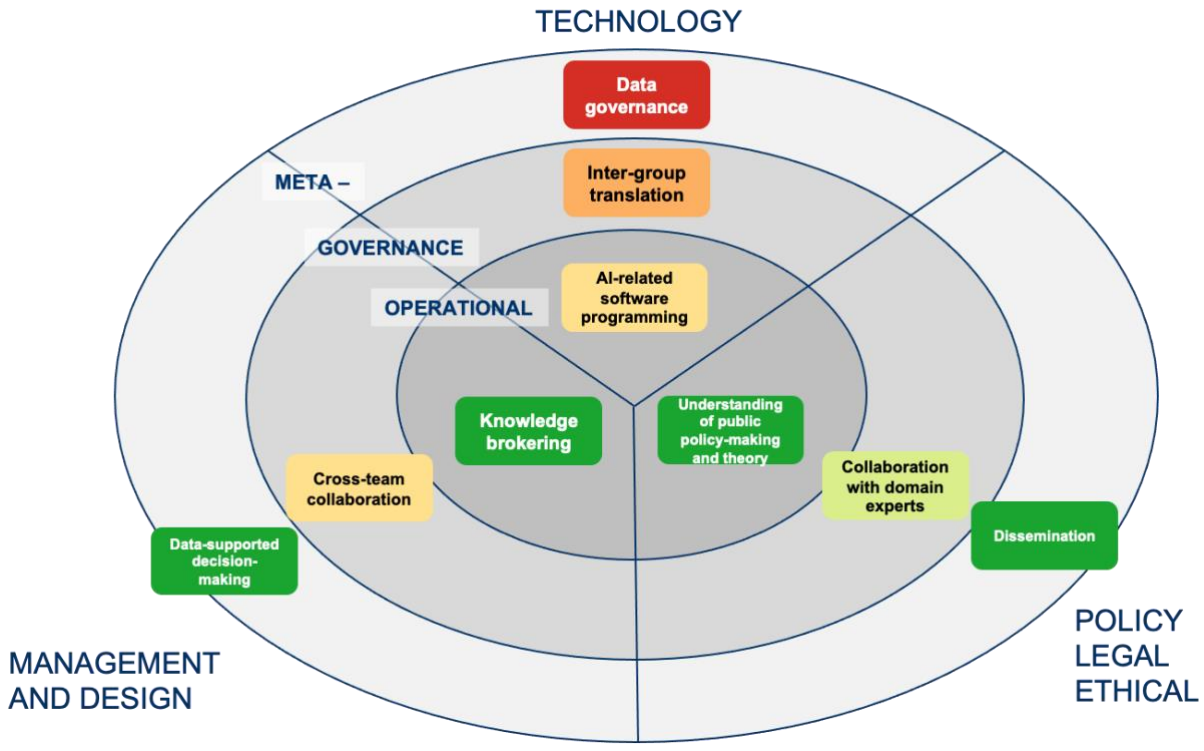


Fig. 3 - An illustration of the "TechnoSteward" competence profile.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5.2 Example 2: the Policy Sentinel

Using a similar approach, we showcase another exemplary profile that can be devised using the AI4Gov Functional Specialist Canvas.

This exemplary profile also combines nine competences in a persona that is realistically obtainable. We label this persona as the "Policy Sentinel", and illustrate its combination of competences in Table 2.

	Technology			**Management and design**			**Policy / legal / ethical**			**Total**	
		Imp.	*μ*		*Imp.*	*μ*		*Imp.*	*μ*	*Imp.*	*μ*
Operational	Data collection	136	89	Budgeting	84	90	**Specialized legal expertise**	98	121	*318*	*300*
Governance	Choice of machine learning techniques	100	95	Partnership development	103	100	**AI procurement literacy**	108	110	*311*	*305*
Meta-	Positive attitude towards AI	106	44	User-centricity	104	83	**Policy design**	113	111	*323*	*238*
		342	*228*		*291*	*273*		*319*	*342*	**952**	**843**

Tab. 2 - Competences of the "Policy Sentinel" functional specialist persona.

The competences for this example profile have also been selected within the constraint of a maximum of μ=900. However, the construction of this profile aims at having a special focus on the policy dimension. Therefore, all three competences in the policy / legal / ethical dimension have been chosen to have a very high coefficient of difficulty to obtain. These are (highlighted in bold type in Table 2): specialized legal expertise (μ=121), AI procurement literacy (μ=110), and policy design (μ=113).

On the other hand, in the other two dimensions (technology, management and design), competences with low coefficients of difficulty have necessarily been selected. The three least difficult competences (highlighted in red in Table 10) are, in fact, a positive attitude towards AI (μ=44), and data collection (μ=89), in the technology dimension, and user-centricity (μ=83), in the management and design dimension.

For the rest of the competences of this profile – whose sum of the coefficients of difficulty is as close as possible to 900, but without exceeding it (μ=843) – the Policy Sentinel encapsulates the persona's expertise in AI policy development, coupled with some relevant management and also some technological competences. "Sentinel" evokes a sense of watchfulness, indicating their role in safeguarding public interests and ensuring responsible AI governance. This persona is adept at navigating the regulatory landscape and shaping policies that strike a balance between innovation and policy and compliance considerations.

Figure 4 illustrates the competence profile of the Policy Sentinel using the AI4Gov Canvas.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

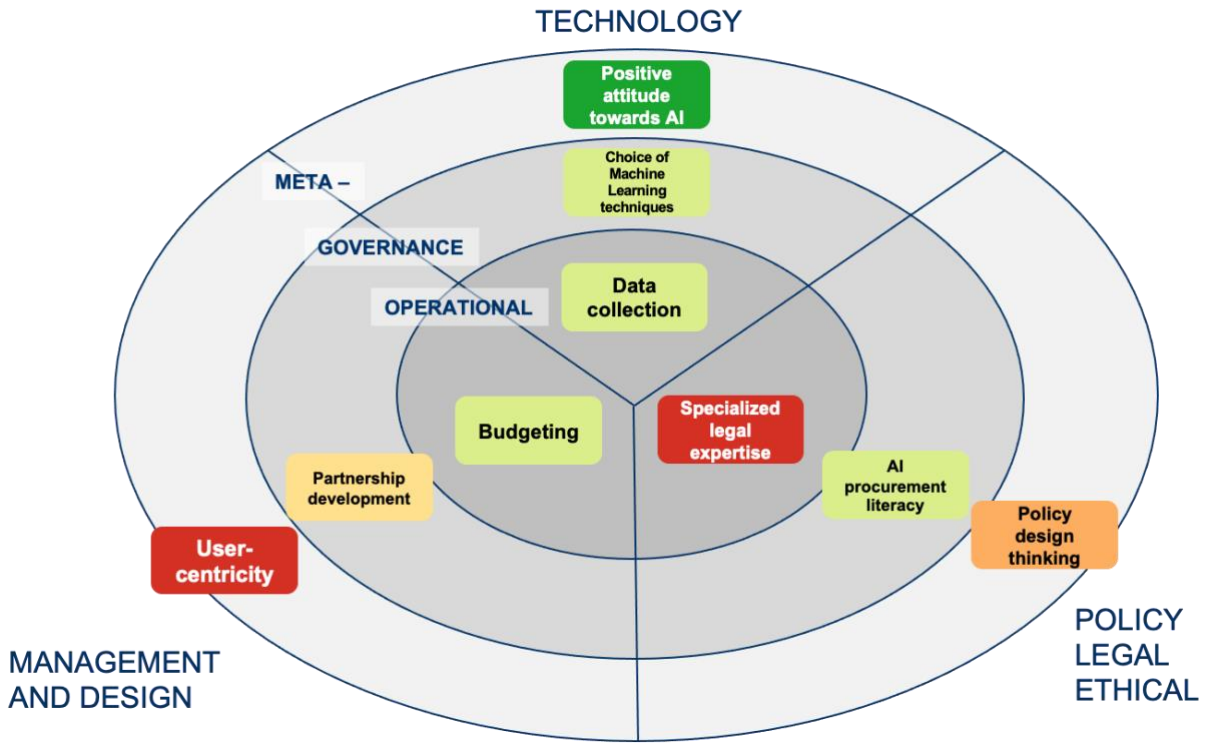


Fig. 4 - An illustration of the "Policy Sentinel" competence profile.

The Policy Sentinel features an in-depth understanding of the AI policy landscape, with specialized legal expertise, familiarity with the practices of procuring AI, and adopting a design thinking approach for devising and implementing AI policies in an iterative and user-centered way. But this persona is also able to budget, to develop partnerships, and to grasp technological dilemmas, such as choosing the right type of machine learning techniques needed in a specific situation.

Being generated within the constraints of the AI4Gov Canvas, this blend of competences spans various dimensions and is likely to be achievable, since it includes competences that vary in difficulty to acquire.

6. Lessons learned and next steps

Developing a competence framework for a Functional Specialist in AI for public services is crucial for ensuring that professionals in this domain have the necessary skills and expertise. However, it can be considered as a first step in the broader journey of investigating competence profiles for the future of AI in the public sector.

To continue developing the framework and to put it into fruitful use, we propose the following lines of action:

1) Refining / integrating the list of competences

This action involves further refining the list of competences required for AI specialists in the public sector. It may include reviewing industry standards, consulting experts, and considering specific job roles within the sector. Integration of competences should ensure that the framework covers all relevant skills and knowledge areas.

2) Soliciting feedback on clustering and levels of importance / difficulty to obtain

This action involves seeking further feedback from subject matter experts, practitioners, and stakeholders for validating the clustering of competences and determining their relative importance and difficulty to obtain. This feedback will help prioritize competences and create a more realistic framework. Moreover, it will help mitigating one of the limitations of the current version of the Canvas, which is the limited number of survey respondents on which its coefficients are based.

3) Soliciting feedback on the usability of the framework

Usability testing is vital to ensure that the competence framework is user-friendly. This action involves collecting feedback from potential users to identify any usability issues, such as unclear language, or confusing terminology,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and make necessary adjustments. This testing should involve different user personas, including entry-level AI specialists, mid-career professionals, and senior leaders. Mechanisms for users to provide feedback on the framework's usability should be included, to collect and analyse user feedback and allow iterative improvements.

4) Identifying use cases for the framework

This action is concerned with systematically identifying various use cases for the AI4Gov Canvas. Given that competence frameworks are non-binding, users are not obligated to follow them rigidly. Instead, they are encouraged to apply them with flexibility, allowing for customization and adaptation to suit their specific needs (Bacigalupo, 2022).

Uses of the Canvas that should be further explored include:

- *Training and development*. The most immediate use of the Canvas can be experimented with in the educational programme of the AI4Gov Master on Artificial Intelligence in the Public Sector. The Canvas can guide the design of training and development programs for AI specialists. Within public organizations, the Canvas can be used to ensure that employees receive the necessary training to engage with AI.
- *Self-assessment.* The tool can serve as a self-assessment platform, allowing public managers to evaluate their current competences, identify areas for improvement, and set personal development goals.
- *Career development.* public managers can use the framework to plan their career trajectories and identify the competences needed for advancement in their roles.
- *Recruitment and hiring.* Public sector organizations can utilize the framework as a reference when recruiting AI specialists. The Canvas can help in creating job descriptions, evaluating candidates, and aligning hiring practices with competence requirements.
- *Performance evaluation.* Managers and supervisors can use the framework to assess the skills and competences of their team members, facilitating more informed performance evaluations.
- *Benchmarking and reporting.* The tool can support the creation of reports and benchmarks to help public organizations track the overall competence level of their workforce and to identify areas where further investment is needed.

5) Integrating with existing frameworks

This action focuses on developing compatibility and integration with existing competence frameworks in the field of AI competences, such as those from national governments and international organizations. This integration can enhance the credibility and usefulness of the framework and reduce redundancy. For example, an immediate possibility for integration of the AI4Gov Canvas is with the UNESCO framework "*Artificial Intelligence and Digital Transformation: Competences for Civil Servants* (Broadband Commission, 2022), as also suggested in Misuraca *et al.* (2024). The alignment with the UNESCO framework would allow for the extension of the scope of the AI4Gov Canvas to a global horizon, beyond the one of Europe. The integration between the two frameworks could be based on the complementarity between the focus that the AI4Gov Canvas has on *individual* competences, and the focus of the UNESCO framework on *organizational* capabilities.

6) Guideline for an ecosystem of digital talent in AI, data spaces and digital transformation of the public sector

Finally, the authors have also used the AI4Gov Canvas as the foundation of the four-year AI4Gov-Accelerate project (2025-2029), funded by the Digital Europe Programme of the European Commission, that seeks to strengthen public administrations by enhancing their ability to attract digital talent and by fostering an educational ecosystem primed for innovation in AI, data spaces, and digital governance transformation. The AI4Gov Canvas has shaped the three key components – AI4Gov-X, AI4Scale, and AI4Engine – that collectively serve as core pillars of this project. First, the AI4Gov-X educational platform formalizes the knowledge base through a master program complemented by micro-credentials and extracurricular training, empowering participants with the skills required by rapidly evolving digital transformations where the AI4Gov Canvas will help participants to select their learning path. The AI4Scale sandbox then extends these learnings into practice by offering a collaborative environment where AI applications can be deployed, tested, and incubated, thus bridging academia, industry, and the public sector and again completing the practical skills addressed in the AI4Gov Canvas. Last, the AI4Engine innovation mapping – in the shape of an AI agent – is expected to serve as new input for the evolution of the AI4Gov Canvas by identifying emerging trends, and best practices on a global scale. By bringing these three elements together, AI4Gov Canvas not only cultivates individual competencies but also provides guidelines for human-centric AI-based public services.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

7. Conclusion

As public organizations face the challenges of designing, implementing, and managing AI applications, the need for equipping public servants with the relevant competences becomes increasingly pressing. Given the specificity of artificial intelligence and its benefits and risks, the definition of competences needs to be not only as focussed and as granular as possible, but also grounded in empirical data. Our proposal, the AI4Gov Canvas, is an attempt to establish a data-driven competence framework that not only draws on an analysis of existing research and policy documents, but that also grounds it claims on empirical data from relevant actors involved in AI projects.

We hope that the framework can serve both as a tool for conceptualizing AI competences in the public sector; but also as a practical instrument that practitioners can use in strategic and tactical decisions related to the adoption of AI in the public sector.

Acknowledgments

The research underpinning this paper has been conducted as part of the AI4Gov Master on Artificial Intelligence for Public Services, a project co-funded by the European Union under the Connecting Europe Facility – CEF Telecom Programme (Grant Agreement number: INEA/CEF/ICT/A2020/2265375) and implemented by the Universidad Politécnica de Madrid (UPM) and Politecnico di Milano (POLIMI). See: https://www.polidesign.net/en/formazione/business-design/master--artificial-intelligence-for-public-services/

References

Ahn, M. J., & Chen, Y.-C. (2022). Digital transformation toward AI-augmented public administration: The perception of government employees and the willingness to use AI in government. *Government Information Quarterly*, *39*(2), 101664. https://doi.org/10.1016/j.giq.2021.101664

Bacigalupo, M. (2022). Competence frameworks as orienteering tools. *RiiTE Revista Interuniversitaria de Investigación En Tecnología Educativa*, 20–33. https://doi.org/10.6018/riite.523261

Bacigalupo, M., Kampylis, P., Punie, Y., & Brande, G. V. den. (2016). *EntreComp: The entrepreneurship competence framework*. Publications Office of the European Union. https://data.europa.eu/doi/10.2791/160811

Böhm, R., Letmathe, P., & Schinner, M. (2023). The monetary value of competencies: A novel method and case study in smart manufacturing. *Technological Forecasting and Social Change*, *189*, 122331. https://doi.org/10.1016/j.techfore.2023.122331

Broadband Commission. (2022). *Artificial Intelligence and Digital Transformation: Competencies for Civil Servants*. UNESCO. https://www.broadbandcommission.org/wp-content/uploads/2022/09/Artificial-Intelligence-and-Digital-Transformation-Competencies-for-Civil-Servants.pdf

Desarbo, W. S., Ramaswamy, V., & Chatterjee, R. (1995). Analyzing Constant-Sum Multiple Criterion Data: A Segment-level Approach. *Journal of Marketing Research*, *32*(2), 222–232. https://doi.org/10.1177/002224379503200209

Edelmann, N., Mergel, I., & Lampoltshammer, T. (2023). Competences That Foster Digital Transformation of Public Administrations: An Austrian Case Study. *Administrative Sciences*, *13*(2), Article 2. https://doi.org/10.3390/admsci13020044

European Centre for the Development of Vocational Training (Ed.). (2008). *Terminology of European education and training policy: A selection of 100 key terms*. Office for Official Publications of the European Communities.

European Commission. (2021). *Study on the development of a European framework for interoperability skills and competences in the public sector (EIFISC)*. Publications Office of the European Union. https://data.europa.eu/doi/10.2799/920925

Fest, I., Wieringa, M., & Wagner, B. (2022). Paper vs. practice: How legal and ethical frameworks influence public sector data professionals in the Netherlands. Patterns, *3*(10), 100604.

Hofmann, S., & Ogonek, N. (2018). Different but still the same? How public and private sector organisations deal with new digital competences. Electronic Journal of e-Government, *16*(2), 127–135.

Hooda, A., & Singla, M. L. (2020). Core-competencies-a key to future-oriented and sustainable e-governance implementation: A mixed method research. *Transforming Government- People Process and Policy*, *15*(1), 80–107. https://doi.org/10.1108/TG-12-2019-0122

Hunnius, S., & Schuppan, T. (2013). Competency Requirements for Transformational E-Government. *2013 46th Hawaii International Conference on System Sciences (HICSS)*, 1664–1673. https://doi.org/10.1109/HICSS.2013.139

Jackson, D., & Chapman, E. (2012a). Empirically derived competency profiles for Australian business graduates and their implications for industry and business schools. *The International Journal of Management Education*, *10*(2), 112–128. https://doi.org/10.1016/j.ijme.2012.04.002

Jackson, D., & Chapman, E. (2012b). Non-technical competencies in undergraduate business degree programs: Australian and UK perspectives. *Studies in Higher Education*, *37*(5), 541–567. https://doi.org/10.1080/03075079.2010.527935

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Mankevich, V., Magnusson, J., & Svahn, F. (2022). The great wave: The increasing demand for digital competence within the public sector. *Information Polity: The International Journal of Government & Democracy in the Information Age*, 1–24. https://doi.org/10.3233/ip-220012

Medaglia, R., Mikalef, P., & Tangi, L. (2024). *Competences and governance practices for artificial intelligence in the public sector*. Publications Office of the European Union, https://data.europa.eu/doi/10.2760/7895569

Mergel, I., Dickinson, H., Stenvall, J., & Gasco, M. (2023). Implementing AI in the public sector. *Public Management Review*, 1–13, https://doi.org/10.1080/14719037.2023.2231950

Misuraca, G., & Rossel, P. (2023) Towards a Digital Governance and AI Compass for Policymakers and Regulators. Report delivered to UNESCO.

Misuraca, G., Rossel, P., & Sibal, P. (2024). Towards mastering Artificial Intelligence and digital governance in the public sector: Principles and recommendations. In *Pesquisa sobre o uso das tecnologias de informação e comunicação no setor público brasileiro: TIC Governo Eletrônico 2023*. Núcleo de Informação e Coordenação do Ponto BR.

Neumann, O., Guirguis, K., & Steiner, R. (2022). Exploring artificial intelligence adoption in public organizations: a comparative case study. *Public Management Review*, *26*(1), 114–141. https://doi.org/10.1080/14719037.2022.2048685

Ogonek, N., Gorbacheva, E., Räckers, M., Becker, J., Krimmer, R., Broucker, B., & Crompvoets, J. (2016). *Towards Efficient EGovernment: Identifying Important Competencies for EGovernment in European Public Administrations*. *23*, 155–162. https://doi.org/10.3233/978-1-61499-670-5-155

Reis, J., Santo, P. E., & Melão, N. (2019). Impacts of Artificial Intelligence on Public Administration: A Systematic Literature Review. *2019 14th Iberian Conference on Information Systems and Technologies (CISTI)*, 1–7. https://doi.org/10.23919/CISTI.2019.8760893

Roehl, U. B. U., & Crompvoets, J. (2024). Public Management Competencies in a Digital World: Lessons from a Global Frontrunner. In M. R. Johannessen, C. Csáki, L. Danneels, S. Hofmann, T. Lampoltshammer, P. Parycek, G. Schwabe, E. Tambouris, & J. Ubacht (Eds.), *Electronic Participation* (pp. 64–82). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-70804-6_5

Roman, A. V., Van Wart, M., Wang, X., Liu, C., Kim, S., & McCarthy, A. (2018). Defining E-leadership as Competence in ICT-Mediated Communications: An Exploratory Assessment. *Public Administration Review*, *79*(6), 853–866. https://doi.org/10.1111/puar.12980

Selten, F., & Klievink, B. (2024). Organizing public sector AI adoption: Navigating between separation and integration. *Government Information Quarterly*, *41*(1), 101885.

Sharma, G. D., Yadav, A., & Chopra, R. (2020). Artificial intelligence and effective governance: A review, critique and research agenda. *Sustainable Futures*, *2*, 100004. https://doi.org/10.1016/j.sftr.2019.100004

Sousa, W. G. de, Melo, E. R. P. de, Bermejo, P. H. D. S., Farias, R. A. S., & Gomes, A. O. (2019). How and where is artificial intelligence in the public sector going? A literature review and research agenda. *Government Information Quarterly*, *36*(4), 101392. https://doi.org/10.1016/j.giq.2019.07.004

Tsoutsa, P., & Lampropoulos, I. C. (2022). Preparing for smart cities' future competences: Trends arising through keyword and review analysis. In P. Fitsilis (Ed.), *Building on smart cities skills and competences: Human factors affecting smart cities development* (pp. 37–51). Springer International Publishing.

Vuorikari, R., Kluzer, S., & Punie, Y. (2022, March 17). *DigComp 2.2: The Digital Competence Framework for Citizens - With new examples of knowledge, skills and attitudes*. JRC Publications Repository. https://doi.org/10.2760/115376

Wirtz, B. W., Langer, P. F., & Fenner, C. (2021). Artificial Intelligence in the Public Sector—A Research Agenda. *International Journal of Public Administration*, *44*(13), 1103–1128. https://doi.org/10.1080/01900692.2021.1947319

Wirtz, B. W., Weyerer, J. C., & Kehl, I. (2022). Governance of artificial intelligence: A risk and guideline-based integrative framework. *Government Information Quarterly*, *39*(4), 101685. https://doi.org/10.1016/j.giq.2022.101685

Zhang, Y., & Kimathi, F. A. (2022). Exploring the stages of E-government development from public value perspective. *Technology in Society*, *69*, 101942.

Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly*, *38*(3), 101577. https://doi.org/10.1016/j.giq.2021.101577

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Appendix A

Technology competences

Level of abstraction	*Competence label*	*Description*	*Coefficient of importance*	*Coefficient of difficulty to obtain (μ)*
Meta-competences	Foundational knowledge of AI	Being able to understand the fundamentals of AI at the conceptual level	129	116
	Data governance	Being able to apply data governance practices	124	169
	Positive attitude towards AI	Being able to have a positive attitude towards AI technologies in the public sector	106	44
	Basic data literacy	Being able to understand the basics of data	95	78
	Technical design	Being able to approach innovation of AI technology in an iterative and user-centered way	91	93
	Technology inquisitiveness	Being able and willing to keep learning on new developments in AI	86	109
	Data-oriented culture	Being able to think of data as central in the activity of a public manager	86	102
	Awareness of fairness challenges	Being able to be aware of challenges to fairness in the use of AI technologies	83	89
Governance competences	Technical fairness risk mitigation	Being able to assess fairness risks of AI and to mitigate these risks through technical instruments	126	105
	Inter-group translation	Being able to translate concepts from a bureaucratic language to a language that is understandable by users of AI public services	120	113
	Choice of machine learning techniques	Being able to know when to use a certain algorithm, tool, and library in specific situation	100	95

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Level of abstraction	*Competence label*	*Description*	*Coefficient of importance*	*Coefficient of difficulty to obtain (μ)*
	Choice of AI architecture	Being able to know when and how use which AI architecture and why (e.g., cloud infrastructure)	97	105
	Compliance with AI technical standards	Being able to adhere to and develop AI based on ethical and legal technical standards	95	97
	Re-use of AI-related components	Being able to reuse AI-related components from other sources during the development of AI solutions	91	107
	Data sharing	Being able to share data for AI-related purposes	70	78
Operational competences	Data collection	Being able to collect data for AI-related purposes	136	89
	Data quality assessment	Being able to assess the quality of data for AI-related purposes	133	90
	Understanding the fundamentals of machine learning	Being able to understand key objectives and applications of machine learning	133	91
	Understanding of causal analysis and decision theory	Being able to understand cause and effect relationships and being aware of decision theory related to data science practice	111	105
	AI-related software programming	Being able to use relevant programming languages for the development of AI, such as Python and R	87	114
	Database management	Being able to conduct data and database management effectively	83	107
	Understanding of computer vision and Natural Language Processing	Being able to understand AI computer vision and natural language processing	73	111
	Understanding of applied maths	Being able to understand and use applied mathematics	43	93

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Management and design competences

Level of abstraction	*Competence label*	*Competence description*	*Coefficient of importance*	*Coefficient of difficulty to obtain (μ)*
Meta-competences	Problem identification and framing	Being able to identify and distinguish between different types of problems that require either data science or another approach	130	124
	Foresight	Being able to anticipate future needs of functional managers, suppliers and customers and proactively design AI solutions to support these needs	106	121
	User-centricity	Being able and willing to collaborate with users of AI digital services and valuing their feedback	104	83
	Leadership	Being able to lead to support AI initiatives	100	96
	Data-supported decision-making	Being able to make decisions based on data	96	76
	AI benefits understanding	Being able to understand the benefits of AI	90	83
	Risk proclivity	Being able to take risks in pursuing AI projects	89	107
	Digital-by-design thinking	Being able to think digital first in thinking of new AI services, policy, and practices	85	109
Governance competences	Change leadership	Being able to identify opportunities to improve the organisation and overcome structural and institutional obstacles to change	119	118
	Risk anticipation and mitigation	Being able to anticipate and mitigate risks of AI (e.g., privacy, security and ethical)	114	116
	Multidisciplinarity	Being able to blend traditional public service skills with modern digital skills	104	93

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Level of abstraction	*Competence label*	*Competence description*	*Coefficient of importance*	*Coefficient of difficulty to obtain (μ)*
	Partnership development	Being able to develop partnerships, define opportunities for AI projects and define collaboration systems for new AI projects	103	100
	Cross-team collaboration	Being able to collaborate with different teams and organizations to pursue AI projects	101	97
	Project management style evaluation	Being able to identify and distinguish between different types of problems that require either data science or another approach	88	85
	Choice to delegate to AI	Being able to consider relevant factors in deciding whether to delegate a public service or a process to AI	71	91
Operational competences	AI project scoping	Being able to evaluate data quality and availability and that of data sources, consolidate project requirements and design a project roadmap	153	143
	AI initiative and project planning	Being able to define potential AI use cases, map a data journey and enable decision makers to select a use case	106	121
	Knowledge brokering	Being able to access or exchange AI knowledge between different groups	89	72
	Budgeting	Being able to budget AI initiatives	84	90
	Project ownership	Being able to demonstrate ownership of AI projects	67	73

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Policy, legal, and ethical competences

Level of abstraction	*Competence label*	*Competence description*	*Coefficient of importance*	*Coefficient of difficulty to obtain (μ)*
Meta-competences	Critical technology assessment	Being able to understand the limitations of data-driven technologies and choose whether to focus on augmenting experts rather than replacing them	133	121
	Policy design	Being able to approach AI policymaking in an iterative and user-centered way	113	111
	Awareness of sustainability implications	Being able to be aware of implications of AI on environmental sustainability	98	99
	Dissemination	Being able to communicate AI initiatives	79	60
	Empathy	Being able to have an empathetic approach in implementing AI, identifying the needs, wants, and objectives of end users and other stakeholders	77	109
Governance competences	AI procurement literacy	Being able to set up and manage tender contracts on AI in a way that is compatible with public interest values	108	110
	AI-compatible policy formulation	Being able to formulate policy questions as questions that can be answered by AI techniques	104	113
	Collaboration with domain experts	Being able to work together with domain experts from varying professional backgrounds	98	95
	Collaboration with AI ethicists	Being able to work with specialised ethicists who provide legal and ethical assessments on AI	90	82
Operational competences	Understanding of legal and ethical frameworks	Being able to understand and be aware of relevant legal and ethical frameworks on AI	115	96

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Level of abstraction	*Competence label*	*Competence description*	*Coefficient of importance*	*Coefficient of difficulty to obtain (μ)*
	Specialized legal expertise	Being able to utilise specialised legal expertise such as on data rights, intellectual property, licensing, relevant, and domain-specific legislation	98	121
	Understanding of public policy making and theory	Being able to understand policymaking processes, governance, and public management theory and practices	97	77
	Auditing	Being able to apply auditing techniques to ensure compliance with design, performance, and liability standards	91	106

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Emerging models of national competent authorities under the EU AI Act.

Emanuele Parisini [a*], *Eduard* Dervishaj [b*]

[a] Department of Computer Science, University of Pisa, Pisa, Italy, emanuele.parisini@phd.unipi.it, ORCID number 0009-0005-8267-3800.

[b] Independent researcher, Milan, Italy, eduard.dervishaj@outlook.it, ORCID number 0009-0008-2057-1966.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. This paper examines the emerging models of national competent authorities under the European Union's Artificial Intelligence Act (AI Act), providing novel insights into how different jurisdictions approach AI governance institutionalization. Through systematic analysis of official documents from early implementing Member States, we identify three fundamental dimensions that characterize distinct regulatory approaches. First, the organizational architecture reveals a spectrum from centralized to fragmented oversight models, reflecting different philosophies about coordinated versus distributed AI governance. Second, the institutional choices between leveraging existing regulatory bodies versus establishing new AI-specific authorities highlight contrasting approaches to building governance capacity and expertise. Third, the regulatory scope demonstrates a critical divide between horizontal and vertical oversight frameworks, with some jurisdictions pioneering hybrid solutions that attempt to balance specialized knowledge with coordinated supervision. Our methodology combines document analysis of legislative proposals, government resolutions, and administrative acts with a three-dimensional analytical framework examining degrees of centralization, institutional arrangements, and oversight models. The findings contribute to the theoretical understanding of AI governance by revealing how different jurisdictions interpret and operationalize regulatory requirements, balance competing institutional priorities, and address the complex challenge of overseeing AI systems. Furthermore, the analysis offers insights into the evolution of AI governance structures and contributes to the broader discourse on institutional design for emerging technology oversight. While our analysis is limited to early implementers and based primarily on formal documents rather than operational evidence, it provides a foundation for future research examining the effectiveness of different models, their evolution over time, and their impact on AI innovation and oversight. Future studies could benefit from comparative analyses of implementation outcomes, stakeholder perspectives, and the practical challenges of operationalizing these different governance frameworks.

Keywords. Artificial intelligence, European Union, AI Act, AI governance, National competent authorities
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1007

1. Introduction

The rapid evolution of artificial intelligence (AI) technologies and their increased integration into various sectors have generated both enthusiasm and a greater level of attention towards policy frameworks and governance. The European Union (EU) has taken a pioneering step in this direction with the introduction of the Artificial Intelligence Act (Regulation (EU) 2024/1689), establishing the first comprehensive regulatory framework across European Member States. This regulation is designed to enhance innovation by fostering trustworthy AI, ensuring the protection of societal well-being (Laux, 2024), in compliance with EU values and fundamental rights. This highlights the need for robust oversight mechanisms to build public trust in AI technologies while guaranteeing a

flexible and comprehensive regulatory framework to accommodate cultural differences and bridge gaps across different national legal systems (Gasser, 2017). The AI Act, which came into force in August 2024, sets the standard framework that European Member States must comply with to ensure that society understands AI's capabilities and limitations, while promoting development and innovation (Lu, 2024). The AI Act also mandates the inclusion of diverse stakeholders in the governance scheme to ensure equitable representation and avoid potential biases (Cancela-Outeda, 2024). Since the conclusion of the technical negotiations in January 2024, Member States have adopted various strategies to implement the new regulation. The challenges they face are primarily focused on resource allocation, both financial and human. The latter is particularly driven by the complexity of the matter, which demands expertise from diverse fields as the technology evolves (Cancela-Outeda, 2024) with regulatory standards, addressing ethical concerns, and promoting transparency in AI decision-making (Bellogìn, 2024). This paper provides a comparative analysis of the implementing approaches adopted by European Member States in response to the European Union's Artificial Intelligence Act, in terms of national governance of artificial intelligence systems. It focuses on the legal and governance repercussions and emphasizes the diversity of models implemented at the national level, ranging from centralized to fragmented systems. While other scholars identified the possible divergences in the selection of national competent authorities by Member States (Novelli, 2024), comprehensive studies in the field are still limited. The aim is to offer practical insights into the challenges and opportunities of AI governance implementation. The paper is organized as follows: this first section introduces the key features of AI governance and its objectives. The second section presents research methods. The third section highlights the legal framework (AI Act), together with the implementation challenges related to the complexity of the regulatory infrastructure that should guarantee both effective surveillance and operational capabilities. The fourth is a detailed analysis of the different national models adopted, ranging from centralized to fragmented, from existing bodies to newly established institutions, and from horizontal to vertical oversight, mainly because of different national administrative and economic needs. The fifth presents the main discussion of the governance paths encountered. The final section offers conclusions and recommendations for policymakers, together with the limitations and potential future directions of the research.

2. Research methods

2.1 Document analysis

The document analysis process relied on official legislative and administrative sources from EU Member States. Our data collection focused on four main categories of official documents: (1) legislative proposals submitted to national parliaments; (2) government resolutions and administrative acts; (3) official online communications from relevant ministries and regulatory bodies; and (4) draft laws and amendments to existing legislation. These documents were collected through systematic monitoring of official government websites, parliamentary databases, and official journals of Member States. To ensure comprehensiveness, we based our research on documents in their original languages, employing translations, when necessary, which inevitably introduces interpretive considerations and risk of misinterpretation. The selection criteria required documents to: (a) explicitly address the implementation of Articles 28 and 70 of the AI Act regarding competent authorities, (b) represent formal government positions rather than preliminary or unofficial proposals, and (c) contain specific details about institutional arrangements and governance structures. This approach allowed us to focus on concrete implementation steps while excluding general policy discussions or preliminary proposals that had not reached formal legislative or administrative status. In some cases, such as Cyprus and Malta, we supplemented documentary evidence with correspondence with officials of the relevant institutions. While this enhanced our understanding of these specific cases, the dynamic nature of implementation processes across Member States suggests that current institutional arrangements may continue to evolve beyond what is captured in official documentation. This initial mapping provides a foundation for ongoing research as the practical implementation of the AI Act unfolds across the European Union.

2.2 Temporal framework

In addition, this research adopts a defined temporal framework shaped by two key dates: the entry into force of the EU AI Act (August 2024) and our data collection cutoff date (April 2025). This timeframe captures the initial months of implementation efforts by Member States, providing insights into early strategic approaches while acknowledging that the process remains ongoing until the deadline of August 2025 set by the AI Act for appointing national competent authorities. The decision to analyze this early implementation period, rather than waiting for the complete implementation across all Member States, is methodologically significant for several reasons. First, it allows us to identify emerging patterns and potential challenges in the implementation process as they unfold, providing valuable insights for Member States still developing their approaches. Second, examining early adopters' choices helps understand different interpretative approaches to the AI Act's requirements, particularly regarding institutional arrangements and governance models. Finally, while this temporal limitation means our analysis cannot capture the complete EU-wide implementation landscape, it offers a crucial snapshot of how Member States

with different administrative traditions and regulatory capacities interpret and operationalize the AI Act's requirements for competent authorities.

2.3 Comparative analysis

Considering the insights already identified in the different patterns of AI national competent authorities (Novelli, 2024), the analysis employs a three-dimensional framework developed to systematically examine different implementation models. This framework emerged from iterative analysis of the implementation approaches and theoretical considerations from the literature on regulatory governance. The first dimension analyzes the degree of centralization in oversight responsibilities, categorizing approaches as centralized (single government authority with broad mandate), unified (single independent authority), or fragmented (multiple authorities with distributed responsibilities). The second dimension examines institutional choices between leveraging existing regulatory bodies versus establishing new AI-specific institutions, focusing on how Member States balance their organizational needs with the deadlines of the AI Act. The third dimension considers the scope of oversight, distinguishing between sectoral/verical approaches (domain-specific regulation) and broad/horizontal oversight (comprehensive cross-domain supervision). For each dimension, we developed specific indicators to ensure consistent categorization: centralization is assessed through the number and hierarchical relationships of designated authorities; institutional choice is evaluated based on whether new bodies are created, or existing ones are empowered; and oversight scope is determined by examining the breadth of regulatory mandates and coordination mechanisms. While limited in scope, this framework enables systematic comparison while accommodating the complexity and diversity of national implementation strategies.

2.4 Clustering

The clustering methodology involved a systematic comparison of national implementation models based on their shared characteristics and divergences. We first developed a comparative matrix (presented in Table 1) mapping each country's designated authorities against two key variables: type of national authority (market surveillance and notifying) and governance approach (government control vs. independent body). This initial mapping enabled the identification of distinct implementation clusters. The clustering process followed three sequential steps: first, countries were grouped based on their primary organizational approach (centralized, unified, or fragmented); second, within each primary cluster, we analyzed sub-patterns related to institutional choices (existing vs. new bodies) and oversight models (sectoral vs. horizontal); finally, we examined outlier cases and hybrid approaches that combined elements from different models. This multi-level clustering approach revealed not only the predominant implementation patterns but also the nuanced variations within each cluster, particularly in how Member States balance different institutional and governance requirements.

3. Theoretical background

The theoretical background of this research is the European Union's Artificial Intelligence Act, or AI Act (Regulation (EU) 2024/1689). The AI Act establishes a comprehensive framework for the regulation of artificial intelligence systems in the European Union, requiring Member States to designate or establish competent authorities for its implementation. These authorities, comprising market surveillance authorities (art. 70) and notifying authorities (art. 28), are fundamental to ensuring compliance with the regulation's requirements and maintaining oversight of AI systems within the EU market.

3.1 Legal framework

The AI Act defines two types of competent authorities: market surveillance authorities and notifying authorities. While Member States have the flexibility to designate or establish these authorities according to their organizational needs, the regulation sets forth strict requirements regarding their independence, resources, and operational capabilities. A key principle established by Article 70 is that these authorities must "exercise their powers independently, impartially and without bias so as to safeguard the objectivity of their activities and tasks." This independence in exercising their powers is crucial for ensuring effective oversight of AI systems and maintaining public trust in the regulatory framework.

3.2 Market surveillance authorities

The market surveillance authority plays a crucial role in the AI Act's enforcement mechanism. While building upon established market surveillance principles from Regulation (EU) 2019/1020, the AI Act extends these authorities' responsibilities to address the unique challenges of AI systems under Article 70 provisions. Market surveillance authorities - responsible for the national supervision of AI systems - may take measures in relation to all AI systems when they present a risk in accordance with the AI Act (e.g. high-risk AI systems in the area of biometrics), perform market surveillance duties under Article 74 and report to the European Commission about the use of prohibited practices that occurred during that year and about the measures taken. Member States must designate one market surveillance authority as their single point of contact for the AI Act, creating a clear channel for coordination at

both national and EU levels. This designation facilitates the exchange of information and best practices among authorities across Member States, as encouraged by Article 70(7).

3.3 Notifying authorities

Article 28 outlines distinct responsibilities for notifying authorities, focusing on their role in the conformity assessment ecosystem. Their core functions include: (1) setting up and carrying out procedures for assessment of conformity assessment bodies, (2) designating and notifying these bodies, (3) monitoring their ongoing compliance, and (4) developing these procedures in cooperation with other Member States' notifying authorities. To maintain integrity in the assessment process, notifying authorities must: ensure decisions about notification are made by different personnel than those conducting assessments, avoid any conflicts of interest with conformity assessment bodies, refrain from offering services that conformity assessment bodies perform, maintain strict confidentiality of information obtained during their activities.

3.4 Structural and organizational requirements

The regulation provides Member States with significant flexibility in organizing their competent authorities. Article 70(1) explicitly states that the activities and tasks may be performed by one or more designated authorities, according to each Member State's organizational needs. However, this flexibility is balanced with specific structural requirements: (1) at least one notifying authority and one market surveillance authority must be designated, (2) one authority must be designated as a single point of contact, (3) information about how to contact these authorities must be publicly available through electronic means, and (4) regular reporting to the Commission on resources and adequacy is required.

3.5 Resource and expertise requirements

The AI Act places significant emphasis on ensuring competent authorities are adequately resourced and staffed. Article 70(3) mandates that Member States must provide their national competent authorities with adequate technical, financial, and human resources, along with the necessary infrastructure to effectively fulfill their tasks under the regulation. Specifically, competent authorities must maintain a sufficient number of permanently available personnel with expertise in: AI technologies, data and data computing, personal data protection, cybersecurity, fundamental rights, health and safety risks, existing standards and legal requirements. Member States are required to assess and update these competences and resource requirements annually, ensuring their authorities maintain the capacity to address evolving technological challenges. This comprehensive expertise requirement reflects the complex and multidisciplinary nature of AI oversight (Dwivedi, 2021).

3.6 Implementation challenges

The implementation of competent authorities under the AI Act presents several significant challenges that Member States must address to ensure effective oversight of AI systems. The resource allocation requirement represents a substantial hurdle, as Member States must ensure adequate funding and staffing by 2 August 2025 to ensure the appointment of national competent authorities (Article 70(2)). From an institutional theory perspective, it might pose challenges in terms of competition among institutions for resource allocation (Shao, 2020). The biennial reporting obligation to the Commission on financial and human resources creates an ongoing accountability mechanism, but also highlights the sustained commitment required. Member States must not only secure initial funding but also maintain and potentially increase resources as the AI landscape evolves and regulatory demands grow, a global tendency in AI governance worldwide (Zaidan, 2024). In terms of AI governance frameworks, those authorities can represent the operationalization of the technical and the social/legal layers of the layered model for AI governance in Gasser and Almeida (2017). The need for personnel with deep understanding across multiple domains creates significant recruitment and retention difficulties. Competent authorities must compete with private sector employers who can often offer more attractive compensation packages to professionals with expertise in AI, data science, and cybersecurity. Moreover, the requirement for expertise in market surveillance and legal frameworks alongside technical knowledge creates a need for either rare multidisciplinary professionals or carefully balanced teams that can work effectively together. Indeed, the expertise requirements pose a particularly complex challenge in the current technology labor market (Medaglia, 2024). Coordination complexity emerges as another significant challenge, particularly in cases where AI systems intersect with multiple regulatory domains (Feijóo, 2020). The requirement for consultation with authorities under other EU legislation demands careful orchestration of administrative processes and decision-making procedures. This becomes especially challenging when time-sensitive decisions are required, or when different authorities may have overlapping or potentially conflicting perspectives on specific AI applications. The mandate to maintain operational independence while ensuring effective oversight creates institutional design challenges that go beyond simple organizational structures (Fountain, 2004). Member States must establish governance mechanisms that protect authorities from undue influence while maintaining appropriate accountability. This becomes particularly complex in Member States where regulatory responsibilities are distributed across multiple bodies, requiring careful balancing of autonomy and coordination.

4. Analysis of implementation models of competent authorities

This section analyzes the implementation pattern of countries that took concrete steps from a normative point of view (e.g. legislative proposals, regulations, mandates, etc.) to address the appointment of AI competent authorities under the EU AI Act (art. 28 and 70). The deadline set forth by the AI Act for the appointment of such authorities is 2 August 2025. In April 2025, most of the EU countries did not take official legislative steps to appoint neither the notifying authority, nor the market surveillance authority. These are Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, France, Germany, Greece, Ireland, Latvia, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden. It should be noted that the AI Act is a text with European Economic Area relevance, meaning that it also applies to Iceland, Norway and Liechtenstein. Nonetheless, none of them appointed the national competent authorities before April 2025. It should also be noted that two countries, Cyprus and Malta, already identify competent authorities in their government websites, but with no implementing law in place at the moment of the analysis. These are marked as *planned*.

4.1 Cyprus (planned)

Cyprus has taken initial steps toward implementing the AI Act, with the Council of Ministers approving a national governance structure in January 2025 (Vice Minister of Research press release of 22 January 2025) to designate competent authorities for oversight. Cyprus has divided responsibilities between just two existing regulatory bodies, creating a streamlined system. The Commissioner for Communications serves multiple key roles: notifying authority, market surveillance authority, and the single point of contact required by the AI Act. This concentration of responsibilities reflects a centralized approach using existing regulatory infrastructure rather than creating new institutions. The Commissioner for Personal Data Protection serves as an additional market surveillance authority, specifically for matters related to its existing areas of application. This allocation of oversight responsibilities to the data protection authority follows a pattern seen in other Member States, recognizing the overlap between AI governance and data protection concerns. The Commissioner for Communications, which already has a broad mandate in electronic communications and postal services markets, extends its regulatory functions to encompass AI systems. This leverages existing regulatory expertise and infrastructure while expanding to address challenges presented by artificial intelligence. Without implementing legislation currently in place, specific procedural details and enforcement mechanisms remain undefined, including how the two designated authorities will coordinate their activities and how sanctions will be determined and applied for non-compliance with the AI Act's provisions.

4.2 Finland

In June 2024, the Finnish Ministry of Employment and the Economy issued a proposal to designate the independent AI authorities that would act as market surveillance authority and notifying authority (Government's bill n. TEM050:00 of 2024). The Finnish proposal distributes oversight responsibilities of market surveillance across multiple existing government regulatory bodies rather than creating a single centralized authority. The agencies that currently monitor product safety, transportation, digital systems, healthcare equipment, and financial markets – in addition to the data protection authority - extend their supervisory duties to include AI systems within their respective domains. Specifically, these are: the Safety and Chemicals Agency, the Transport and Communications Agency (also acting as the single point of contact referred to in Article 70(2) of the AI Act), the Ministry of Social Affairs and Health, the occupational safety and health divisions of Regional State Administrative Agencies, the Centre for Safety and Development of Medicinal Products, the Energy Authority, the South Savo Centre for Economic Development, Transport and the Environment, the Financial Supervisory Authority, the National Supervisory Authority for Welfare and Health, councilors elected by Parliament, and the Data Protection Supervisor. At the same time, the Ministry of Economic Affairs and Employment, the Transport and Communications Agency, the Medicines Agency, the Ministry of Social Affairs and Health, and the Data Protection Supervisor have been proposed as notifying authorities. Governance models emphasizing distributed authority potentially enhance substantive effectiveness through domain-specific expertise while introducing coordination challenges that compromise procedural efficiency. Recognizing this trade-off carries important implications for institutional design generally, highlighting the necessity of governance arrangements that maintain appropriate equilibrium between specialized expertise and coordination capacity.

4.3 Hungary

According to the latest resolution (Government resolution n. 1301of 2024), Hungary established the new Hungarian Artificial Intelligence Council, which shall perform the official tasks both of notifying and market surveillance authorities under the AI Act. The Council is established under the supervision of the Minister of National Economy. This single organization is designed to provide a streamlined "one-stop shop" for AI governance while fulfilling all the regulatory requirements prescribed by the AI Act, including serving as the mandated single point of contact. The institutional innovation strategy of establishing a new AI-specific body represents a distinctly different conceptualization of effective AI governance, one that prioritizes specialized focus and organizational adaptability over institutional continuity and established expertise.

4.4 Italy

The Italian Parliament (Senate Bill n. 1146 of 2024) proposed to appoint the National Cybersecurity Agency (ACN) as market surveillance authority with monitoring, inspection and enforcement powers, and the Agency for Digital Italy (AgID) as notifying authority. Both agencies - the first managing the national cybersecurity issues, the latter being the technical IT agency of the government - work under the supervision of the Presidency of the Council of Italy. The designation of a cybersecurity agency as the primary market surveillance authority reflects Italy's strategic view of AI governance as fundamentally intertwined with digital security concerns. AgID instead provides experience in developing technical standards, managing digital transformation initiatives, and coordinating public administration technology adoption. To ensure effective coordination, the legislation establishes a Coordination Committee at the Presidency of the Council of Ministers, composed of the directors general of both agencies and the head of the Department for Digital Transformation. This mechanism aims to maintain consistency in Italy's overall approach to AI governance despite the functional division between market surveillance and notification responsibilities.

4.5 Lithuania

In Lithuania, the amendments adopted by the government (Government resolution n. 860 of 2024) set out a specific role for the Innovation Agency, which, together with the Communications Regulatory Authority (*Lietuvos Respublikos ryšių reguliavimo tarnyba*, RRT), will be the main body responsible for implementing the EU's Artificial Intelligence Act. RRT is meant to be an agency transcending traditional supervisory functions to become a facilitative partner promoting coordination and multi-stakeholder dialogue. The Innovation Agency has been designated as the national notifying authority, while the Communications Regulatory Authority will act as the market supervisor and single point of contact. Innovation Agency Lithuania is a non-profit agency under the Lithuanian Ministry of Economy and Innovation. The Communications Regulatory Authority of the Republic of Lithuania is an independent state institution regulating electronic communications, postal, rail markets and as well as performing supervision of trust service providers. Lithuania's implementation approach for the AI Act reflects a pragmatic balance between centralization and specialization. By assigning distinct but complementary roles to two established agencies, Lithuania has created a governance structure that avoids both excessive fragmentation and complete consolidation

4.6 Luxembourg

Luxembourg's Parliament introduced a new law to enact the AI Act (Parliament bill n. 8476 of 2024). The bill outlines the designation of national authorities responsible for applying and monitoring the AI Act, including the Luxembourg Institute for Standardization, Accreditation, Safety and Quality of Products and Services and the Government Data Protection Commission as notifying authorities. It also designates the National Commission for Data Protection as the market surveillance authority for high-risk AI systems used by law enforcement and other sectors and specifies other authorities for market surveillance based on sectoral supervision. Namely: Judicial Supervisory Authority, Financial Sector Supervisory Commission, Supervisory Authority for the Insurance Sector, Luxembourg Institute for standardization, accreditation, safety and quality of products and services, Luxembourg Regulatory Institute, Luxembourg Agency for Medicines and Health Products, and the Luxembourg's independent audiovisual authority. On top of this, as the horizontal market surveillance authority by default, the Commission for Data Protection (*Commissariat du gouvernement à la protection des données auprès de l'Etat, CGPD*) is responsible for coordination with market surveillance authorities and designated as the single point of contact. Luxembourg's approach to implementing the AI Act reveals a distinctive regulatory philosophy that emphasizes highly specialized oversight distributed according to existing regulatory competencies. This fragmented governance structure may offer advantages in terms of leveraging deep domain expertise but also creates potential coordination challenges that the CNPD, in its role as coordinator, will need to address.

4.7 Malta (planned)

As mentioned in their official websites in January 2025 and confirmed by their officials in January 2025 via direct correspondence, the Malta Digital Innovation Authority (MDIA) and the Information Data Protection Commission (IDPC) have been identified as market surveillance authorities in Malta by the latest draft government law. At the same time, the MDIA and the National Accreditation Board have been identified as notifying authorities. The MDIA is the primary government authority responsible for promoting governmental policies that promote Malta as the center for excellence for technological innovation. The IDPC is the national independent supervisory authority responsible for upholding the fundamental right of individuals to have their personal data protected and to monitor the application of data protection law in Malta. This designation reflects the Act's emphasis on protecting fundamental rights and freedoms of individuals potentially affected by autonomous decision-making technologies, with particular focus on transparency, security, data protection, robustness, accuracy, non-discrimination, and sustainability principles. The National Accreditation Board is a public entity, with no share ownership, commercial or other interest in any conformity assessment body and it operates on a not-for-profit basis. It is responsible for accreditation in accordance with the relevant national, international and European standards and guides, and the

applicable national, international and European regulations. This regulatory architecture demonstrates Malta's strategic approach to implementing the AI Act while leveraging existing institutional competencies.

4.8 Poland

The Polish draft act on artificial intelligence systems (Government bill n. UC71 of 2024) planned to establish a new market surveillance authority for artificial intelligence models and systems, which will be the Artificial Intelligence Development and Security Commission. The work of the Commission will be managed by the Chairman appointed by the Prime Minister of Poland. It is also proposed to designate the Department of Digital Affairs of the Chancellery of the Prime Minister of Poland, the institution responsible for computerization, as the authority responsible for notification of conformity assessment bodies and as the notifying authority. Poland has opted for a primarily consolidated regulatory architecture with clearly defined jurisdictional boundaries. This approach reflects Poland's strategic decision to create dedicated AI governance institutions rather than distributing responsibilities across existing regulatory bodies, enabling more focused expertise development while maintaining centralized coordination.

4.9 EU Institutions

Finally, as regards AI systems put into service or used by European Union institutions, the AI Act references to national competent authorities or market surveillance authorities shall be construed as references to the European Data Protection Supervisor (EDPS). In fact, artt. 70 and 74 state that where Union institutions, bodies, offices or agencies fall within the scope of the AI Act, the European Data Protection Supervisor shall act as the competent authority for their supervision, and as their market surveillance authority, except in relation to the Court of Justice of the European Union acting in its judicial capacity. The EDPS is an independent supervisory authority responsible for ensuring that EU institutions and bodies comply with data protection law when processing personal data.

Tab. 1 summarizes the results of the research.

Tab. 1: Emerging governance models of national competent authorities under the EU AI Act (*last update: January 2025*)

Country	Type of national authority	Institution	Governance	
			Government control	Independent body
Cyprus	Market surveillance authorities	Commissioner for Communications	X	
		Commissioner for Personal Data Protection		X
	Notifying authority	Commissioner for Communications	X	
Finland	Market surveillance authorities	Safety and Chemicals Agency	X	
		Transport and Communications Agency	X	
		Ministry of Social Affairs and Health	X	
		Regional State Administrative Agencies	X	
		Medicines Agency	X	
		Energy Authority	X	
		South Savo Centre for Economic Development, Transport and the Environment	X	
		Financial Supervisory Authority		X
		National Supervisory Authority for Welfare and Health	X	
		Councilors elected by Parliament	X	
		Data Protection Supervisor		X
	Notifying authorities	Ministry of Economic Affairs and Employment	X	
		Transport and Communications Agency	X	
		Medicines Agency	X	
		Ministry of Social Affairs and Health	X	
		Data Protection Supervisor		X
Hungary	Market surveillance authority	Artificial Intelligence Council	X	
	Notifying authority	Artificial Intelligence Council	X	

Italy	Market surveillance authority	National Cybersecurity Agency	X	
	Notifying authority	Agency for Digital Italy	X	
Lithuania	Market surveillance authority	Communications Regulatory Authority		X
	Notifying authority	Innovation Agency	X	
Luxembourg	Market surveillance authorities	National Commission for Data Protection		X
		Judicial Supervisory Authority		X
		Financial Sector Supervisory Commission	X	
		Supervisory Authority for the Insurance Sector		X
		Luxembourg Institute for standardization, accreditation, safety and quality of products and services	X	
		Luxembourg Regulatory Institute		X
		Luxembourg Agency for Medicines and Health Products		X
		Luxembourg's independent audiovisual authority		X
	Notifying authorities	Luxembourg Institute for Standardization, Accreditation, Safety and Quality of Products and Services	X	
		National Commission for Data Protection		X
Malta (*planned*)	Market surveillance authorities	Malta Digital Innovation Authority	X	
		Information Data Protection Commission		X
	Notifying authorities	Malta Digital Innovation Authority	X	
		National Accreditation Board		X
Poland	Market surveillance authority	Artificial Intelligence Development and Security Commission	X	
	Notifying authority	Department of Digital Affairs of the Chancellery of the Prime Minister	X	
EU	Market surveillance authority	European Data Protection Supervisor		X
	Notifying authority	European Data Protection Supervisor		X

Source: authors

5. Discussion

5.1 Centralized, unified, fragmented approaches

The analysis of early implementations of AI Act national competent authorities reveals three distinct organizational approaches among Member States. While most EU countries have yet to designate their competent authorities, the emerging patterns from early adopters provides valuable insights into different implementation strategies. These divergent implementation strategies reflect fundamental differences in administrative traditions, institutional capacities, and conceptualizations of effective technology governance across the European regulatory landscape. The centralized approach, adopted by Hungary, Italy, and Poland, places both market surveillance and notifying authority functions under direct government control. This approach suggests a preference for strong governmental coordination in AI oversight, potentially facilitating faster decision-making and unified policy implementation. The Hungarian model exemplifies this approach through its establishment of the Artificial Intelligence Council under the direct supervision of the Minister of National Economy, creating a consolidated institutional structure with comprehensive authority over AI oversight functions. Similarly, Poland's proposed Artificial Intelligence Development and Security Commission and Italy's designation of government agencies under the Presidency of the Council demonstrate variations of this centralized institutional design. However, this model also raises questions about the independence of oversight mechanisms, particularly given the AI Act's emphasis

on authorities exercising their powers "independently, impartially and without bias" (Article 70). The unified approach, interestingly, has only been adopted by EU institutions through the European Data Protection Supervisor (EDPS). This model combines both functions within a single independent authority, potentially offering clearer lines of accountability and more streamlined operations. However, its limited adoption by Member States might suggest practical challenges in implementing this approach at the national level, where existing regulatory landscapes are more complex, the market presents more AI systems for market surveillance activities, and robust capacity in AI is needed, notably towards the need for public acceptance (Middleton, 2022). The predominant avoidance of this model by early implementing Member States indicates significant practical barriers, potentially including resource constraints, institutional path dependencies, and challenge in developing the multidimensional expertise necessary for comprehensive AI oversight within a single independent regulatory entity. The fragmented approach emerges as the predominant choice among early implementers, with countries like Finland, Lithuania, Luxembourg, and Malta adopting various mixed models. Within this landscape, institutional arrangements vary from moderately distributed (e.g., Lithuania's dual-agency model) to highly complex configurations (e.g., Luxembourg's eight-authority framework). The distributed approach operationalizes theoretical insights regarding the diversity of expertise necessary for effective technology governance, acknowledging that different regulatory domains require distinct forms of specialized knowledge that may not be readily consolidated within singular institutional structures. This organizational fragmentation potentially enhances the depth of domain-specific understanding but simultaneously creates significant coordination burdens and risks of inconsistent implementation across regulatory domains. Luxembourg's implementation particularly exemplifies this approach, with multiple sectoral authorities sharing market surveillance responsibilities while maintaining the National Commission for Data Protection as a horizontal coordinator. Similarly, Lithuania combines a government agency for notification with an independent authority for market surveillance. This approach potentially leverages existing expertise across different domains – that requires developing a nuanced understanding of a highly complex policy landscape (Margetts, 2024) – but may face increased administrative complexity and coordination challenges (Mikhaylov, 2018). The prevalence of the fragmented approach among early implementers might indicate a pragmatic response to the AI Act's comprehensive requirements. By distributing responsibilities across existing bodies, Member States can potentially meet the August 2025 deadline while leveraging established regulatory expertise. However, this choice also reflects the complexity of AI governance, where different aspects of oversight may require distinct types of regulatory approaches and expertise (Choi, 2023). These early implementation patterns also reveal an important tension between the need for coordinated AI oversight and the practical advantages of distributed regulatory responsibility. While centralized approaches might offer more straightforward coordination, fragmented implementations might better address the multifaceted nature of AI regulation, from technical standards to market surveillance duties.

5.2 Institutional continuity vs. new bodies

The results also reveal a clear dichotomy in institutional approaches to AI oversight, with most Member States opting to leverage existing regulatory bodies while only a few create new AI-specific institutions. This pattern offers important insights into different strategies for building AI governance capacity. The majority of early implementing states have chosen to adapt and expand the mandates of existing institutions. Finland distributed oversight responsibilities across established regulatory bodies in various sectors, while Luxembourg designated existing authorities like the Institute for Standardization, Accreditation, Safety and Quality of Products and Services and National Data Protection Commission for different aspects of AI oversight. Similarly, Italy appointed its National Cybersecurity Agency and Agency for Digital Italy, while Malta leveraged the existence of its Digital Innovation Authority and the Data Protection Commission. This approach suggests a pragmatic strategy that capitalizes on established regulatory expertise and existing strong institutional frameworks (Winfield, 2018). It may also reflect practical considerations regarding the ambitious implementation timeline, as creating entirely new institutions by August 2025 could present significant organizational challenges. In contrast, Hungary and Poland have opted to establish new AI-specific bodies. Hungary's creation of a dedicated AI Council and Poland's proposed Artificial Intelligence Development and Security Commission represent a more transformative approach to AI governance. These new institutions might offer advantages in terms of specialized focus and clear mandate, but they also face the challenge of building regulatory capacity and expertise from the ground up. The choice to create new bodies might reflect these countries' vision of AI oversight as a distinct regulatory domain requiring dedicated institutional frameworks rather than an extension of existing regulatory functions, highlighting the tension in diverse AI public management and organization (Selten, 2024). This approach acknowledges that effective AI oversight requires diverse forms of what may already exist within established regulatory frameworks. Moreover, building on existing institutions might facilitate faster operational capability and more efficient resource utilization, particularly important given the comprehensive expertise requirements outlined in Article 70(3) of the AI Act. However, the institutional continuity approach also presents potential challenges. Existing bodies may need significant adaptation to handle AI-specific oversight responsibilities, and there might be risks of institutional path dependency (Chiodo, 2024), limiting the development of novel regulatory approaches needed for AI governance. Conversely, while new AI-specific bodies might offer more flexibility in developing tailored oversight mechanisms, they face the substantial challenge of building institutional capacity and expertise within a limited timeframe. This institutional design dichotomy reflects deeper theoretical questions regarding the nature of effective technology governance - specifically, whether novel technological systems like artificial intelligence represent extensions of

existing regulatory domains requiring evolutionary adaptation or fundamentally different governance challenges necessitating revolutionary institutional transformation. The empirical evidence from early implementation patterns suggests that most jurisdictions have adopted the former perspective, conceptualizing AI governance as an extension of existing regulatory domains that can be effectively addressed through institutional adaptation rather than creation.

5.3 Vertical vs. horizontal oversight

Finally, the examination of Member States' implementation choices highlights a critical divide between comprehensive and domain-specific regulatory architectures for AI oversight, each reflecting distinct philosophies about effective AI governance. At one end of the spectrum lies the vertical and domain-specific model, with Finland and Luxembourg as prime examples of jurisdictions embracing specialized regulatory frameworks. The Finnish implementation distributes competencies across multiple domain experts, from transport regulators to healthcare authorities, while Luxembourg's framework carefully delineates oversight based on sector-specific expertise. This granular approach stems from an understanding that AI systems pose distinct challenges depending on the application context (Alhosani, 2024), demanding tailored oversight mechanisms. Standing in stark contrast is the comprehensive oversight model, epitomized by Hungary and Poland's approaches through their dedicated AI authorities. By establishing single entities with broad supervisory mandates, these Member States prioritize unified governance over sector-specific considerations. Their implementation strategy suggests a conception of AI oversight as fundamentally cross-cutting, requiring coordinated supervision that transcends traditional regulatory boundaries (Taeihagh, 2021). This fundamental divergence in regulatory architecture carries significant implications. The domain-specific model offers the advantage of nuanced, context-aware supervision but risks creating regulatory silos and inconsistent interpretation of AI Act requirements. Meanwhile, comprehensive oversight promises more uniform implementation but may struggle to address the technical intricacies and operational specificities of different sectors. Some jurisdictions are developing hybridized frameworks that attempt synthetic reconciliation of these competing architectural principles (e.g. Cyprus, Malta). Though empirical validation of this approach's effectiveness remains pending, its theoretical framework suggests potential for balancing competing regulatory imperatives. This balanced framework might offer valuable insights for other Member States still formulating their implementation strategies, though its practical effectiveness remains to be evaluated. The emergence of these architectural variations demonstrates the complex multidimensionality of AI governance, requiring institutional frameworks capable of simultaneously addressing cross-cutting principles and sector-specific requirements The diversity of architectonic approaches among early-implementing Member States illuminates the fundamental governance challenge of balancing systemic coherence with contextual adaptability, revealing tensions between implementation uniformity and calibration that persist across diverse administrative contexts.

6. Conclusion

Our analysis of early implementation approaches to the EU AI Act's requirements for national competent authorities reveals fundamental dimensions that characterize distinct regulatory strategies. First, regarding organizational architecture, while most EU countries have yet to designate their competent authorities, early implementers show a clear pattern. The fragmented approach emerges as predominant, with countries like Finland, Lithuania, Luxembourg, and Malta distributing responsibilities across multiple bodies. In contrast, Hungary, Italy, and Poland opted for more centralized models, while the unified approach has been primarily adopted only at the EU institutional level through the EDPS. The predominance of fragmented approaches among early implementers suggests a pragmatic recognition of AI's complex, multi-faceted nature and the diverse expertise required for effective oversight. While this distributed model leverages specialized knowledge across different domains, it also introduces significant coordination challenges that Member States must address through careful institutional design. Second, our analysis reveals a strong preference for leveraging existing regulatory bodies over establishing new AI-specific institutions. Most early implementing states, including Finland, Luxembourg, Malta, and Italy, chose to expand the mandates of established authorities, likely capitalizing on existing expertise and institutional frameworks. Only Hungary and Poland opted to create new dedicated AI oversight bodies, highlighting different philosophies about building regulatory capacity. The strong preference for leveraging existing regulatory bodies over creating new AI-specific institutions reflects both practical and strategic considerations. This approach allows Member States to build on established expertise and operational capabilities, potentially facilitating faster implementation given the AI Act's ambitious timeline. However, this choice also raises questions about whether traditional regulatory frameworks can adequately adapt to the unique challenges of AI oversight. Third, we observed a critical divide between comprehensive and domain-specific oversight frameworks. While some jurisdictions like Finland and Luxembourg embraced specialized regulatory frameworks across different sectors, others like Hungary and Poland prioritized unified governance through broad supervisory mandates. Notably, some states are pioneering hybrid solutions that attempt to balance specialized knowledge with coordinated supervision. The tension between sectoral and horizontal oversight models emerges as a critical challenge in institutional design. While sector-specific approaches offer deeper domain expertise and contextual understanding, they risk creating regulatory fragmentation and inconsistent interpretation of AI Act requirements. Conversely, comprehensive oversight models promise more uniform implementation but may struggle to address

sector-specific technical complexities. Early implementing states' diverse approaches to resolving this tension provide valuable insights for other Member States still formulating their implementation strategies. Looking forward, these early implementation choices may have lasting implications for the effectiveness of AI oversight in Europe. The institutional architecture being established now will likely shape how Member States approach future challenges in AI governance, from ensuring consistent interpretation of requirements to fostering innovation while maintaining adequate oversight. Moreover, these diverse approaches to implementing the AI Act may offer valuable lessons for other jurisdictions worldwide as they develop their own AI governance frameworks.

Several important limitations of this study should be acknowledged. Our analysis focuses on early implementing Member States during the initial months following the AI Act's entry into force, capturing only the first wave of implementation approaches. This temporal limitation, while providing valuable early insights, means our findings may not fully reflect the complete landscape of implementation strategies that will emerge as more Member States designate their competent authorities. Additionally, our analysis relies primarily on formal documents and legislative proposals rather than operational evidence, as these authorities are not yet fully functioning. These limitations point to important directions for future research. First, longitudinal studies tracking the evolution of these different regulatory models would provide valuable insights into their effectiveness and adaptability over time. As Member States operationalize their institutional frameworks and develop practical coordination mechanisms, comparative assessment of regulatory outcomes would illuminate how different structural arrangements influence governance effectiveness. Second, comparative governance studies across technological domains would enhance understanding of whether findings from AI governance extend to other emerging technologies. Research examining institutional arrangements for quantum computing, biotechnology, or autonomous systems governance could identify common patterns and distinctive challenges, potentially revealing domain-specific factors that influence optimal institutional design. Third, research examining stakeholder perspectives, including industry actors and civil society, would enhance understanding of how different institutional arrangements impact innovation and public trust in AI governance. Empirical assessment of coordination mechanisms between market surveillance authorities, notifying bodies, and sectoral regulators would address a critical gap in current understanding. Future research could examine information flows, decision-making processes, and procedural integration across institutional boundaries, potentially identifying best practices for effective coordination despite structural fragmentation. Finally, future studies should investigate how these different models perform in practice, particularly regarding their ability to meet the AI Act's requirements for expertise, independence, and effective oversight. This could include examining coordination mechanisms in fragmented systems, capacity building in new institutions, and the effectiveness of different approaches to balancing sectoral expertise with comprehensive oversight.

Acknowledgements

- **Contributor Statement**: Author 1: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Supervision, Resources, Validation, Visualization, Writing – Original Draft, Writing - Review & Editing. Author 2: Methodology, Project administration, Resources, Validation Writing – Original Draft, Writing - Review & Editing.
- **Use of AI**: During the preparation of this work, the authors used DeepL in order to translate official legislative acts. After using this tool, the authors reviewed, edited, made the content their own and validated the outcome as needed, and takes full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

1. Alhosani, K., Alhashmi, S. M. (2024). Opportunities, challenges, and benefits of AI innovation in government services: a review. *Discov Artif Intell 4, 18.* https://doi.org/10.1007/s44163-024-00111-w
2. Bellogín, A., Grau, O., Larsson, S., Schimpf, G., Sengupta, B., & Solmaz, G. (2024). The EU AI Act and the Wager on Trustworthy AI. *Communications of the ACM, 67(12), 58-65*. https://doi.org/10.1145/3665322
3. Bianchi, C., Nasi, G., Rivenbark, W. (2021). Implementing collaborative governance: models, experiences, and challenges. *Public Management Review. 23. 1-9.* https://doi.org/10.1080/14719037.2021.1878777
4. Cancela-Outeda, C. (2024). The EU's AI act: A framework for collaborative governance. *Internet of Things, Volume 27, 101291, ISSN 2542-6605*. https://doi.org/10.1016/j.iot.2024.101291

5. Chiodo, M., Müller, D., & Sienknecht, M. (2024). Educating AI developers to prevent harmful path dependency in AI resort-to-force decision making. *Australian Journal of International Affairs*, *78(2), 210–219*.
https://doi.org/10.1080/10357718.2024.2327366
6. Choi, H., Park, M. J. (2023). To govern or be governed: an integrated framework for AI governance in the public sector, *Science and Public Policy*, *Volume 50, Issue 6, Pages 1059–1072*
https://doi.org/10.1093/scipol/scad045
7. Dwivedi, Y. K., et al. (2021). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management.*
https://doi.org/10.1016/j.ijinfomgt.2019.08.002
8. Feijóo, C., et al. (2020). Harnessing artificial intelligence (AI) to increase wellbeing for all: The case for a new technology diplomacy. *Telecommunications Policy, Volume 44, Issue 6*.
https://doi.org/10.1016/j.telpol.2020.101988
9. Fountain, J. E. (2001). Building the Virtual State: Information Technology and Institutional Change. *Brookings Institution Press*.
10. Gasser, U. and Almeida, V. A. F. (2017). A Layered Model for AI Governance. *IEEE Internet Computing*, vol. 21, no. 6, pp. 58-62, November/December 2017
https://doi.org/10.1109/MIC.2017.4180835
11. Government's bill n. TEM050:00 of 2024 (Finland). Government proposal to Parliament for legislation supplementing the EU Regulation on Artificial Intelligence. Accessed in January 2025.
https://api.hankeikkuna.fi/asiakirjat/0904a749-72c4-4301-8e13-85bad0a85062/8ce02987-9aa4-4187-9226-d012024bc47a/LAUSUNTOPYYNTO_20241028083630.PDF
12. Government bill n. UC71 of 2024 (Poland). Draft Act on Artificial Intelligence Systems. Accessed in January 2025.
https://www.gov.pl/web/premier/projekt-ustawy-o-systemach-sztucznej-inteligencji#:~:text=Organem%20w%C5%82a%C5%9Bciwym%20w%20tym%20zakresie,skargowe%20zako%C5%84czone%20b%C4%99dzie%20wydaniem%20decyzji
13. Government resolution n. 1301/2024 (Hungary). Government Resolution 1301/2024 (IX. 30.) on measures necessary for the implementation of the Regulation of the European Parliament and of the Council on artificial intelligence. Accessed in January 2025.
https://njt.hu/jogszabaly/2024-1301-30-22
14. Government resolution n. 860 of 2024 (Lithuania). Resolution on amendment of articles 1, 2, 11, 13, 14, 17, 21 of the law of the republic of Lithuania on technology and innovations no. xiii-1414 and supplementation of the law by the draft law and law of the republic of Lithuania on information society services no. x-614 submission of the draft law on amendment of articles 1, 2, 23 and the annex to the Seimus of the republic of Lithuania. Accessed in January 2025.
https://www.e-tar.lt/portal/lt/legalAct/ca88ddf38c7e11ef92b19bb92dd76d17
15. Laux, J., Wachter, S., Mittelstadt, B. (2023). Trustworthy artificial intelligence and the European Union AI act: On the conflation of trustworthiness and acceptability of risk. *Regulation & Governance 18, 3–32*
https://doi.org/10.1111/rego.12512
16. Lu Q., Zhu L., Xu X., Whittle J., Zowghi, D., Jacquet A. (2024). Responsible AI Pattern Catalogue: A Collection of Best Practices for AI Governance and Engineering. *ACM Comput. Surv. 56, 7, Article 173 (July 2024), 35 pages*.
https://doi.org/10.1145/3626234
17. Mikhaylov, S. J., Esteve, M., and Campion, A. (2018). Artificial intelligence for the public sector: opportunities and challenges of cross-sector collaboration. *Phil. Trans. R. Soc. A.37620170357*
http://doi.org/10.1098/rsta.2017.0357
18. Margetts, H., Dorobantu, C. and Bright, J. (2024), How to Build Progressive Public Services with Data Science and Artificial Intelligence. *The Political Quarterly, 95: 653-662*.
https://doi.org/10.1111/1467-923X.13448
19. Medaglia, R., Mikalef, P. and Tangi, L., European Commission: Joint Research Centre. (2024) Competences and governance practices for artificial intelligence in the public sector. *Publications Office of the European Union, Luxembourg, 2024*
https://data.europa.eu/doi/10.2760/7895569
20. Middleton, S. E., Letouzé, E., Hossaini, A. and Chapman, A. (2022). Trust, regulation, and human-in-the-loop AI: within the European region. *Commun. ACM 65, 4 (April 2022), 64–68*.
https://doi.org/10.1145/3511597
21. Novelli, C., Hacker, P., Morley, J., Trondal, J., & Floridi, L. (2024). A robust governance for the AI act: AI office, AI Board, scientific panel, and national authorities. *European Journal of Risk Regulation*, 1-25. https://doi.org/10.1017/err.2024.57
22. Parliament bill n. 8476 of 2024 (Luxembourg). Draft law implementing certain provisions of Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 establishing harmonized rules concerning artificial intelligence. Accessed in January 2025.

https://wdocs-pub.chd.lu/docs/exped/0150/154/301543.pdf
23. Regulation (EU) 2024/1689 of the European Parliament and of the Council. Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202401689
24. Selten, F., Klievink, B. (2024). Organizing public sector AI adoption: Navigating between separation and integration. *Government Information Quarterly, Volume 41, Issue 1, 101885, ISSN 0740-624X.* https://doi.org/10.1016/j.giq.2023.101885
25. Senate Bill n. 1146 of 2024 (Italy). Provisions and delegation to the Government regarding artificial intelligence. Accessed in January 2025. https://www.senato.it/service/PDF/PDFServer/BGT/01418921.pdf
26. Shao, Z., Yuan, S. and Wang, Y. (2020). Institutional Collaboration and Competition in Artificial Intelligence. *IEEE Access, vol. 8, pp. 69734-69741.* https://doi.org/10.1109/ACCESS.2020.2986383
27. Taeihagh, A. (2021). Governance of artificial intelligence. *Policy and Society, 40(2), 137–157*. https://doi.org/10.1080/14494035.2021.1928377
28. Winfield, A. F. T., Jirotka, M. (2018). Ethical governance is essential to building trust in robotics and artificial intelligence systems. *Phil. Trans. R. Soc. A.37620180085* http://doi.org/10.1098/rsta.2018.0085
29. Zaidan, E., Ibrahim, I. A. (2024). AI Governance in a Complex and Rapidly Changing Regulatory Landscape: A Global Perspective. *Humanit Soc Sci Commun 11, 1121.* https://doi.org/10.1057/s41599-024-03560-x

Transforming Justice: The Rise of AI in Brazilian Courts

Fernanda Suriani [a], *Eduardo* Pacheco [b]

[a] Lawgorithm Association for Artificial Intelligence Research, University of São Paulo, São Paulo, Brazil, fenanda.suriani@alumni.usp.br, https://orcid.org/0009-0000-7667-2944

[b] Lawgorithm Association for Artificial Intelligence Research, University of São Paulo, São Paulo, Brazil, eduardo.caruso.pacheco@alumni.usp.br, https://orcid.org/0009-0007-9887-9189

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 27 June 2025

Abstract This paper examines Artificial Intelligence (AI) implementation and evolution in the Brazilian judicial system from 2021 to 2023, focusing on institutional framework, governance, and applications. Analyzing data from the National Justice Council's (CNJ) AI project dashboards, we identified patterns in project development, survival rates, and categorical shifts in AI applications. Our findings reveal a 238% increase in AI projects, yet with a high mortality rate; over 65% were deprecated by 2023.

The research indicates an evolution from basic data classification applications towards more sophisticated uses like procedural intelligence and user-focused services. While initial projects targeted efficiency, newer ones demonstrate transformative potential, including novel mediation and fraud detection. The study also assesses the regulatory framework (CNJ Resolution n. 615/2025) and its adaptation to emerging technologies like generative AI. Despite progress, challenges persist in the coordinated development and strategic implementation of AI systems. The paper concludes with recommendations for enhancing cross-court collaboration, establishing impact-focused metrics, and monitoring the new regulatory framework to ensure AI improves efficiency, transparency, and access to Justice, while considering risks like algorithmic bias, data quality, and accountability. These findings also provide valuable insights for other judicial systems undertaking similar transformations, highlighting the need for strong governance and strategic coordination for a successful AI integration.

Keywords. Artificial Intelligence, Brazilian Justice System, Digital Transformation, Judicial Innovation, Legal Technology.
Policy paper, DOI: https://doi.org/10.59490/dgo.2025.1049

1. Introduction

Enhanced efficiency, transparency, and access to Justice drive the Brazilian Justice System's digital transformation. With a backlog of 83 million court cases, 99% in digital format (Brazil, CNJ, 2023), AI adoption was natural for task automation, data analysis, and informed decision-making, improving justice delivery speed and quality. The National Justice Council – CNJ plays a pivotal role in this transformation, especially in mapping and coordinating the implementation of AI and establishing guidelines to ensure trustworthy AI adoption by Brazilian courts.

Performing existing tasks faster through the use of AI certainly improves court efficiency and is desirable. Nonetheless, it is important to note that improving working practices using technology is only a partial enhancement. As highlighted by Susskind, technology can play a more relevant role: "It can displace and revolutionize conventional working habits—doing new things, rather than old things in new ways" (SUSSKIND, 2019). The primary challenge lies in enhancing civil litigation efficacy while ensuring equitable trial conditions for all stakeholders engaged in the process.

Therefore, it is crucial to understand how AI is being used in Brazilian Courts and whether it is being implemented to overcome inequalities, improve efficiency, transparency, and coherence, and consequently improve the quality of judicial service as a whole.

Despite potential benefits, AI use in the Judiciary presents risks and challenges. There are concerns about algorithmic bias, data quality, accountability, and the preservation of human judgment in judicial decision-making. Establishing robust governance frameworks and ethical standards is necessary to mitigate these risks and ensure

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

responsible AI deployment. The CNJ enacted Resolution n. 615 on March 11, 2025, superseding the previous one from 2020 with updated directives to address the evolving technological landscape, especially generative AI.

Since 2021, to advance AI Governance in Brazilian Courts, the CNJ, beyond regulation, has collected and publicly shared court AI project data via open dashboards. We analyze this data to assess CNJ's coordination of collaborative AI for judicial efficacy and explore AI's problem-solving applications and its impact on transparency and access to Justice.

This paper aims to comprehensively analyze the evolution of AI's implementation within the Brazilian Justice System, including its applications, benefits, and potential challenges.

2. Implementation and Adoption of AI in the Brazilian Judicial System

2.1 Institutional Context Shaping AI Systems

The institutional framework of the Brazilian judicial system profoundly impacts AI Systems formulation and execution. The legal system is based on civil law tradition, with an emphasis on codified statutes and laws, but it also integrates common law elements through binding precedents from higher courts. The precedent system started to be developed in 2008 to manage the immense volume of lawsuits that reflect the mass relationships in modern society. The CNJ Great Litigants dashboard shows that in 2024, 25% of the judicial cases involved big companies or the Government (repeat players). It means that a great percentage of Brazilian court backlogs are fundamentally low-value, high-volume cases with similar facts and legal issues; they are considered mass or repetitive litigation. In brief, according to the new rules, when superior courts identify this type of case proliferation, the court selects a leading case and suspends the proceedings in similar cases. Once the leading case is decided, it becomes a precedent that must be applied to the suspended and future similar cases.

This establishes a systematic milieu conducive to AI applications, as algorithms can be effectively trained utilizing established legal structures and precedents and analyzing similar cases.

This blended system raises concerns about the use of AI as decision-making support systems, because it can affect the judges' discretion and the fairness of the judicial process. There is a debate on whether these systems should replicate previous judicial decisions while allowing judges to maintain their freedom or if they should promote greater uniformity in decisions, respecting higher judicial precedents. This indicates that integrating AI could either constrain or enhance judicial discretion, depending on its design and implementation (CASIMIRO, 2024).

The hierarchical structure of the Brazilian Judiciary, with multiple levels of appeal, also influences AI adoption. AI tools can be deployed at different levels to address specific needs and challenges. The diversity in court types, sizes, and composition further influences AI adoption, as different courts may have varying needs and challenges that AI can address (BRASIL, CNJ, 2022) and different budgets to invest in technology.

The Brazilian judicial system comprises two main types of courts: legal and special courts, and both have two layers of appeal plus the Supreme Federal Court:

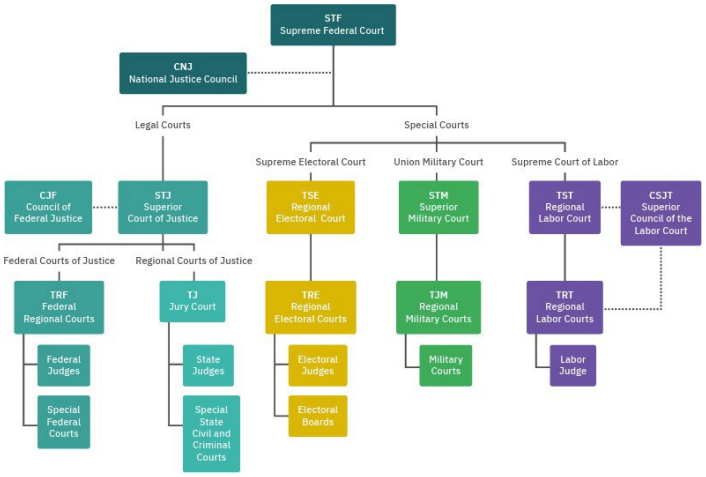


Fig. 1- Brazil, CNJ (2022).

Another important factor to consider is the enormous amount of digital legal data that has been produced for a long time. Electronic processes have been in Brazil since 2002 (Special Federal Courts), when courts introduced

digital case management systems. This trend was boosted in 2006 when the Law on digitizing judicial proceedings was enacted. Years later, in 2013, when more than 50 systems were in use by courts, the National Council of Justice established the Electronic Judicial Proceedings (PJe) as the official procedural tool. In 2015, the PJe Governance Network was created in an effort to unify the systems and facilitate communication among them. (Brazil. CNJ, 2022). Unfortunately, until now, the unification has not been accomplished, and other solutions are being studied and implemented to foster the systems communication, like the use of Application Programming Interface – API.

All this diversity led to an organic implementation of AI, and many courts were separately trying to solve the same problem by deploying different AI projects. In 2020, when the COVID-19 pandemic hit the courts and everything went virtual, the CNJ, in partnership with the United Nations Development Programme (UNDP), launched the Justice 4.0 Program – Innovation and Effectiveness in Achieving Justice for All, to coordinate better, foster collaboration and rationalize the human and material resources for the AI use in courts. The program is aligned with the United Nations Sustainable Development Goals (SDGs) 2030, especially the number 16, which includes the promotion of access to Justice for all.

It is worth mentioning three major initiatives of the program that aim to provide the infrastructure for the collaborative development of AI by courts, adopt the idea of Justice as a service, and promote data quality: the Judiciary's Digital Platform (PDPJ), the Synapses Platform, and the Codex Platform.

The Judiciary's Digital Platform (PDPJ) was launched in 2021, and its main objective is modernizing the Electronic Judicial Proceedings (PJe)transforming it into a multiservice system. It operates as a marketplace for justice services, enabling the courts to consume the functionalities created by other courts through APIs and permitting adaptations for their specific needs. The PDPJ is based on a central cloud infrastructure and fosters communication between the judicial services systems that are already in use within a unified and integrated platform, which includes other CNJ databases (Brazil, CNJ, 2022).

The Synapses Platform is an AI development and deployment platform, often referred to as an "AI Model Factory," that streamlines the delivery of AI models. It allows for creating AI microservices, which can be independently developed and integrated with various systems, especially the PJe. The platform provides an interface for supervised training of classification and text extraction models, which allows legal experts to curate and create new models tailored to specific legal needs. It also supports versioning of AI models, enabling model evolution tracking and maintaining multiple active versions. Hence, the platform facilitates the management and auditing of models in production, generating reports that detail their predictions and decision-making processes. This feature supports AI models' ethical and legal validation in the judicial environment. (Brasil, CNJ, 2019).

The Codex Platform consolidates procedural databases, providing textual content from documents and structured data. It serves as a repository of procedural information, accessible to a wide range of applications, such as producing business intelligence dashboards and reports, implementing intelligent and unified searches, and providing data for creating AI models.

On top of those platforms, the Datajud platform was created, a data lake that provides legal data from all Brazilian courts in real-time. It is the official source for the Brazilian justice statistics system. Based on the Datajud, the CNJ publishes regular court management and performance reports and maintains several dashboards. The Datajud was created in an open-source format that is accessible to the public in general, permitting researchers and anyone to audit the Courts' numbers. It contributes to developing judicial management tools based on evidence and enhancing transparency.

2.2 AI Governance in the Brazilian Judicial System

The governance of AI in Brazilian courts is a complex issue that interlaces technological innovation with ethical and regulatory challenges. While integrating AI into the Judiciary aims to enhance efficiency and precision in legal processes, it raises significant concerns regarding transparency, bias, and accountability.

In addition to the initiatives based on the Justice 4.0 Program described above, the CNJ also enacted in 2020 Resolution n. 322 to foster responsible artificial intelligence development and deployment in the Brazilian courts. Its primary objectives revolved around establishing principles and guidelines for the ethical and responsible integration of computational solutions aimed at enhancing process management and the overall effectiveness of judicial services. The structure of the Resolution was inspired by the principles proposed by the European Commission for the Efficiency of Justice – CEPEJ's ethical Charter (CEPEJ, 2018). Those principles are: i) the principle of respect for fundamental rights; ii) the principle of non-discrimination; iii) the principle of quality and security; iv) the principle of transparency, impartiality, and fairness; v) the principle of "under user control"; vi) the principle of accountability. Criticism of the Resolution n. 332/2020, relies on the difficulty of its enforcement and its inadequacy with the new technologies that have arrived.

With the objective of updating the regulatory framework for AI in the Judiciary, the CNJ enacted Resolution n. 615 on March 11, 2025, explicitly revoking Resolution n. 332/2020. The primary impetus behind this revision lies in the exponential growth and increasing sophistication of AI technologies, particularly generative AI, that are already being used in courts. This new Resolution introduces several key novelties and amendments designed to address these advancements' unique challenges and opportunities. The highlights are below.

The new Resolution brings the same principles as the old one, emphasizing human oversight's importance at all stages of AI development and use, particularly in decision-making processes. AI should serve as an auxiliary tool, and the judges retain full responsibility for their decisions. It also emphasizes data protection and security, requiring compliance with the Brazilian General Data Protection Law and adopting privacy by design and default principles. Data for training AI models must be representative, anonymized whenever possible, and subject to curation and monitoring.

Inspired by the European Artificial Intelligence Act (Europe, European Commission, 2024), it adopts a risk-based approach to categorize AI applications, with definitions of low-risk and high-risk categories placed in an annex to facilitate updating. The risk evaluation will consider factors such as the potential impact on fundamental rights, the complexity of the AI model, its financial sustainability, its intended and potential uses, and the amount of sensitive data it utilizes. It also forbids the Judiciary from developing or using AI solutions that pose excessive risks to information security, fundamental rights, or the independence of judges, especially those that 1) lack human oversight, 2) establish profiles for predicting crime or for supporting decisions in labor cases, 3) ranks individuals based on behavior or social status, and 4) uses biometrics to recognize emotions.

According to the annex of the Resolution, the following purposes and contexts for developing AI solutions are considered high risk: 1) identifying profiles and behavioral patterns of individuals or groups; 2) assessing the evidence suitability and value in court cases, mainly if it affects the final decision; 3) investigating, evaluating, classifying, and interpreting facts as crimes; 4) formulating conclusive judgments on the application of legal rules or precedents to specific sets of facts, 5) facial or biometric identification and authentication for monitoring the behavior of individuals, unless it is to confirm someone's identity or for justified public safety with strong safeguards and monitoring.

On the other hand, AI used for the following purposes is considered low risk: 1) performing routine procedural tasks or supporting judicial administration, like organizing documents and data; 2) finding patterns in past court decisions to help ensure consistency, but without replacing a judge's own review; 3) Providing judges with decision-making support through management reports and analyses using jurimetrics, as long as the AI does not make moral judgments; 4) producing supporting text to facilitate the drafting of judicial acts as long as the judge supervises and produces the final version of the document; 5) improving a previously performed human activity without changing the result; 6) doing statistical analysis for court policy, with human checks to avoid bias; 7) transcribing audio and video recordings, with a human reviewing the final transcript; 8) anonymizing documents.

Specific attention is given to Large Language Models (LLMs) and other GenAI systems, outlining their permitted use as auxiliary tools for management or decision support, preferably through corporate solutions offered by the court. Direct contracting by judges and staff is permitted under specific conditions, including mandatory training and restrictions on using sensitive data for unauthorized training or high-risk purposes.

To foster governance, the Resolution establishes a National Committee for Judicial Artificial Intelligence with a plural composition to oversee and implement the guidelines. It promotes transparency through clear indicators and public reports on AI usage. It especially requires algorithmic impact assessments for high-risk solutions, which must be made public in summary form.

Also, the Resolution establishes mandatory continuous curation and monitoring mechanisms, with provisions for corrective measures or discontinuation of AI solutions in case of discriminatory bias or non-compliance.

The Sinapses platform remains the repository for registering AI solutions, respecting intellectual property, and eliminating the need to deposit large databases. AI models must, when technically possible, have explainable mechanisms, allowing judicial operators to understand and audit their decisions and operations.

The Resolution encourages collaboration between judicial bodies in the development and sharing of AI solutions while maintaining the courts' autonomy.

Regulating new technologies whose applications are not fully understood presents a significant challenge; however, this new Resolution marks an important step towards governing the use of AI in the courts, effectively balancing innovation with the essential principles of ethics, transparency, security, and the protection of fundamental rights.

In the following sessions we describe the methodology and proceed to the analysis of the courts' AI data considering both the institutional context and the new AI regulation.

3. Methodology

3.1. Dataset

To analyze the survival of projects in the Brazilian Judiciary, we downloaded consolidated data from the dashboards

Dashboards and data available at: https://www.cnj.jus.br/sistemas/plataforma-sinapses/paineis-e-publicacoes/ of the artificial intelligence research conducted by the National Justice Council - CNJ. These dashboards compile questionnaires sent to courts about the use, development, and implementation of AI projects in the Judiciary.

After downloading the data corresponding to the compiled results for each year in .csv files, we manually inspected them to identify data quality issues. Some cleaning steps were performed, such as removing records of projects unrelated to AI, records that simply denied the existence of AI in that category and duplicate records. To enable comparison, we also standardized the project names, which had slight variations between years.

After cleaning the data, we merged everything into a single table and added a field identifying the year of origin.

The fields in the consolidated table are:

ID → Unique identifier

Year → Reference year of the project

Court → Name of the court where the project was implemented or developed

Project → Name of the Project

Description → Description of the Project

3.2. Data Processing

Since our goal is to understand project mortality, we need to determine which projects existed and which ceased to exist. To achieve this, we created three fields:

- has_2021, has_2022, has_2023 → indicating whether the project existed in each year.

Next, we created an algorithm to ensure each project had a single entry, avoiding duplicate rows for the same project in different years. The algorithm works as follows:

- If a project has not yet been processed for a given court, check whether it appears in each analyzed year.

- Assign True or False for each year accordingly.

This structure enables easy visualization of each project's timeline and facilitates the mortality study. We can see the mortality results in the graphs displayed in the use cases section.

3.3. Classification

Once the data was prepared, we took a sample from 2023 and manually classified it based on the framework created by Suriani in a preview study regarding AI project categories in the Brazilian Judiciary and explained in the following session (SURIANI, 2022).

We used this labeled dataset as a seed to create a classifier using an LLM with GPT-4o-mini. In the prompt, we:

- Described each category

- Provided two examples for each

- Instructed the model to classify each case sequentially

The model was instructed to return its response in JSON format with two fields:

- Class → The assigned category

- Reasoning → Explanation for debugging and improving classification results

After classification, we generated the same mortality chart for the following year, enabling comparison.

4. AI Use Cases in Brazilian Courts

The Brazilian Judiciary handles a substantial volume of cases (83 million), primarily processed electronically (99%), with a considerable percentage classified as mass or repetitive litigation (25%). A distinctive characteristic of mass litigation is the factual and/or legal similarity of the underlying issues, which allows for identifying patterns for classification and grouping. The major success of artificial intelligence in Law has been achieved through data-based models that identify and correlate patterns to infer outcomes. These computational models have enough input to develop enormously in the Brazilian legal market. More recently, the development of large language models has innovated AI applications in Brazilian courts. The CNJ has been collecting data on the court's AI Projects since 2021 and publishing them on dashboards. Using the data available on the dashboards, we proceeded to analyze the evolution of AI projects, especially considering what kind of problem the use of AI in courts wants to solve.

To better understand the projects and compare them over time, we used a framework that is anchored on five categories, according to each project's objectives: (i) classification and grouping of procedural data; (ii) procedural intelligence; (iii) case law organization and decision drafting; (iv) service/communication with parties, lawyers or court staff; (v) others. (SURIANI, 2022)

The majority of the legal data produced by court systems is not structured data. Therefore, not surprisingly, a significant number of AI projects are focused on data categorization and clustering functionalities. This category includes, for example, projects aiming to identify and classify legal issues, find documents and case file similarities, perform triage, and operate legal indexing.

Once the data is organized, it is possible to evolve into more complex AI models that aim to improve the efficiency of the case course procedures. Those projects, for example, suggest the appropriate procedural steps, facilitate procedural decision-making, help manage the case flow, automate procedural tasks, and accelerate the case progress. Those are what we call procedural intelligence AI projects. They are especially important in the enforcement phase of the legal procedure, as it is one of the greatest bottlenecks in the Brazilian caseload.

These two categories of projects normally increase courts' efficiency, leveraging technology to accomplish faster and sometimes more accurately what courts' assistants would take longer to achieve. Surveys show that the main barriers to access to the Brazilian courts are the perception that legal proceedings are slow, expensive, and complex (RAMOS, 2021). Thus, those kinds of projects help overcome the time and cost barriers to access to Justice.

Moving to the third category, the case law organization and decision drafting AI models help judges to understand the norms and precedents that may apply to the cases, supporting decision-making. Some AI models suggest or generate decision drafts once the correct rule or precedent is identified. More recently, with generative AI, some projects also aim to assist legal writing. Those projects help the courts achieve consistency and transparency on top of increasing efficiency. However, this kind of project might need a better understanding of the responsible use of AI and its ethical considerations, especially the interference with the judge's discretion and procedural fairness.

Finally, some projects seek to assist internal and external users of the legal system. They often use chatbots or other interfaces to answer procedural queries, provide and receive cases or legal information, and facilitate and simplify communication through the use of plain language and other legal design tools. These projects focus on user needs and mainly contribute to helping lay people through procedural complexities. It's an innovative way to interact with and serve citizens.

Some of the projects have more specific objectives that are not related to the above categorization, they are categorized as *others*. For example, projects that apply facial recognition for security reasons in the courts, and that predict the likelihood of revictimization in domestic violence cases to support public policies.

4.1 AI projects survival

As seen before, AI projects have arisen organically, and the CNJ is putting a lot of effort into changing this scenario to foster the collaborative development and deployment of AI and to rationalize the human and material resources for AI use in courts.

The data shows evidence that a potentially high level of experimentation may still be happening during this initial period of AI expansion. The vast majority of the projects launched during the analyzed period are already deprecated. Between 2021 and 2022, 145 projects were created, and on average, 50% of the projects survived at least 1 year, and 35% survived the entire period.

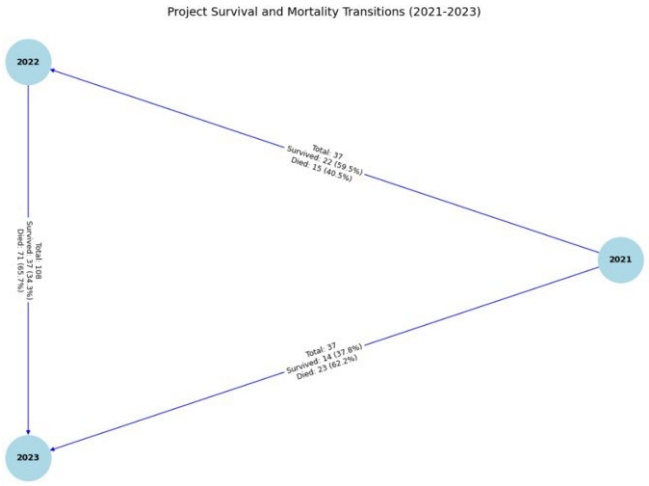


Fig. 2 – Survival and Mortality Transitions

The number of AI projects had a steep increase in the period, with a staggering rate of 238% since 2021. Also relevant, the number of projects that were shut down substantially increased. At the end of 2023, over 65% of projects created were deprecated. In other words, despite the substantial increase in the number of AI projects that could indicate clear progress on AI deployment in courts, two-thirds of those active in 2022 were short-lived. This may indicate high experimentation and a lack of a coordinated guideline roadmap for innovation.

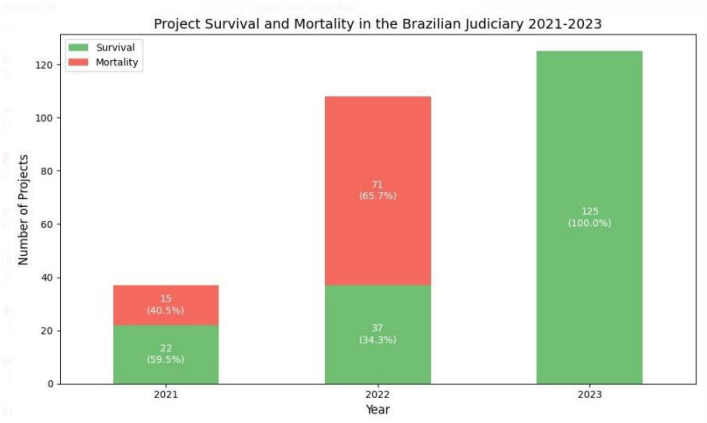


Fig. 3 – Survival and Mortality of AI Projects

4.2 Evolution by category

When looking at the data by category (Fig. 4), it is possible to see that the majority of AI projects were developed within the category Classification and grouping of procedural data. That might indicate that the foundation for an AI-based solution starts with the organization and classification of data, so it makes sense to see more projects aiming that at this initial phase of AI expansion. As we can see in Fig. 5, over time, the prevalence of this type of project is declining while other types are becoming more significant. This might show that, once the data classification problem is being solved, this is becoming less important, bringing more opportunities for developing more analytical types of projects. Another possibility is that AI models are becoming more sophisticated and require less data organization.

Procedural Intelligence projects come in second place in terms of representativeness. This shows a potential interest in going beyond data organization (a more short-term solution) towards an analytical focus. This has a much more direct impact on the efficiency of courts, delivering faster judicial service to citizens.

On the other hand, more strategic initiatives to, for example, improve the understanding of Brazilian jurisprudence, which can help enhance the legal system's cohesion and transparency, are still lagging, with only 29 out of the 210 projects falling in this category.

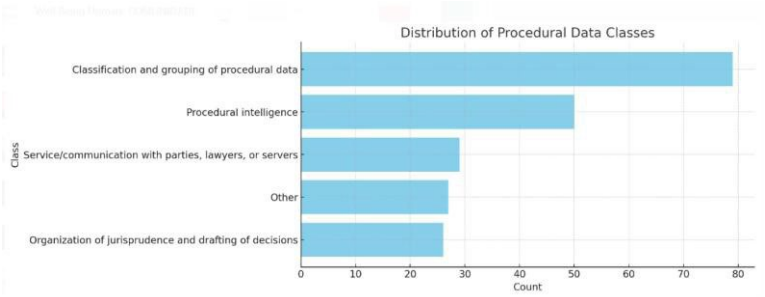


Fig. 4 – number of AI projects by category

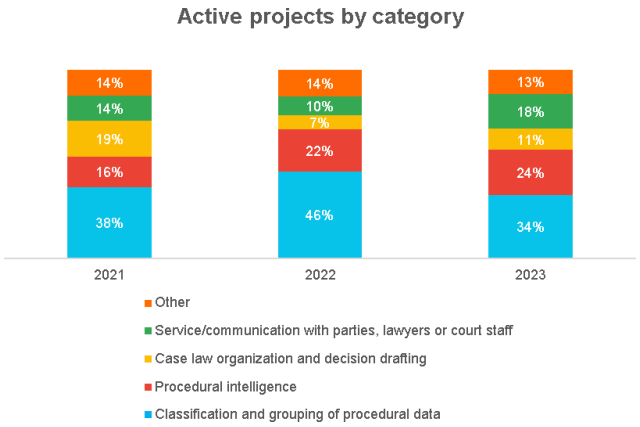


Fig. 5 – AI projects by category overtime

Looking specifically into the four main categories (Fig. 6), it is also clear that all projects are increasing, in absolute terms, when comparing 2023 with 2021. However, one of the categories (Classification) declined in 2023, reinforcing the hypothesis raised above that the need for data classification is becoming less relevant – either because it has been solved or because the AI models do not need organized data to perform, especially the LLM-based AI models.

It is also important to highlight that, despite a relative decline in the period (from 19% to 11%—Fig 5), projects aiming to organize caselaw and decision drafting saw a significant increase in absolute numbers, going from 7 to 14 in 2023 (Fig 6).

Also, regarding absolute numbers, the two categories with the most significant increase of initiatives over time, increasing 5 times in the period, were service/communication with parties and procedure intelligence. The one that increased the least, 2 times in the period, was the case law organization and decision drafting. According to Resolution CNJ 615/25, this type of initiative can be considered of higher risk, requiring a more conservative approach to its development, which may be one of the reasons for the lower rates of increase compared to other lower-risk categories.

It is important to consider that the consistent use of predictive systems, even when presented as recommendations, may make it progressively harder for judges to justify deviating from them. This is due to technological bias, the inclination to believe that algorithmic outputs are inherently more accurate and impartial than human reasoning. This situation also presents ethical challenges. If judges regularly rely on predictive system recommendations to justify their rulings, it subtly alters accountability and responsibility, shifting it from the judge to the systems and their developers. Moreover, if private entities create predictive systems, the privatization of judicial decision-making, as noted by Surden, becomes a potential problem (SURDEN, 2019).

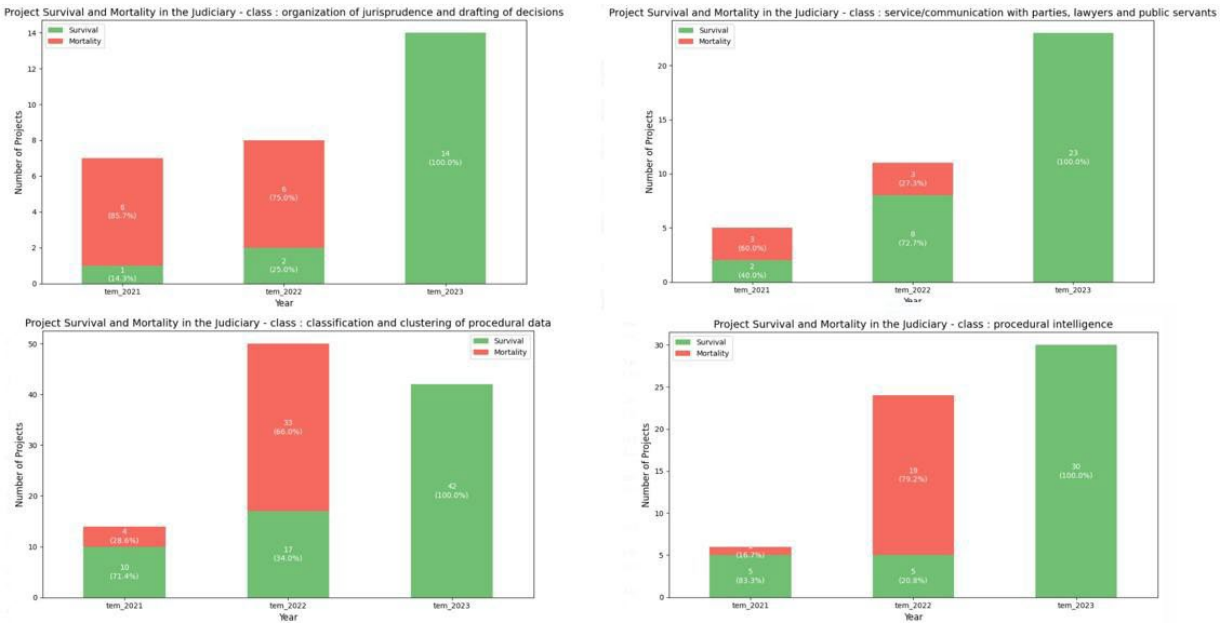


Fig. 6 – AI projects by category and mortality overtime

In 2023, new types of projects that bring an innovative way to manage conflicts have risen. More specifically, five new projects focused on identifying cases with higher chances of being resolved through mediation. Those cases are then directed to mediators for a consensual solution instead of following the regular judicial procedure. Also, there are five projects focused on identifying fraud and/or abuse of litigants who try to take advantage of the system in borderline situations and end up bloating the Judiciary. According to Resolution 615/25, those projects will probably be considered high-risk.

The report "Mapping AI risks within the Brazilian Judiciary" (Relatório de Pesquisa: mapeando riscos da IA no Poder Judiciário brasileiro) (CABALLERO et al., 2024) analyzed the projects active in the 2023 dashboard and suggests that 65% of them will probably be considered of low risk, around 18% will be considered of high risk, and 1% will be considered of excessive risk. Around 16% are inconclusive.

Finally, highlighting the increasing use of GenAI, five projects reported its application in 2023. A recent CNJ survey indicates widespread adoption of GenAI by judges and their assistants, with 50% of respondents having used it and approximately 30% of that group employing it in jurisdictional tasks (Brasil, CNJ, 2024).

Resolution 615 established that when GenAI is used to help draft a judicial act, the judge may mention this in the body of the decision. However, it must be automatically recorded in the court's internal system for tracking data, checking how it is being used, and for possible future review. It will be a huge challenge, though, to track the diffuse use of GenAI when the court's systems do not provide it and if it is being used in a responsible way.

When the National Committee for Judicial Artificial Intelligence starts implementing Resolution 615/25, we will have more clarity and data for further investigation on this issue.

5. Conclusion

The implementation of AI in Brazilian courts is rapidly progressing; however, this quick expansion has also been less organized than expected, potentially hindering the development of a more structured and strategic approach to AI implementation. The high experimentation rate and lack of a coordinated guideline or roadmap for innovation have led to a significant number of short-lived AI projects.

Also, several challenges persist. Despite the CNJ's efforts to promote collaboration through initiatives like the Justice 4.0 Program, the Synapses Platform, and the PDPJ, AI projects' organic and somewhat fragmented development indicates a need for stronger coordination and strategic alignment. The current regulatory framework, established by Resolution n. 615/2025, while providing critical ethical guidelines, brings updates to address emerging technologies, particularly generative AI, and to establish more effective enforcement mechanisms.

Establishing clear and relevant success metrics for AI projects in the Brazilian justice system is a crucial aspect that needs careful consideration. The evolving landscape can be misleading and give a false sense of progress if the

primary metric is only the number of AI-related projects. While the increase in AI projects indicates growing interest and investment, it does not necessarily translate into meaningful impact or improvement in the justice system.

As the Brazilian AI landscape progresses, three key areas require attention: first, establishing more robust cross-court collaboration and resource-sharing mechanisms to reduce redundant efforts and promote more sustainable AI implementations. Second, developing clear success metrics that go beyond project counts to measure the actual impact on judicial efficiency and access to Justice. Third, the implementation of the new regulatory framework must be monitored because it will be challenging to address emerging technologies better while maintaining the balance between innovation and ethical considerations. Ongoing monitoring, evaluation, and adaptation of AI governance frameworks will be essential to ensure that AI serves as a tool for enhancing justice delivery and promoting equitable outcomes for all stakeholders.

The Brazilian Judiciary's experience with AI implementation offers valuable lessons for other judicial systems undertaking similar digital transformations. It demonstrates that successful AI integration requires not only technological capability but also strong governance frameworks, strategic coordination, and a clear focus on sustainable, impactful solutions rather than short-term experimentation.

References

Brasil, CNJ. (2024) *Justiça em números 2024*, www.cnj.jus.br, accessed January 22, 2025, https://www.cnj.jus.br/wp-content/uploads/2024/05/justica-em-numeros-2024.pdf

Brasil, CNJ. (2024) *O uso da Inteligência Artificial Generativa no Poder Judiciário Brasileiro*, www.cnj.jus.br, accessed March 22, 2025, https://bibliotecadigital.cnj.jus.br/jspui/handle/123456789/976

Brasil, CNJ. (2022) *Justice 4.0 Program*, www.cnj.jus.br, accessed January 22, 2025, https://www.cnj.jus.br/wp- content/uploads/2022/05/justice-4-0-program.pdf

Brasil, CNJ. (2019) *Inteligência Artificial no Poder Judiciário brasileiro*, www.cnj.jus.br, accessed January 22, 2025, https://bibliotecadigital.cnj.jus.br/jspui/handle/123456789/98

Caballero, B. I.; Meier, I. F.; Lopes, J. G.; Junquilho, T. A.; Menezes de Azevêdo, U. (2024) Relatório de pesquisa: mapeando riscos da IA no Poder Judiciário brasileiro. Org. JUNQUILHO, T; MENDES, L. Brasília: Laboratório de Governança e Regulação de Inteligência Artificial (LIA) do Instituto Brasileiro de Ensino, Desenvolvimento e Pesquisa (IDP).

Casimiro, J. S. C., & Teixeira, S. T. (2024). Artificial Intelligence Approaches within the Brazilian Judiciary's Contemporary Jurisdictional Model. Beijing Law Review, 15, 730-748, Accessed January 22, 2025: https://doi.org/10.4236/blr.2024.152044

Europe. European Commission for the Efficiency Of Justice – CEPEJ. European ethical Charter on the use of Artificial Intelligence in judicial systems and their environment. Strasbourg: CEPEJ, 3-4 dez. 2018, Accessed January 22, 2025: https://rm.coe.int/ethical-charter-en-for-publication-4-december-2018/16808f699c

Europe. European Commission (2024), The Artificial Intelligence Act - Regulation (EU) 2024/1689, www.aritificalintelligence.eu, accessed January 29, 2025, https://artificialintelligenceact.eu/

RABINOVICH-EINY, Orna e KATSH, Ethan. The new new courts, 67 American University Law Review, 165, October 2017.

RAMOS, L. (coord.). Índice de Confiança na Justiça Brasileira – ICJBrasil. (2021) São Paulo: FGV Direito SP, 2021. Accessed January 23, 2025: https://direitosp.fgv.br/en/publicacoes/icj-brasil.

Suriani, F. (2022) Online courts in Brazil and the impact on the access to Justice. In: NUNES, Dierle; WERNECK, Isadora e LUCON, Paulo Henrique dos Santos (org.), Direito Processual e tecnologia: os impactos da virada tecnológica no âmbito mundial, São Paulo: Editora Juspodivm, pp.107-136.

Surden, H. (2019) The Ethics of Artificial Intelligence in Law: Basic Questions. University of Colorado Law Legal Studies Research Paper, n. 29, 22 ago. Accessed January 29, 2025: https://ssrn.com/abstract=3441303.

Susskind, R. (2019). Online Courts and the Future of Justice, OUP Oxford. Kindle Edition.

Track 3: Data-Driven Services in Government for Evidence-Based Policy and Public Value

Track Description

The Data-Driven Services in Government track aims to investigate how public sectors can complement services and policies through Information and Communication Technologies (ICTs) and various forms of data, such as open data, big data, and linked data. The track aimed to gather papers exploring the interactions of data application, data governance, and/or data policy. More specifically, it aimed to (i) examine the relationship between data and evidence-based policy formulation and execution; (ii) the impact of data on various types of policies at all levels of government, including health policy, social policy, water use policy, energy policy, and more; and (iii) a view on data-driven services for public value creation from various angles: the sectoral view, user view, stakeholder view, and more. Evidence-based Policy means creating, applying, and assessing policies and social programs based on the most reliable and relevant evidence available. It emphasizes making decisions grounded in current social and behavioral science research and promotes proven interventions. Creating value from government data and services is particularly important to many stakeholders, including governments, the private sector, and citizens.

Track Chairs

H.-L. Tseng, National University of Taiwan, Taiwan
M. Ciesielska, Gdańsk University of Technology, Poland

Contents

Digital Public Service Quality (PS-DigQual): Proposal of a Multidimensional Framework 267
J. N. Alves, L. F. Battistella, E. dos R. Lehnhart, K. M. Vieira, and V. C. da S. Zonatto

Factors Affecting the Use of Evidence in Public Sector Programmes in South Africa: A Systematic Review of Outcome 8 programmes 282
L. S. Matlala

Triple Transition Ecosystem As Catalyst of Public Value Generation 297
D. Symeonidis and A. Nikiforova

Improving Public Health Supply Chains: Time Series Techniques for Medication Demand Forecasting 310
I. C. De Meo and J. V. M. Gonçalves

Digital Public Service Quality (PS-DigQual): Proposal of a Multidimensional Framework

Juliano Nunes Alves [a]*, *Luciana Flores Battistella* [b], *Eliete dos Reis Lehnhart* [c], *Kelmara Mendes Vieira* [d], *Vinícius Costa da Silva Zonatto* [e]

[a] Federal University of Santa Maria - UFSM, Brasil, email address: juliano.alves@ufsm.br, ORCID: https://orcid.org/0000-0001-5435-3758
[b] Federal University of Santa Maria - UFSM, Brasil, email address:luttibattistella@gmail.com, ORCID: https://orcid.org/0000-0001-9620-2093
[c] Federal University of Santa Maria - UFSM, Brasil, email address:eliete.lehnhart@ufsm.br, ORCID: https://orcid.org/0000-0001-6676-8547
[d] Federal University of Santa Maria - UFSM, Brasil, email address: kelmara@smail.ufsm.br, ORCID: https://orcid.org/0000-0002-8847-0941
[e] Federal University of Santa Maria - UFSM, Brasil, email address: viniciuszonatto@gmail.com, ORCID: https://orcid.org/0000-0003-0823-6774

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. This study introduces a multidimensional framework designed to assess Digital Public Service Quality (PS-DigQual) within e-government systems. The proposed framework integrates three pivotal dimensions: System Quality (QSt), Operation Quality (QOp), and Information Quality (QInf). QSt ensures a robust technical foundation through infrastructure reliability, navigability, and compliance with accessibility standards. QOp focuses on responsiveness, personalization, and user support to enhance service delivery. QInf emphasizes transparency, accuracy, and the timely availability of information, thereby fostering trust and accountability. Addressing gaps in traditional models such as SERVQUAL and E-S-QUAL, the framework adapts to the unique requirements of public digital services, where transparency, inclusion, and citizen engagement are critical. The research methodology is grounded in a systematic literature review and bibliometric analysis, spanning publications from 1990 to January 2025. This approach ensures a comprehensive theoretical foundation and identifies critical gaps in existing frameworks. The study further applies the PS-DigQual framework in practical scenarios, demonstrating that improvements in one dimension positively impact others, creating a cycle of continuous enhancement. Key contributions include a scalable analytical tool for policymakers and a robust foundation for further academic inquiry. The framework's adaptability allows it to be tailored across different cultural and institutional contexts, with the potential for incorporating emerging technologies such as artificial intelligence and blockchain. By promoting efficiency, transparency, and inclusion, PS-DigQual represents a significant advancement in evaluating and improving digital public services. The study concludes with suggestions for future research, emphasizing the development of measurement scales and strategies to ensure sustainable public value in the digital era.

Keywords. E-Government, Digital Public Services, System Quality, Operation Quality, Information Quality, Public Sector Innovation.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1056

1. Introduction

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital transformation in the public sector, enabled by e-government (e-gov), has reconfigured the paradigms of public administration. By transforming governmental processes, e-government enhances operational efficiency, promotes transparency, and fosters citizen engagement, thereby creating a new interaction model between governments and society (Janssen & van der Voort, 2020; Mergel et al., 2019). The success of these initiatives depends on the adoption of appropriate frameworks to assess and ensure the quality of digital services.

Traditional quality frameworks, such as SERVQUAL and E-S-QUAL, have been widely employed to measure service quality across various private sector contexts. However, studies indicate that these models fail to address critical dimensions required for the evaluation of digital public services, such as transparency, democratic participation, and accountability (Fernandes et al., 2020; Lampeão, 2023). These gaps are concerning, as they undermine the effectiveness of digital service quality measurement in the public sector, hindering the development of public policies aimed at meeting the growing demands for digital inclusion and responsiveness (Santos & Souza, 2021).

Traditional quality frameworks, such as SERVQUAL and E-S-QUAL, have been widely employed to measure service quality across various private sector contexts. However, when applied to the e-government milieu, these models exhibit distinct limitations. Specifically, E-S-QUAL, although adapted for electronic services, prioritizes consumer-centric indicators such as efficiency and reliability, while neglecting essential public sector attributes like transparency, civic engagement, and the ethical use of information (Ahmed et al., 2020; Çelik, 2021). For example, E-S-QUAL does not adequately capture the need for participatory mechanisms or the public value generated by open data initiatives, both of which are central to digital governance. Consequently, the indicators currently utilized in these models may fail to accurately gauge the multidimensional quality expected in public digital services, particularly in contexts where accountability and inclusiveness are paramount.

In the public sector, the complexity and interdependence of technology, processes, and governance render existing approaches insufficient for evaluating quality in e-government. Traditional models overlook key elements of the public sphere, such as the social impact of digital services and their capacity to meaningfully engage citizens. Furthermore, there is a lack of frameworks that integrate technical, social, and informational dimensions to meet the evolving demands of public administrations operating in a digital environment.

This article proposes a multidimensional conceptual framework for evaluating Digital Public Service Quality (PS-DigQual), structured around three interdependent dimensions: System Quality (QSt), Operation Quality (QOp), and Information Quality (QInf). The model addresses theoretical and practical gaps by providing an analytical foundation that combines technical principles with social demands, thereby promoting both efficiency and digital inclusion.

The objective of this study is to develop and validate a multidimensional framework for assessing the quality of digital public services within e-government systems. To guide this endeavor, the following research questions are posed: (1) What are the critical dimensions that define digital public service quality in the context of e-government? (2) How do existing quality models fall short in addressing the unique requirements of public digital services? (3) In what ways can the proposed framework enhance the evaluation and continuous improvement of digital public services, considering diverse sociotechnical and institutional contexts?

The structure of the article is organized into five main sections. Following this introduction, the Theoretical Foundation section presents the theories and existing frameworks that support the proposed model. The Methodology section details the systematic review approach used to develop the framework. The Framework section introduces and discusses the core dimensions and their interrelations. Finally, the article concludes with a section on Contributions and Future Research, highlighting the study's key insights and suggesting avenues for further investigation.

2. Theoretical Framework

This section presents the fundamental concepts related to quality in e-government, as well as the existing challenges and gaps. It discusses the limitations of traditional frameworks for evaluating digital public services and highlights the need for a multidimensional model that integrates technical, social, and informational dimensions, aligning with the specific demands of the public sector.

2.1. Quality in e-Government

E-government requires balancing technical efficiency with transparency, digital inclusion, and social responsiveness, demanding models tailored to the public sector's unique context (Meijer & Bekkers, 2015; Haug,

Dan & Mergel, 2024). While most frameworks stem from Western research, recent studies from Asia, Africa, and Latin America highlight additional challenges, such as digital literacy gaps, infrastructure disparities, and the influence of local governance (Alhassan et al., 2022; Chen et al., 2023; Souza & Silva, 2021). For example, South Korea and Singapore focus on digital identity integration, while Kenya and Brazil address access barriers and community engagement. These diverse perspectives enrich the theoretical basis for digital public service quality and emphasize the need for adaptable frameworks.

The DeLone and McLean Information Success Model (2003) is foundational, proposing System Quality, Information Quality, and Service Quality as key, interacting dimensions for evaluating user satisfaction and organizational outcomes. System Quality ensures robust, secure, and accessible platforms, reducing failures and building trust (Teo et al., 2009). However, usability and navigability are also vital for digital inclusion, especially for users with limited skills or access.

Information Quality, as defined by DeLone and McLean (2003), supports decision-making and interaction by ensuring data is clear, accurate, and timely, which strengthens transparency and accountability—crucial for public trust (Zaidi & Qteishat, 2012). Service Quality relies on robust systems and reliable information, enabling responsive and personalized services, especially important for real-time or high-demand situations (Teo, 2020).

These dimensions are interdependent. Strong technical infrastructure enables rapid, accurate information processing, supporting responsive services and fostering public trust, which drives continuous improvement (Lindgren et al., 2019). Transparency, closely tied to Information and Service Quality, ensures citizens understand data use and have access to reliable information. However, the emphasis on democratic values like transparency and participation varies by context, sometimes conflicting with efficiency or New Public Management principles.

The PS-DigQual framework addresses these nuances, allowing flexible integration of democratic principles according to local priorities and cultures, thus remaining relevant across diverse environments and supporting both efficiency and inclusive governance. Digital inclusion cuts across all dimensions, ensuring accessibility for all citizens and promoting equity and participation (Teo, 2020; Zuiderwijk et al., 2021).

In sum, the interdependence of these dimensions highlights the need for integrative approaches in e-government, as reliable systems and information enhance service quality, engagement, and trust, ultimately generating sustainable public value (DeLone & McLean, 2003; Zaidi & Qteishat, 2012). Quality in e-government must be operationalized in an integrated way to foster efficiency, transparency, and citizen engagement.

2.2. Integration of Dimensions and Operationalization in E-Government

The Digital Public Service Quality (PS-DigQual) Framework adopts a multidimensional approach, addressing gaps in traditional models by incorporating the specific needs of the digital public sector. Transparency and accountability are fundamental for evaluating digital public services, fostering trust and citizen engagement (Miller & Sanders, 2023). Integrating these elements into assessment frameworks strengthens governmental accountability and ensures digital services are more responsive to citizens' needs (Torres, Pina & Acerete, 2024).

Unlike traditional models focused on technical and relational aspects of the private sector, PS-DigQual broadens the perspective by including transparency, digital inclusion, and accountability. These elements reflect core public governance values and highlight the need for greater interaction between technology, information, and citizens. The framework links technical robustness, information reliability, and user experience, showing how these interdependencies generate public value.

The integration of System Quality (QSt), Information Quality (QInf), and Operation Quality (QOp) forms a framework that aligns technical, informational, and relational aspects with demands for transparency, responsiveness, and accountability (Janowski et al., 2018; Lindgren et al., 2019; Miller & Sanders, 2023; Torres et al., 2024). Grounded in Sociotechnical Systems Theory, it emphasizes the interdependence of technology, processes, and users (Trist, 1981). Recent frameworks also stress the need for transparency and accountability to enhance trust and engagement.

QSt is the technical foundation, covering Robust Infrastructure, Navigability, Accessibility, and Security. These ensure stable, inclusive, and secure platforms, supporting high traffic and protecting data (Yang et al., 2019; Zuiderwijk et al., 2021). Metrics like response time and accessibility standards ensure the infrastructure supports services and citizen interaction, underpinning QInf and QOp.

QInf centers on Transparency, Accuracy, and Relevance, ensuring data is clear, reliable, and useful. Transparent information boosts accountability, while accuracy reduces ambiguities. Operationalization includes clarity, real-

time updates, and data in multiple formats (Meijer & Bekkers, 2015; Cucciniello et al., 2019). Digital inclusion, linked to QSt, ensures marginalized groups can access services (Teo, 2020; Zuiderwijk et al., 2021).

QOp focuses on the interaction between systems and citizens, including Support, Efficiency, Responsiveness, and Personalization. Unlike SERVQUAL, the model values the government's ability to meet demands in a personalized, agile way. Responsiveness measures issue resolution speed, while Personalization assesses adaptation to user needs (Panagiotopoulos et al., 2019).

Integrating these dimensions is critical. QSt enables efficient, responsive services; QInf builds trust through accurate information; and their synergy, supported by iterative evaluation, drives continuous improvement in e-government (Lindgren et al., 2019; Cordella & Paletti, 2019).To consolidate the differences between the proposed PS-DigQual framework and existing models, Table 1 presents a comparative analysis, highlighting the gaps in traditional models and demonstrating how the proposed framework comprehensively addresses essential aspects of e-government. This includes the integration of technical, informational, and social dimensions, which are either overlooked or inadequately addressed by previous approaches.

Table 1. Comparative Analysis: Proposed Framework vs. Traditional Models

Dimension	**COBRA**	**SERVQUAL**	**E-S-QUAL**	**Miller & Sanders (2023)**	**Torres et al. (2024)**	**Other Frameworks**	**Proposed Framework**
System Quality	Does not directly address technical infrastructure but includes cost-benefit analysis.	Partially addresses technical reliability without focusing on infrastructure.	Emphasizes usability and security, but limited to the e-commerce context.	Emphasizes robust and secure infrastructure to support essential public services and minimize technical risks.	Focuses on scalability and technical resilience to promote inclusion and trust, aligned with digital accountability.	Examples: GovQual, TAM – Focus on flexibility and technical efficiency in systems.	Integrates robust infrastructure, universal accessibility, and technical security with digital inclusion.
Operation Quality	Focus on cost-benefit, risk, and opportunity for user satisfaction.	Based on responsiveness, empathy, and reliability in the private sector.	Evaluation based on efficiency and reliability without considering citizen responsiveness.	Emphasizes responsiveness and personalization as means to maximize the impact of digital public services.	Adopts metrics to measure responsiveness and support as a foundation for accountability and citizen engagement.	GovQual and other models include reliability and technical user support.	Focuses on citizen support, operational efficiency, and responsiveness in the public context.
Information Quality	Explores accuracy and relevance without explicit focus on transparency.	Addresses information quality in a limited manner, focusing on user perception.	Focuses on information quality as support for e-commerce.	Transparency as a central pillar, linked to data clarity and ethical information usage.	Prioritizes transparency and information accessibility as tools for citizen engagement and trust.	Models like TAM emphasize accuracy, relevance, and information usability.	Centers transparency and accountability as essential for public trust and citizen engagement.
Refer	Osman	Parasurama	Parasuraman	Miller, J., &	Torres, L.,	Batini et al.,	Mergel et al.,

ences	et al., (2014); Weera kkody et al., (2013)	n et al., (1988); Papadomich elaki & Mentzas, (2009)	et al., (2005); Zeithaml et al., (2002)	Sanders, R. (2023)	Pina, V., & Acerete, B. (2024)	(2009); Papadomich elaki & Mentzas, (2012); Venkatesh et al., (2003)	(2019); Lindgren et al., (2019); Panagiotopo ulos et al., (2019)

Source: Research Data

Table demonstrates that System Quality (QSt) is insufficiently addressed by traditional models. COBRA and SERVQUAL do not directly explore technical infrastructure, while E-S-QUAL focuses on usability and security but is limited to the context of e-commerce. In contrast, the frameworks proposed by Miller and Sanders (2023) and Torres et al. (2024) take a step forward by emphasizing the need for technical resilience, scalability, and support for digital inclusion in public services. The proposed framework builds on these recent approaches, further broadening the scope by integrating robust infrastructure, universal accessibility, and technical security while considering digital inclusion as a cross-cutting aspect. This approach addresses the specific demands of the digital public sector by ensuring resilient, accessible systems that align with the transparency and accountability required in contemporary e-government.

In the dimension of Operation Quality (QOp), traditional models focus on factors such as cost-benefit, responsiveness, and empathy—typical characteristics of the private sector. E-S-QUAL, for example, evaluates efficiency but overlooks the citizen responsiveness required in e-government. Conversely, the frameworks by Miller and Sanders (2023) and Torres et al. (2024) make significant contributions by emphasizing personalization and responsiveness as mechanisms to strengthen trust and accountability in public services. The proposed framework complements these approaches by prioritizing citizen support, operational efficiency, and responsiveness, aligning with the requirements of the public sector, where trust and engagement are essential. This evolution is noteworthy as it treats the user not merely as a customer but as an active participant in the delivery of digital services.

The analysis of Information Quality (QInf) reveals that models such as COBRA and SERVQUAL address accuracy and relevance but overlook transparency and accountability—critical elements for e-government. The frameworks by Miller and Sanders (2023) and Torres et al. (2024) place transparency at the center, linking it to data clarity and ethical information usage. The proposed framework goes further by centralizing transparency and accountability as essential components for fostering public trust and citizen engagement. This reinforces the role of clear, reliable, and verifiable information in digital governance, highlighting its interdependence with other dimensions.

In conclusion, the proposed framework addresses the gaps in traditional models by offering a holistic view of quality in digital public services. Its practical application extends beyond academic analysis, providing public managers with a structured tool to diagnose strengths and weaknesses in digital service delivery. For instance, by systematically evaluating system robustness, information transparency, and operational responsiveness, policymakers can identify targeted interventions to enhance user experience and foster greater citizen trust.

Additionally, the framework supports benchmarking across different governmental units and facilitates the monitoring of progress over time, thereby informing strategic decisions and resource allocation in digital transformation initiatives.

3. Method

To support the proposal of a multidimensional conceptual framework for evaluating the quality of digital services in e-government, a systematic literature review with a bibliometric approach was conducted. The selection protocol, while rigorous, adopted strict inclusion and exclusion criteria to ensure the relevance and quality of the analyzed studies.

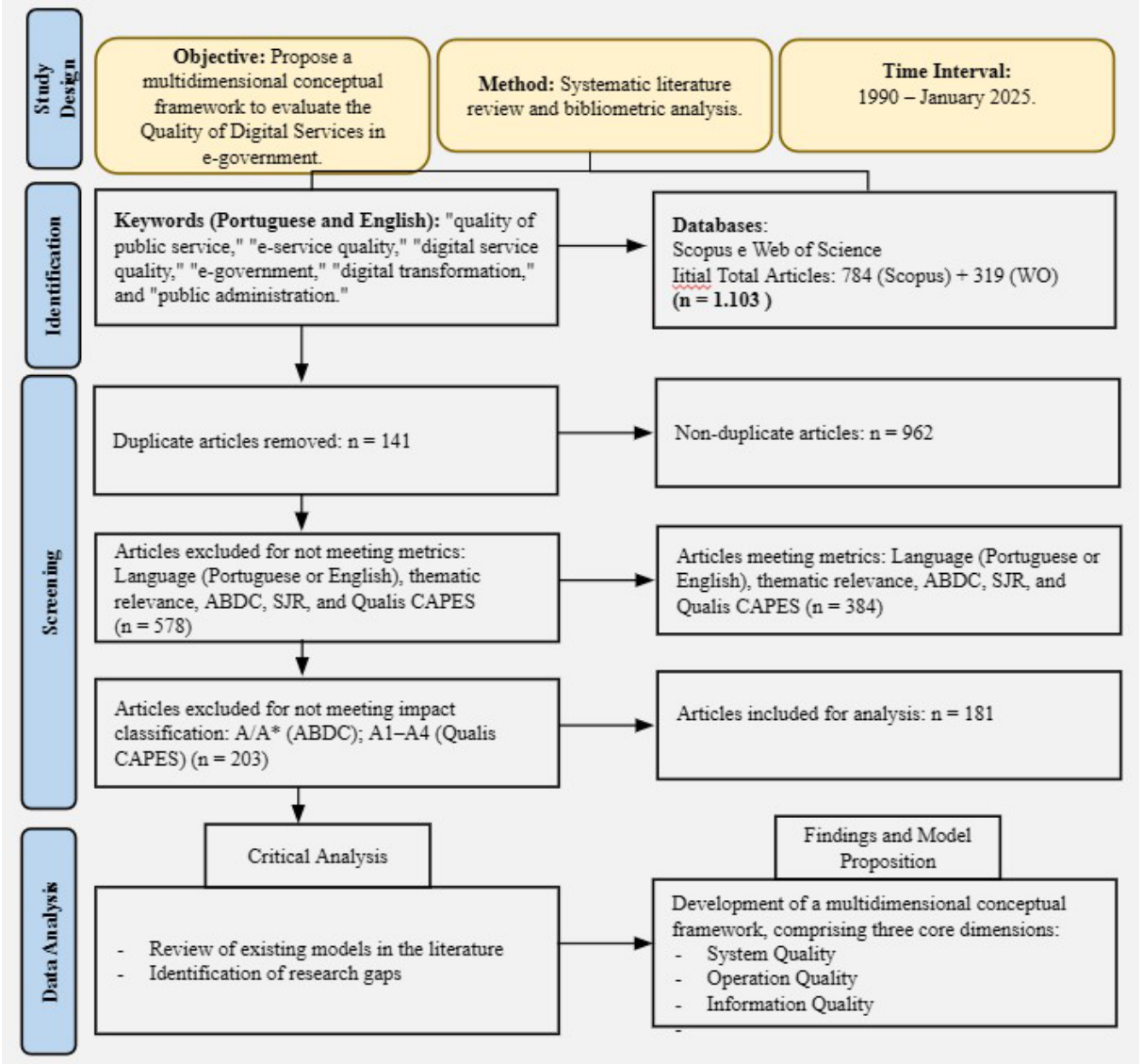
However, this narrow focus may have inadvertently excluded pertinent research, particularly studies published in non-English languages or in regional journals not indexed in major databases. This limitation suggests that some relevant perspectives, especially from emerging economies or underrepresented regions, may not have been fully captured. Future research should consider expanding the scope of the review to include a broader array of sources, thereby enriching the analysis and enhancing the global applicability of the proposed framework.

By integrating both quantitative and qualitative analyses, as well as tools such as the Bibliometrix package in RStudio and manual validations, the SLR-4 model identifies trends, gaps, and provides a robust foundation for discussions and future recommendations, directly contributing to the study's objectives. This approach is particularly suitable for fields such as e-government, which require integrative analyses to capture theoretical

advancements, identify emerging trends, and explore gaps in the literature.

The chosen methodology ensures methodological rigor, a comprehensive and detailed overview of the state of the art in the field, and reliable outcomes for guiding future research (Tranfield, Denyer & Smart, 2003; Kitchenham, 2004; Donthu et al., 2021). Figure 1 illustrates the research design followed in this study.

Figure 1: Research Design



Source: Prepared by the authors (2025)

Once the research objective and method were defined—outlined in the first stage presented in Figure 1 (Study Design)— 1990 to January 2025 was established. The next phase, referred to as Identification, involved the following steps:

Definition of keywords: Terms in both English and Portuguese were selected to cover three main areas: digital public service quality, e-government, and emerging technologies.

Database search: The search was conducted in the Scopus and Web of Science databases, resulting in the initial identification of 1,103 articles. This process was carried out at the end of the second semester of 2024.

Additionally, the search strings were constructed using Boolean operators to combine the keywords and ensure precision in article retrieval. The search in the Scopus database was conducted as follows: (TITLE-ABS-KEY("qualidade do serviço público" OR "quality of public service" OR "service quality" OR "public service efficiency" OR "public service delivery" OR "e-service quality" OR "digital service quality") AND (TITLE-ABS-KEY("e-government" OR "e-gov" OR "digital government" OR "e-government services" OR "digital transformation"

OR "inovação tecnológica" OR "technological innovation" OR "tecnologias da informação" OR "information technology" OR "ICT" OR "TIC" OR "digital governance" OR "information systems" OR "interoperability")) AND (TITLE-ABS-KEY("setor público" OR "public sector" OR "administração pública" OR "public administration" OR "serviço público" OR "public service" OR "gestão pública" OR "public management")) AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "re")). Na Web of Science, a estratégia de busca foi: TS=("quality of public service" OR "service quality" OR "public service efficiency" OR "public service delivery" OR "e-service quality" OR "digital service quality") AND TS=("e-government" OR "digital government" OR "e-government services" OR "digital transformation" OR "technological innovation" OR "information technology" OR "ICT" OR "digital governance" OR "information systems" OR "interoperability") AND TS=("public sector" OR "public administration" OR "public service" OR "public management") AND (LIMIT-TO(DOCTYPE, "article") OR LIMIT-TO(DOCTYPE, "review")).

The screening phase involved the removal of duplicates, language criteria, thematic relevance, academic quality metrics, and impact classification. A total of 141 duplicate articles were removed, and the remaining documents were initially screened based on language (English and Portuguese), thematic relevance, and recognized academic metrics such as the Australian Business Deans Council (ABDC), SCImago Journal Rank (SJR), and Qualis CAPES. As a result, 578 articles were excluded, leaving 384 studies for further analysis.

The selection of ABDC, SJR, and Qualis CAPES as metrics serves as a benchmark for classifying journals according to their academic quality: ABDC is one of the main indicators in the field of management (ABDC, 2022), SJR measures the visibility and impact of scientific journals by considering both the number of citations and the quality of the citing articles, making it a reliable indicator of international research impact (SJR, 2023) and Qualis CAPES is a Brazilian system for evaluating academic production, used to assess the quality of journals across various fields of knowledge. The choice of these metrics was essential to ensure that the study relied on high-quality literature. By combining these metrics, the study encompasses both international academic quality and relevant regional indicators.

Further in the screening process, 203 articles not classified by impact (A/A* in ABDC and A1–A4 in Qualis CAPES) were excluded, resulting in 181 articles. The impact classification reflects the decision to prioritize articles published in high-impact and highly relevant journals, which are more likely to contain robust theoretical and methodological approaches and significant contributions to advancing knowledge in the studied field.

The data analysis phase involved a critical review of the 181 selected articles, which, through a meticulous reading process, enabled the identification and study of existing models on service quality and digital service quality in the literature, as well as the identification of research gaps in this field. This process provided the foundation for recognizing three key dimensions: System Quality, Operation Quality, and Information Quality. These dimensions were critical in the development of the multidimensional conceptual framework, the central objective of this study.

Since the main focus of this research is the proposition of the conceptual model, which was made possible by preliminary analyses, including bibliometric analysis, detailed results of these analyses are not presented. Instead, the description and discussion of the proposed multidimensional conceptual framework are prioritized. However, it is worth noting that preliminary analyses using the Bibliometrix package in R Studio generated keyword co-occurrence maps, collaboration networks, and temporal evolution charts, which provided valuable insights for developing the framework.

These preliminary analyses played a crucial role by offering a comprehensive view of trends and gaps in the literature, guiding the construction of the proposed model. Additionally, they helped to theoretically support the key dimensions that comprise the framework, ensuring its relevance and alignment with the current needs of the field of study.

4. Proposed Framework for Digital Public Service Quality (PS-DigQual)

The PS-DigQual Framework is an integrated structure developed to assess and enhance the quality of digital public services in the context of e-government.

4.1. General Structure of the Framework

Grounded in the core dimensions of System Quality (QSt), Operation Quality (QOp), and Information Quality (QInf), the framework combines technical, relational, and informational aspects to address the complexities of the digital public sector. This multidimensional approach ensures transparency, inclusion, and efficiency in an increasingly challenging digital governance environment (Mergel et al., 2019; Lindgren et al., 2019).

Figure 2 integrates the three dimensions, illustrating how each contributes to the overall quality of e-government services:

QSt (System Quality) provides the necessary technical infrastructure.

QOp (Operation Quality) focuses on responsiveness and personalized citizen service.

QInf (Information Quality) ensures the transparency and clarity of the information provided.

The interaction between these dimensions fosters public trust, citizen engagement, and sustainable public value.

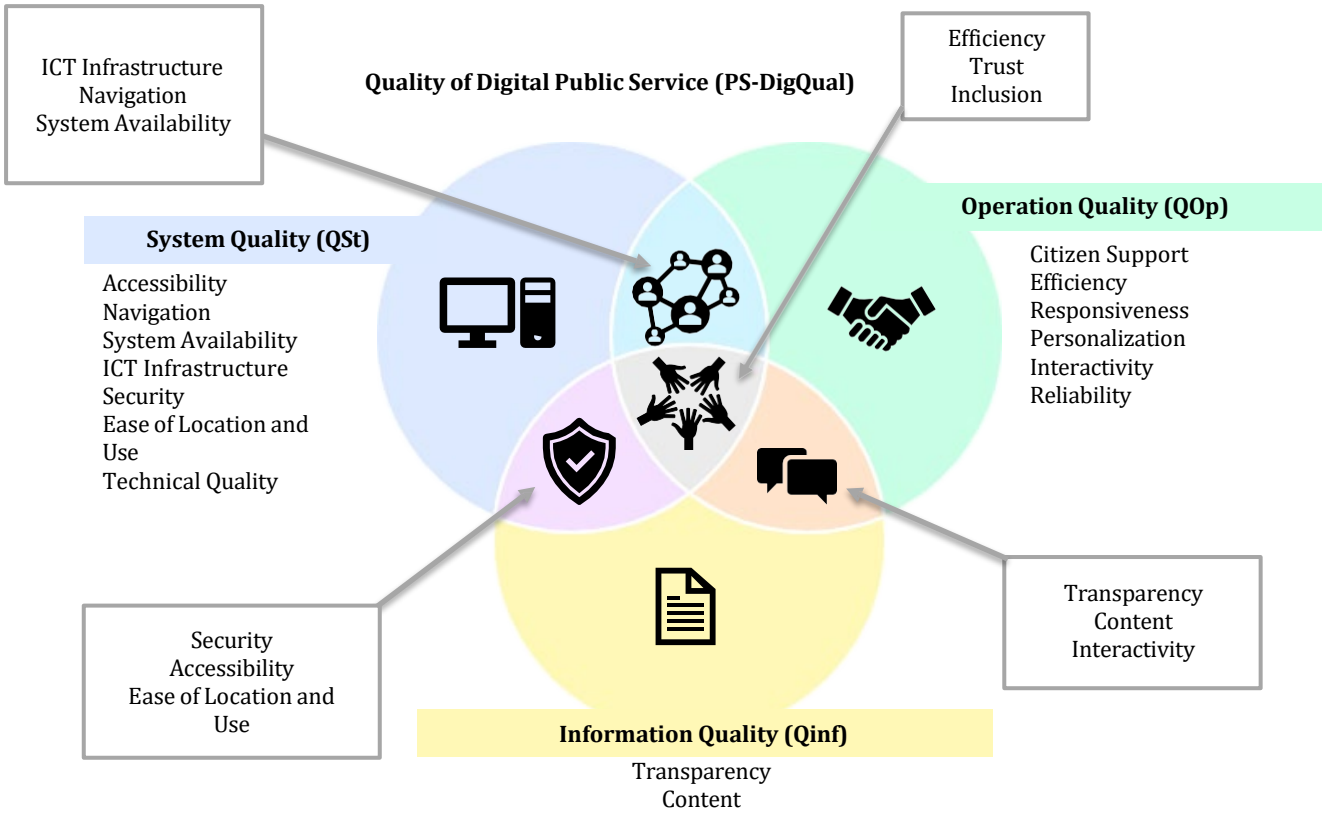


Figure 2. Quality of Digital Public Service Framework
Source: Research Data

The intersections between the dimensions reflect relationships and synergies that underpin the framework's effectiveness. The technical robustness of QSt ensures stability and security, supporting the transparency and informational accessibility of QInf. Simultaneously, this reliable information strengthens citizen trust and makes personalized support, part of QOp, more efficient (Panagiotopoulos et al., 2019; Cucciniello et al., 2019; Miller & Sanders, 2023; Torres et al., 2024). Additionally, frameworks proposed by Lindgren et al. (2019) and Mergel et al. (2019) emphasize the importance of integrating technical, relational, and informational dimensions to promote greater digital inclusion and accountability in public digital services.

The ultimate goal of the framework is achieved at the intersection of the dimensions, represented by Efficiency, Trust, and Inclusion. This centrality reflects the ambition to foster a robust and responsive e-government, where reliable systems, clear information, and interactive services work together to maximize public impact. This approach integrates the principles of Sociotechnical Systems Theory, which highlights the importance of dynamic interactions between technology, citizens, and public institutions (Trist, 1981; Janowski et al., 2018).

Moreover, the framework addresses gaps identified in traditional models, such as SERVQUAL and E-S-QUAL, by adapting to the specificities of the digital public sector. Although widely used, these models fail to capture critical elements such as transparency, digital inclusion, and governmental accountability. The multidimensional integration proposed in the framework addresses these limitations, offering a robust foundation for the continuous

evaluation and improvement of public digital services (Twizeyimana & Andersson, 2019).

The overall structure of the framework also responds to the growing need for more inclusive and efficient digital governance. Platforms such as GOV.UK and Gov.br can directly benefit from this approach by using the metrics associated with each dimension to continuously monitor and adjust their services. This adaptability makes the framework a valuable tool for public managers seeking to align digital transformation with the demands and expectations of contemporary society (Cordella & Paletti, 2019).

In summary, the PS-DigQual Framework represents a significant contribution to both the practice and theory of e-government. Its ability to integrate technical, informational, and service dimensions into a cohesive model provides not only a basis for quality evaluation but also a strategic guide for innovation and continuous improvement in the digital public sector. This framework establishes a more comprehensive analytical paradigm for public governance, aligning with the demands for efficiency, trust, and inclusion (Lindgren et al., 2019; Yang et al., 2019).

4.2. Detailed Description of Core Dimensions

The following section discusses the core dimensions of the PS-DigQual Framework and the specific components that support e-government quality. Each dimension—QSt, QInf, and QOp—is analyzed in terms of its relevance and impact on the delivery of digital services. This approach fosters a comprehensive evaluation based on quality metrics.

4.2.1. System Quality

System Quality (QSt) is the technical pillar of the framework, providing the necessary foundation for the efficient and secure operation of public digital services. Components such as robust infrastructure, intuitive navigability, accessibility, and technical security ensure that systems can support high user volumes, promoting a reliable and inclusive experience (Zuiderwijk et al., 2021; Panagiotopoulos et al., 2019; Medaglia et al., 2024).

Robust Infrastructure is essential to meet large-scale demands, particularly for digital services accessed by millions of citizens simultaneously. Studies by Klievink et al. (2017), Janowski et al. (2018), and Bassey (2022) emphasize that resilient and scalable systems not only handle high traffic volumes but also ensure the integrity and continuity of operations, even in critical scenarios. This robustness is crucial for enabling integration with other framework dimensions.

Intuitive Navigability and Accessibility play key roles in promoting digital inclusion. Platforms adhering to accessibility standards, such as WCAG, ensure that individuals with varying abilities or technological limitations can effectively interact with public services. This approach broadens access and enhances the user experience, especially for vulnerable groups, aligning with the recommendations of Lindgren et al. (2019), Medaglia, Rukanova & Zhang (2024), and Cordella & Paletti (2019).

Technical Security is indispensable for safeguarding sensitive data and enhancing public trust by ensuring information integrity in digital environments. Secure systems prevent data breaches and cyberattacks, which can undermine platform credibility. Security is a critical element for ensuring the sustainability and continued adoption of e-government services, particularly in high-risk and complex contexts (Yang et al., 2019; Wirtz et al., 2022; Bassey, 2022).

4.2.2. Information Quality

Information Quality (QInf) is a central element of the framework, aimed at promoting governmental transparency and strengthening citizen engagement. Clear, accurate, and accessible information ensures that citizens understand government actions, fostering accountability and public trust. The reliability of information is critical to sustaining the legitimacy of public institutions and promoting responsive and transparent governance (Meijer & Bekkers, 2015; Cucciniello et al., 2019; Medaglia, 2024).

In the context of e-government, QInf goes beyond merely providing data; it encompasses characteristics such as relevance, clarity, and real-time updates. These attributes ensure that users have access to reliable and useful data, enabling meaningful interactions with public digital services. Meijer and Bekkers (2015) and Janowski et al. (2018) emphasize the connection between informational reliability and active citizen participation, promoting engagement in decision-making processes.

Transparency is an indispensable component for accountability and legitimacy in e-government. It guarantees that

decisions, processes, and data are accessible and understandable, promoting inclusive and trustworthy governance (Batini et al., 2009; Twizeyimana & Andersson, 2019; Medaglia, 2024). Clarity, accuracy, and relevance are equally essential for building public trust: clarity facilitates understanding, accuracy eliminates ambiguities, and relevance ensures that the data meets citizens' needs (Panagiotopoulos et al., 2019; Lindgren et al., 2019; Medaglia, 2024).

These components create a positive cycle, where reliable information fosters greater citizen engagement and governmental legitimacy. This holistic approach reinforces the interdependence between informational transparency and the operational effectiveness of public services. In this way, e-government becomes a more inclusive and accessible environment, aligned with contemporary demands for accountability and digital inclusion (Osman et al., 2014; Lindgren et al., 2019; Cucciniello et al., 2019; Teo, 2020).

To assess QInf, key metrics such as textual clarity, real-time updates, and accessibility in multiple formats are fundamental. Textual clarity facilitates user understanding of data, while frequent updates strengthen the perception of governmental responsiveness (Cucciniello et al., 2019; Meijer & Bekkers, 2015). In turn, accessibility in diverse formats meets the needs of different citizen profiles, promoting digital inclusion and democratic participation (Lindgren et al., 2019; Janowski et al., 2018).

Supported by transparency and robust metrics, QInf is crucial for establishing a reliable and efficient e-government. It ensures that citizens have access to dependable information and strengthens their ability to actively participate in decision-making processes, thereby promoting accountability and continuous engagement (Panagiotopoulos et al., 2019; Twizeyimana & Andersson, 2019; Medaglia et al., 2024).

4.2.3. Operation Quality

Operation Quality (QOp) is a crucial dimension of the framework, directly addressing citizens' needs through responsive and effective digital services. Its implementation ensures interactive and personalized support, fostering continuous engagement and strengthening public trust (Panagiotopoulos et al., 2019; Meijer & Bekkers, 2015). Studies indicate that a well-structured QOp significantly enhances user satisfaction and reinforces the legitimacy of public institutions (Cucciniello et al., 2019; Lindgren et al., 2019). This dimension emphasizes the ability of digital services to adapt to specific citizen demands by offering quick and efficient solutions. Key components such as Citizen Support, Personalization, and Operational Efficiency are fundamental pillars for aligning services with user expectations (Yang et al., 2019; Cordella & Paletti, 2019). Platforms integrating technical and informational support help eliminate access barriers and promote a meaningful and inclusive citizen experience (Meijer & Bekkers, 2015; Panagiotopoulos et al., 2019).

Citizen Support plays a central role by providing immediate and effective assistance, meeting user needs promptly. This approach strengthens trust in e-government, creating a positive perception of public management (Lindgren et al., 2019; Cucciniello et al., 2019). Additionally, Personalization allows services to be tailored to users' specific needs, improving citizen engagement and fostering a sense of digital inclusion (Cordella & Paletti, 2019; Yang et al., 2019). Operational Efficiency complements these efforts by minimizing delays and ensuring reliable service delivery. Robust infrastructures and automated processes optimize response time, reducing costs and operational errors (Zuiderwijk et al., 2021; Klievink et al., 2017).

The integration of personalization and efficiency results in more accessible digital services, enhancing the perception of reliability. Metrics are essential for measuring the effectiveness of QOp. Resolution Time indicates how quickly requests are addressed, while Satisfaction Levels reflect users' perceptions regarding the clarity, personalization, and responsiveness of the service—critical factors for public trust (Panagiotopoulos et al., 2019; Cucciniello et al., 2019).

Tools such as Net Promoter Score (NPS) and Repeat Usage Rate provide insights into user retention and service impact. Combined metrics help managers continuously adjust digital services, promoting continuous improvement cycles and ensuring that citizen demands are met efficiently and inclusively (Lindgren et al., 2019; Yang et al., 2019).

4.3. Framework Contributions

The operationalization of the proposed framework enables its practical and strategic application in contemporary digital government platforms, such as GOV.UK and Gov.br. This model systematizes the evaluation of the dimensions QSt, QOp, and QInf, fostering alignment between administrative efficiency, digital inclusion, and governmental transparency. This multidimensional approach contributes to more responsive and participatory

governance (Medaglia et al., 2024; Schmitz, 2023).

The implementation of the framework involves the application of both qualitative and quantitative metrics. On Gov.br, metrics such as latency and technical stability evaluate system robustness, while on GOV.UK, indicators such as textual clarity and informational updates promote citizen engagement. Technological advances enable the integration of real-time monitoring systems that measure user satisfaction, resolution times, and compliance with accessibility standards. These iterative development practices allow for dynamic data-driven adjustments, resulting in greater responsiveness and operational efficiency. Longitudinal studies corroborate the effectiveness of these practices in strengthening citizen trust and improving public digital services (Yang et al., 2019; Zuiderwijk et al., 2021; Medaglia et al., 2024).

The adaptability of the framework stands out in different e-government contexts. Strategies focused on personalization and reliability improve the user experience on GOV.UK, while Gov.br leverages the dimensional intersections to foster digital inclusion and governmental transparency. These synergies, supported by recent studies, emphasize the importance of integrating technology, processes, and governance to maximize public value (Lindgren et al., 2019; Panagiotopoulos et al., 2019; Twizeyimana & Andersson, 2019).

The framework's operationalization addresses gaps in traditional models and contributes to the creation of more responsive and inclusive public digital services. Its multidimensional approach reinforces the interdependence between quality pillars, demonstrating how robust infrastructure supports personalized services, while enhanced transparency promotes accountability and public trust—an essential integration given the demands of the digital public sector.

The proposed framework addresses significant gaps in traditional models such as SERVQUAL and E-S-QUAL by integrating critical dimensions of transparency, digital inclusion, and citizen support. Conventional models often overlook these characteristics, which are fundamental in the e-government context, where accountability and responsiveness are indispensable for fostering public trust and institutional legitimacy (Mergel et al., 2019; Medaglia et al., 2024). The integration of these dimensions also responds to the growing demand for inclusive and accessible digital services.

By articulating QSt, QOp, and QInf, the framework provides a holistic approach to the evaluation and improvement of digital services. Multidimensional frameworks enhance the capacity to align technical capabilities with citizen needs, promoting more effective, responsive, and accessible services (Lindgren et al., 2019; Schmitz & Wimmer, 2023).

For public managers, the framework serves as a strategic tool, reinforcing citizen trust through transparent governmental processes. Clear and accessible information, supported by robust systems, is crucial for consolidating trust in public institutions. According to Cucciniello et al. (2019) and Medaglia et al. (2024), digital platforms that prioritize clarity and informational reliability promote both engagement and accountability.

Promoting digital inclusion is another direct benefit of the framework. By adhering to accessibility standards and ensuring intuitive navigability, the model ensures that all citizens, regardless of their limitations, can access and utilize digital services. This inclusive focus addresses the growing need for equitable and socially responsive governance, as emphasized by Panagiotopoulos et al. (2019) and Schmitz & Wimmer (2023).

Operational efficiency is improved through the integration of the framework's technical and social dimensions. Robust infrastructures minimize failures and reduce response times, while personalized services significantly enhance the user experience. Studies by Yang et al. (2019) and Lindgren et al. (2022) show that interdependent systems, such as those proposed, enhance operational agility and reduce costs, benefiting both citizens and institutions.

Finally, the framework contributes to responsiveness by offering tools for monitoring and continuous service adjustments. Aligned with the principles of adaptive governance, this iterative approach allows public managers to respond to citizen demands with agility and precision. Meijer and Bekkers (2015) and Medaglia et al. (2024) highlight that monitoring practices and metrics-based adjustments increase the perception of institutional efficiency and legitimacy.

The implementation of the framework addresses structural and functional gaps, promoting inclusive, efficient, and responsive governance. By consolidating citizen trust and optimizing digital services, the model aligns with contemporary demands for public value and digital transformation in the public sector.

Despite the contributions of this study, several limitations must be acknowledged. The reliance on a systematic literature review with a narrowly defined protocol may have restricted the diversity of perspectives included in

the analysis. Additionally, the framework has not yet been empirically tested in a wide range of governmental contexts, which may limit its generalizability. Future research should seek to validate the framework through case studies and comparative analyses, as well as to incorporate feedback from practitioners and citizens to further refine its dimensions and indicators.

5. Conclusion

This study proposes a multidimensional conceptual framework for evaluating the quality of digital services in the e-government context, integrating technical, informational, and service dimensions. The research highlights the importance of models that consider technical robustness while addressing transparency and citizen participation as central components for the success of inclusive and effective public digital services.

The application of the framework demonstrates how improvements in one dimension can positively influence other areas, fostering a virtuous cycle of enhancement. This model addresses gaps identified in previous frameworks by offering an integrative and scalable approach to digital service evaluation, aligning with contemporary demands for responsiveness and accountability in the public sector.

The contributions of this work span both theory and practice, providing a foundation for future research and for public managers seeking to optimize the delivery of digital services. Additionally, the practical implications of the framework include its ability to guide strategic decision-making in e-government, promoting efficiency, inclusion, and sustainable public value.

The existence of a valid and consistent model for evaluating digital services offered by public entities is essential, serving as a means for citizens to directly assess the quality of the services provided. Various digital government regulations in different countries advocate for the evaluation and monitoring of services as a means of ensuring transparency and social participation. However, the lack of a specific framework for evaluating public digital service quality, as initially proposed in this study, has led to the use of tools that are poorly adapted to the unique characteristics of such services.

The proposed approach in PS-DigQual links key elements related to system, operation, and information, which are essential for evaluating public digital service quality. This approach enhances the development of metrics and scales for assessing e-government outcomes, contributing to the continuous improvement of services provided to citizens.

Future research could explore the integration of emerging technologies, such as artificial intelligence and blockchain, into the PS-DigQual framework to automate and enhance the evaluation of digital public service quality. Additionally, comparative studies across different countries and administrative cultures would provide valuable insights into the adaptability and impact of the framework. Researchers are also encouraged to develop and validate measurement scales for each dimension, as well as to investigate the relationship between digital service quality and broader outcomes such as public trust, social inclusion, and sustainable public value.

References

Ahmed, R. R., Vveinhardt, J., Streimikiene, D., & Ashraf, M. (2020). ES-QUAL model and customer satisfaction in online banking: Evidence from multivariate analysis techniques. *Oeconomia Copernicana, 11*(1), 111–133. https://doi.org/10.24136/oc.2020.003

Batini, C., Viscusi, G., & Cherubini, D. (2009). GovQual: A quality driven methodology for E-Government project planning. *Government information quarterly*, *26*(1), 106-117. https://doi.org/10.1016/j.giq.2008.03.002

Bassey, E. (2022). A conceptual framework for digital tax administration: A systematic review. *Government Information Quarterly, 39*(4), 101754. https://doi.org/10.1016/j.giq.2022.101754

Cabral, C. I. R., & Mortari, E. C. M. (2023). Metodologias de avaliação de serviços no ensino superior: Experiências a partir da ferramenta SERVQUAL. *Revista de Ciências da Administração*, *25*(65), 1-16. https://doi.org/10.5007/2175-8077.2023.e77015

Çelik, H. (2021). The effect of e-service quality and after-sales e-service quality on e-satisfaction.

Business and Management Studies: An International Journal, 9(3), 920–939. https://doi.org/10.15295/bmij.v9i3.1898

Cordella, A., & Paletti, A. (2019). Government as a platform, orchestration, and public value creation: The Italian case. *Government Information Quarterly, 36*(4), 101409. https://doi.org/10.1016/j.giq.2019.101409

Cucciniello, M., Porumbescu, G. A., & Grimmelikhuijsen, S. (2019). 25 years of transparency research: Evidence and future directions. *Public Administration Review, 77*(1), 32–44. https://doi.org/10.1111/puar.12930

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19*(4), 9–30. https://doi.org/10.1080/07421222.2003.11045748

Fernandes, A., Silva, S., & Gomes, P. (2020). A lógica fantasmática do e-government e o discurso da inovação em Cabo Verde. Revista de Administração Pública, 54(4), 801–824. https://doi.org/10.1590/0034-761220190156

Haug, N., Dan, S., & Mergel, I. (2024). Digitally-induced change in the public sector: a systematic review and research agenda. *Public Management Review*, *26*(7), 1963-1987. https://doi.org/10.1080/14719037.2023.2234917

Janowski, T., Estevez, E., & Baguma, R. (2018). Platform governance for sustainable development: Reshaping citizen-administration relationships in the digital age. *Government Information Quarterly, 35*(4), S1–S16. https://doi.org/10.1016/j.giq.2018.09.002

Janssen, M., & van der Voort, H. (2020). Agile and adaptive governance in crisis response: Lessons from the COVID-19 pandemic. *International Journal of Information Management, 55*, 102180. https://doi.org/10.1016/j.ijinfomgt.2020.102180

Klievink, B., Bharosa, N., & Tan, Y.-H. (2017). Coordination of big data for public service delivery: The roles of governance, architecture, and data literacy. *Government Information Quarterly, 34*(1), 15–
27. https://doi.org/10.1016/j.giq.2016.12.002

Lampeão, M. (2023). E-gov e mudanças, um olhar à luz das abordagens institucional, de poder e da estruturação. *Observatorio de la Economía Latinoamericana, 21*(8). https://doi.org/10.55905/oelv21n8- 090

Lindgren, I., Madsen, C. Ø., Hofmann, S., & Melin, U. (2019). Close encounters of the digital kind: A research agenda for the digitalization of public services. *Government Information Quarterly, 36*(3), 100837. https://doi.org/10.1016/j.giq.2019.06.002

Medaglia, R., Rukanova, B., & Zhang, Z. (2024). Digital government and the circular economy transition: An analytical framework and a research agenda. *Government Information Quarterly*, *41*(1), 101904. https://doi.org/10.1016/j.giq.2023.101904

Medeiros, M. N., Gonçalves, A. T. P., da Silva, L. J. D., Mota, W. M., & de Moura, H. G. (2020). Aplicação do modelo SERVQUAL na avaliação da qualidade do serviço prestado por uma empresa de segurança em uma Instituição de Ensino Superior. *Gepros: Gestão da Produção, Operações e Sistemas*, *15*(2), 1. https://doi.org/10.15675/gepros.v15i2.2267

Meijer, A., & Bekkers, V. (2015). A metatheory of e-government: Creating some order in a fragmented research field. *Government Information Quarterly, 32*(3), 237–245. https://doi.org/10.1016/j.giq.2015.01.005

Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert

interviews. *Government Information Quarterly, 36*(4), 101385. https://doi.org/10.1016/j.giq.2019.06.002

Miller, J., & Sanders, R. (2023). Evaluating Digital Service Quality in E-Government: A Framework for Transparency and Accountability. *Journal of Public Administration Research and Theory, 33*(2), 345–367. https://doi.org/10.1093/jpart/mud123

Osman, I. H., Anouze, A. L., Irani, Z., Lee, H., Balcı, A., & Medeni, T. D. (2014). COBRA framework to evaluate e-government services: A citizen-centric perspective. *Government Information Quarterly, 31*(2), 243–256. https://doi.org/10.1016/j.giq.2013.10.009

Panagiotopoulos, P., Bigdeli, A. Z., & Glueck, M. (2019). Public value creation in digital government: A systematic review. *Government Information Quarterly, 36*(2), 167–178. https://doi.org/10.1016/j.giq.2018.12.004

Papadomichelaki, X., & Mentzas, G. (2009). e-GovQual: A multiple-item scale for assessing e-government service quality. *Government Information Quarterly, 26*(2), 118–127. https://doi.org/10.1016/j.giq.2008.10.005

Papadomichelaki, X., & Mentzas, G. (2012). Evaluating e-government services: A citizen-centric framework. *Government Information Quarterly, 29*(2), 119–128. https://doi.org/10.1016/j.giq.2011.08.002

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing, 64*(1), 12–40.

Parasuraman, A., Zeithaml, V. A., & Malhotra, A. (2005). E-S-QUAL: A multiple-item scale for assessing electronic service quality. *Journal of Service Research, 7*(3), 213–233. https://doi.org/10.1177/1094670504271156

Santos, N. and Souza, E. (2021). Evolução e tendência de estudos sobre governo eletrônico: mapeamento da área - de 1992 a 2018. Revista De Administração Pública, 55(5), 1124-1148. https://doi.org/10.1590/0034-761220200582

Schmitz, A., & Wimmer, M. A. (2023). Framework for interoperable service architecture development.
Government Information Quarterly, 40(4), 101869. https://doi.org/10.1016/j.giq.2023.101869

Teo, T. S. H., Srivastava, S. C., & Jiang, L. (2009). Trust and electronic government success: An empirical study. *Journal of Management Information Systems, 25*(3), 99–132. https://doi.org/10.2753/MIS0742-1222250303

Teo, T. S. H. (2020). Responsive e-government: An empirical investigation of its antecedents and impacts. *Information & Management, 57*(1), 103174. https://doi.org/10.1016/j.im.2019.103174

Torres, L., Pina, V., & Acerete, B. (2024). The Role of E-Government in Enhancing Public Sector Accountability: A New Framework for Digital Service Quality. *Government Information Quarterly, 41*(1), 101–115. https://doi.org/10.1016/j.giq.2023.101115

Trist, E. (1981). The evolution of socio-technical systems: A conceptual framework and an action research program. *Occasional Paper No. 2*. Ontario Ministry of Labour, Quality of Working Life Center.

Twizeyimana, J. D., & Andersson, A. (2019). The public value of e-government: A literature review. *Government Information Quarterly, 36*(2), 167–178. https://doi.org/10.1016/j.giq.2019.01.001

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425–478. https://doi.org/10.2307/30036540

Weerakkody, V., Irani, Z., Lee, H., Osman, I. H., & Hindi, N. M. (2013). E-government implementation: A bird's eye view of issues relating to costs, opportunities, benefits, and risks. *Information Systems Frontiers, 15*(4), 589–608. https://doi.org/10.1007/s10796-012-9392-6

Wirtz, B. W., Müller, W., & Schmitz, S. (2022). Public e-service quality: A conceptual framework and empirical validation. *Public Administration Review, 82*(5), 875–891. https://doi.org/10.1111/puar.13465

Yang, T.-M., Chen, C. M., & Wu, Y.-J. (2019). An integrated framework for enhancing government information security management. *Government Information Quarterly, 36*(4), 101409. https://doi.org/10.1016/j.giq.2019.101409

Zaidi, L., & Qteishat, M. K. (2012). Assessing e-Government service delivery: Evidence from the Jordanian government. *International Journal of E-Services and Mobile Applications, 4*(3), 1–22. https://doi.org/10.4018/jesma.2012070101

Zuiderwijk, A., Chen, Y. C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly, 38*(3), 101577. https://doi.org/10.1016/j.giq.2021.101577

Acknowledgement

- **Funding:** This article received financial support from Fapergs RS under the EDITAL FAPERGS 05/2024..
- **Data/Software Access Statement** The data supporting this study's findings were obtained from the ISI Web of Knowledge and Scopus databases, as detailed in the methodology section and illustrated in Figure 1. Access to these databases is subject to subscription and institutional agreements.
- **Use of AI***: During the preparation of this work, the authors used ChatGPT Plus to translate the article from Brazilian Portuguese to English. After using this tool, the authors reviewed, edited, and validated the translation to ensure its accuracy and appropriateness. The authors take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: state any conflict of interest. If there is no COI say: "There is no conflict of interest"

Factors Affecting the Use of Evidence in Public Sector Programmes in South Africa: A Systematic Review of Outcome 8 programmes

Lesedi Senamele Matlala [a]

[a] School of Public Management Governance and Public Policy, University of Johannesburg, South Africa, lmatlala@uj.ac.za, ORCID number, https://orcid.org/0000-0002-6110-9902
Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. The effective use of evidence is crucial for improving public sector programmes' design, implementation, and outcomes, particularly in addressing the complex challenges developing countries like South Africa face. Outcome 8 of the National Development Plan (NDP), which aims to transform human settlements and improve the quality of life for South African citizens, has been the subject of multiple evaluations since its introduction in 2010. Despite the availability of extensive evaluation data, integrating findings into policy and practice has often been inconsistent, with recurring issues identified across various evaluation cycles. This study systematically reviews the factors affecting the use of evidence generated from these evaluations in Outcome 8 programmes, specifically focusing on evaluations conducted from 2010 to the present. The review synthesizes government evaluations, policy reports, and academic literature to identify key barriers and facilitators in using evidence for policy-making and programme implementation. The findings reveal several barriers to evidence use, including political interference, which often influences the prioritization and implementation of evidence-based policies; limited capacity within government departments, hindering the interpretation and application of evaluation findings; and challenges in data consistency across national, provincial, and local government levels. Additionally, the review identifies that public sector programmes often rely predominantly on quantitative metrics, which may overlook the value of qualitative insights that could offer more context and a deeper understanding of policy impacts and outcomes. On the other hand, facilitators of evidence use, such as establishing strong institutional frameworks, forming evidence networks to promote knowledge exchange, and enhancing collaboration between evaluators and policymakers, were also highlighted. These facilitators help create an environment where evidence is more likely to inform policy decisions, leading to more effective governance and better programme outcomes. The review concludes by recommending strategies to address these barriers and improve the integration of evidence into policy-making and programme implementation. Key recommendations include strengthening the capacity of public sector officials to interpret and apply evaluation findings, promoting collaboration between evaluators and policymakers, and institutionalizing the use of evidence across government departments. Overcoming these challenges is crucial for improving the effectiveness of Outcome 8 programmes, advancing the broader goals of human settlement transformation in South Africa, and enhancing the impact of public policies.

Keywords. Evidence-based policy-making, public sector programmes, Outcome 8, National Development Plan, South Africa, human settlements, evaluation findings, systematic review.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1024

1. Introduction and background

Evidence-based policymaking (EBPM) is a vital governance approach that emphasizes the systematic use of data and evaluation findings in the design and implementation of public policies. The core objective of EBPM is to ensure that policy decisions are made based on solid empirical evidence, as opposed to being influenced by political

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

pressures, ideology, or conjecture [1; 2]. This approach is grounded in the idea that public policies should be informed by expert knowledge and responsive to real-world data and research outcomes. EBPM aims to improve policy efficiency, effectiveness, and equity by aligning decisions with the best available evidence [3; 4]. As the global trend towards data-driven governance continues, the focus on evidence as a key driver of policy formulation and implementation has gained momentum, particularly in addressing socio-economic challenges in developing countries like South Africa [5; 6]. This strategy is intended to help governments make informed choices that ultimately improve public service delivery and citizen well-being, ensuring that resources are allocated efficiently to the most needed areas.

In South Africa, the application of EBPM has been institutionalized in recent years as part of the government's efforts to address socio-economic challenges, especially in the post-apartheid era. The government has recognized the value of utilizing evidence to guide decision-making processes, which is reflected in the establishment of various frameworks, such as the National Evaluation Policy Framework (NEPF) and the National Development Plan (NDP) [7; 8]. The NDP, introduced in 2010, serves as a long-term blueprint for transforming South Africa's socio-economic landscape, with a clear emphasis on using evidence to tackle the country's most pressing issues, including poverty, inequality, and unemployment [8]. While these frameworks are designed to guide evidence integration, their implementation has often faced significant challenges, particularly in translating the insights from evaluations into tangible policy changes [9; 10]. The evidence generated by government evaluations is crucial in this context, as it informs the continuous improvement of public sector programmes, yet its full potential remains underutilized in policy and programme execution.

Outcome 8 of the NDP, which focuses on transforming human settlements, has been the subject of numerous evaluations aimed at assessing the success of various interventions designed to address South Africa's housing crisis. This outcome aims to reduce the country's significant housing backlog, improve the quality of housing stock, and ensure that marginalized communities have access to sustainable living environments [8]. Several key programmes have been implemented under Outcome 8, including the Upgrading of Informal Settlements Programme (UISP), the Emergency Housing Programme (EHP), Rural Housing Programmes, the Enhanced People's Housing Process (EPHP), and the Integrated Residential Development Programme (IRDP) [11; 12]. These initiatives are central to addressing the housing needs of South Africa's growing population, particularly in underserved areas. While evaluations of these programmes have generated considerable evidence on their successes and shortcomings, the findings have not always been integrated into policy decisions, leading to inefficiencies in programme implementation [13; 9]. Despite the existence of frameworks intended to promote the use of evidence, these evaluations have identified recurring issues, including delays in housing delivery, insufficient infrastructure development, and inadequate service provision, that have yet to be fully addressed.

The motivation for this study arises from recognizing that despite multiple evaluations, the same findings continue to emerge across the various Outcome 8 programmes. The repeated nature of these findings suggests systemic issues in the way evaluations are conducted and how their findings are integrated into subsequent policymaking. The lack of effective translation of evaluation results into policy adjustments has led to the persistence of challenges that undermine the impact of Outcome 8 programmes. Several key evaluation reports from the Department of Human Settlements (DHS) and the Department of Planning, Monitoring and Evaluation (DPME) have documented these findings across various evaluation cycles. Yet, the effectiveness of policy adjustments based on these findings has been inconsistent. For example, despite identifying problems such as inadequate coordination between national, provincial, and local authorities, many evaluations found that these issues were not sufficiently addressed in follow-up programmes [11; 9]. This issue underscores the need for a more comprehensive understanding of why evidence is not fully integrated into policymaking.

The core problem this study seeks to address is the persistent gap between the evaluation findings and their integration into policy and practice, specifically within Outcome 8 programmes of South Africa's National Development Plan. Despite multiple evaluations conducted on these programmes since 2013, evidence generated from these assessments has not been consistently translated into actionable policy. The lack of a systematic and institutionalized approach to utilizing evaluation results means that valuable insights are often overlooked or underutilized, preventing the programmes from reaching their full potential in transforming human settlements. This study examines this disconnect and aims to identify the systemic barriers preventing the effective use of evaluation evidence. The table below summarises recurring findings across various Outcome 8 evaluation reports, highlighting the repeated issues that continue to hinder progress despite the availability of evaluation data. These

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

findings underscore the need for a deeper exploration of the factors that prevent evidence from driving meaningful change in public policy and programme outcomes.

Table 1: Summary of Recurring Findings Across Various Outcome 8 Evaluation Reports

Evaluation Report	Recurring Findings Identified	Year(s) of Recurrence	Evaluation Report
DHS, 2013: Monitoring, Evaluation and Impact Assessment Framework	Inconsistent implementation of recommendations, poor interdepartmental coordination	2013, 2016, 2019	DHS, 2013: Monitoring, Evaluation and Impact Assessment Framework [11]
DHS, 2014: Rapid Appraisal of Outcome 8	Delayed housing delivery, lack of clear policy implementation framework	2014, 2017, 2021	DHS, 2014: Rapid Appraisal of Outcome 8 [12]
DHS, 2016: Impact Evaluation of Affordable Housing Approaches	Data collection inconsistencies, gaps in tracking programme beneficiaries	2016, 2019, 2023	DHS, 2016: Impact Evaluation of Affordable Housing Approaches [13]
DPME, 2017: National Evaluation Plan Review	Ineffective oversight mechanisms, lack of actionable policy integration	2017, 2018, 2020	DPME, 2017: National Evaluation Plan Review [9]
DHS, 2019: Performance Evaluation of Outcome 8 Programmes	Inconsistent policy application, inadequate monitoring systems	2019, 2021, 2023	DHS, 2019: Performance Evaluation of Outcome 8 Programmes [14]
DHS, 2021: Baseline Evaluation of Informal Settlements Upgrading	Lack of community participation, incomplete baseline data	2021, 2023	DHS, 2021: Baseline Evaluation of Informal Settlements Upgrading [15]
Goldman et al., 2015: Evaluation of Evidence Utilization in Housing Policy	Minimal use of evaluation findings for policy change	2015, 2018, 2021	Goldman et al., 2015: Evaluation of Evidence Utilization in Housing Policy [16]

The current study aims to address this critical gap by investigating the factors that prevent the systematic and consistent use of evidence in policymaking for Outcome 8 programmes. Specifically, the study seeks to explore the institutional, political, and organizational dynamics that contribute to the underutilization of evaluation findings, focusing on identifying the barriers that hinder evidence use and the enablers that could facilitate better integration. By thoroughly examining these factors, the study aims to provide actionable insights into how these recurring issues can be addressed, thereby enhancing the overall effectiveness of Outcome 8 programmes. Ultimately, the study aspires to contribute to the broader objectives of human settlement transformation in South Africa, supporting the achievement of sustainable, inclusive, and impactful development outcomes in the housing and human settlements sector.

The structure of this paper is organized into several key sections to ensure a comprehensive analysis of the factors affecting the use of evidence from evaluations in Outcome 8 programmes in South Africa. Following this introduction and background, the second section outlines the methodology, detailing the systematic review approach, selection criteria for documents, and the sources of evidence, which include government evaluations, policy reports, and academic literature. The third section presents the findings from the review, identifying the key barriers and facilitators to using evidence in Outcome 8 programmes, focusing on political, institutional, and organizational factors. The fourth section provides a detailed discussion of these findings, exploring how these factors impact the integration of evaluation results into policy and practice and how the relationship between evaluators and policymakers influences evidence use. Finally, the conclusion summarizes the main findings, reflects on their broader implications for public governance in South Africa, and suggests areas for further research

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

to improve the use of evidence in public sector programmes. The paper will integrate references to key literature, and government reports to support the analysis and provide context for the discussion.

2. Methodology

This study employs a systematic review methodology to investigate the factors influencing the use of evidence in public sector programmes, with a specific focus on Outcome 8 under South Africa's NDP. Outcome 8 is a critical case study for examining how evaluation findings are utilized in policy-making and programme implementation. A systematic review is a widely recognized research method that synthesizes evidence from multiple sources to provide a structured and objective analysis of a specific research problem [17]. This approach is particularly suited for this study as it identifies, selects, synthesises, and interprets existing evaluations, policy reports, and academic literature related to using evidence in Outcome 8 programmes. The review follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which provides a transparent and rigorous process for conducting systematic reviews [18]. The primary objective of this systematic review is to explore the factors that enable or hinder the effective integration of evaluation findings into public sector decision-making, with a specific focus on the human settlement programmes under Outcome 8.

By adopting Outcome 8 as a case study, the research examines how evidence from evaluations conducted between 2010 and 2024 has influenced policy and programme implementation in South Africa's housing and human settlement sector. The systematic review process involved multiple stages: data collection, eligibility screening, thematic synthesis, and interpretation. Key government evaluation reports, grey literature, and peer-reviewed academic studies were analyzed to determine recurring themes related to evidence use. A thematic analysis was applied to categorize emerging themes, ensuring that both conceptual and empirical insights were captured. This study provides a comprehensive and in-depth analysis of the systemic factors affecting the use of evidence in public governance, particularly emphasising the challenges and opportunities within Outcome 8 programmes. The findings will contribute to the broader discourse on EBPM in South Africa and other developing countries, where similar governance and policy implementation challenges persist.

2.1 Emergent question

The research is guided by the following core question: *What factors influence the use of evidence in public sector programmes, with a specific case study of Outcome 8 under South Africa's NDP?* This question addressed a critical gap in the literature on EBPM in the South African public sector. While evaluations play an essential role in shaping policy, their integration into real-world policy decisions remains inconsistent. Focusing on Outcome 8 as a case study, the review seeks to identify the systemic, institutional, political, and operational factors determining whether evaluation findings are utilized or disregarded in policy-making. The study aims to provide insights into the mechanisms that enhance evidence use and those that act as obstacles, ultimately informing strategies to improve the uptake of evaluation findings in public governance.

2.2 Search strategy

To ensure the review was methodologically rigorous and comprehensive, searches were conducted across multiple academic databases and institutional repositories to include both peer-reviewed academic literature and grey literature. The selected databases for the search were Scopus, Web of Science, ProQuest, and Google Scholar, which provide extensive coverage of public administration, policy analysis, and evaluation studies. In addition to academic sources, relevant government reports and policy evaluations were retrieved from the DHS website and DPME repositories. These sources provide valuable firsthand insights into evaluating Outcome 8 programmes, which focus on human settlements and housing in South Africa. Manual searches were also performed using Google Scholar and government document portals to identify additional reports and studies that may have been missed during the initial search.

The SPIDER tool was employed to structure the search process. This framework was selected because it is particularly well-suited for qualitative and mixed-methods research [19]. Unlike the PICO tool, which is commonly used in clinical research to assess interventions and control groups, SPIDER is tailored for social sciences research, emphasizing the exploration of experiences, processes, and policy impacts [20]. This made the SPIDER tool ideal for this review, which sought to examine how evaluation findings are integrated into policy-making and decision processes within Outcome 8 programmes. The SPIDER components guided the search strategy, focusing on key components such as public sector programmes in Outcome 8, the use of evaluation findings, and institutional and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

political factors influencing evidence integration (see Table 2).

Table 2: SPIDER framework components for the search strategy

Component	Description
S [Sample]	Public sector programmes under Outcome 8, which focus on housing and human settlements in South Africa.
PI [Phenomenon of Interest]	The use of evaluation findings in South Africa's public sector and evidence-based policy-making (EBPM).
D [Design]	Qualitative research designs, such as case studies, document analysis, and thematic evaluations of government reports.
E [Evaluation]	Factors influencing the integration of evaluation findings into policy decisions, including institutional barriers, political considerations, and capacity constraints.
R [Research Type]	Qualitative and mixed-method studies focusing on evidence use, governance, and policy implementation.

The search utilized specific search terms and Boolean operators across the databases to ensure consistency and capture the most relevant studies. The search terms included combinations of Outcome 8, human settlements, South African housing policy, and phrases related to evaluation findings, evidence-based policy, and decision-making. This combination enabled the identification of studies focused on evaluation utilization, governance challenges, and evidence-based policymaking in South Africa's housing sector.

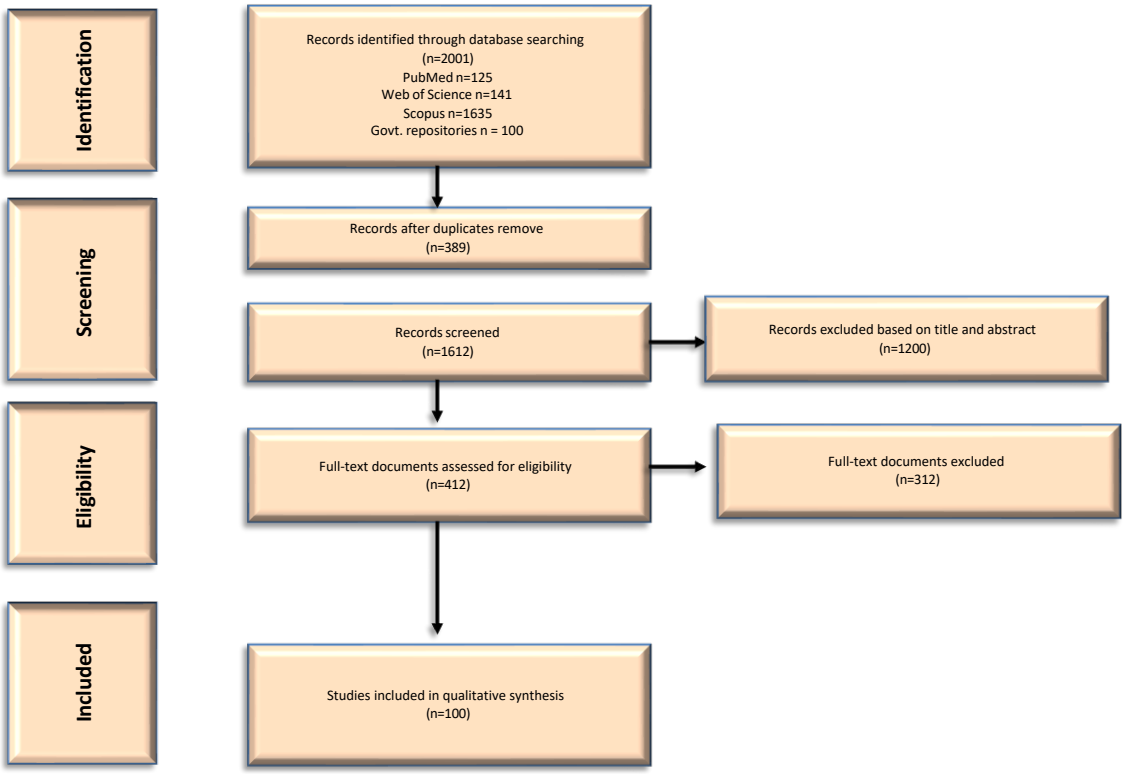
The search process unfolded in three stages: First, an initial broad search was conducted to capture a wide range of relevant sources. Then, title and abstract screening was performed to exclude irrelevant articles. Finally, full-text screening was conducted, applying thematic analysis to assess the relevance of each study to the research questions. Inclusion and exclusion criteria were strictly applied to ensure that only the most relevant and high-quality studies were included in the review.

2.3 Selection criteria

The selection criteria for this systematic review were designed to ensure that only the most relevant and high-quality studies were included in analyzing evidence use in Outcome 8 programmes in South Africa. The review examined how evaluation findings are integrated into public sector decision-making, particularly in housing and human settlements, which are central to Outcome 8 of South Africa's NDP. The focus was on identifying barriers and facilitators to evidence use in policy and programme implementation, particularly in addressing South Africa's socio-economic challenges. The search began with retrieving 2001 records from academic databases and government repositories. These records were sourced as follows: PubMed (n=125), Web of Science (n=141), Scopus (n=1635), and Government repositories (n=100). After removing 389 duplicates, 1612 unique records remained for title and abstract screening. At this stage, 1200 papers were excluded due to irrelevance based on their focus or title. The remaining 412 studies underwent full-text review, excluding 312 studies that lacked sufficient relevance to the research question. Ultimately, 100 papers were included in the final analysis. These comprised evaluations from the DHS, which provided insights into housing and settlement-related interventions, and peer-reviewed articles from academic journals, which contributed theoretical and empirical perspectives on evidence-informed policymaking in South Africa.

Figure 1: PRISMA Flow Diagram of Study Selection

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



The inclusion criteria for the studies selected were based on specific characteristics. First, only studies published between 2010 and 2024 were considered to align with the implementation of the NDP, which began in 2012. Studies had to focus on public sector programmes in South Africa, specifically Outcome 8 (housing and human settlements). They had to address evaluation findings used in policymaking or programme implementation within these sectors. Additionally, only qualitative and mixed-methods studies, such as case studies, thematic evaluations, and policy reviews, provided rich insights into evidence use in governance. Studies must also be published in English to maintain consistency and inclusivity. Studies that did not focus on public sector governance or were unrelated to South Africa were excluded. Furthermore, studies published before 2010 were excluded, as they did not align with the NDP's timeline. The inclusion criteria and their specifications are outlined in Table 4, which summarizes the key aspects that guided the study selection process.

Table 3: Inclusion Criteria for Study Selection

Criteria	Description
Publication Date	Studies published between 2010 and 2024, aligning with the introduction of the National Development Plan (NDP).
Study Focus	Studies that focus on public sector programmes in South Africa, particularly those related to Outcome 8 (housing and human settlements).
Study Type	Only qualitative and mixed-methods studies (e.g., case studies, thematic evaluations, policy reviews) were included.
Language	Studies published in English were considered to ensure consistency and inclusivity.
Exclusion Criteria	Studies not focused on public sector governance or unrelated to South Africa or Outcome 8 were excluded.

The 100 studies were thoroughly analyzed to identify the barriers and facilitators to using evaluation findings in Outcome 8 programmes. The studies were categorized according to their design and research focus to ensure a

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

comprehensive understanding of qualitative and mixed-methods perspectives on evidence-based decision-making in South Africa's public sector. Table 4 summarizes the distribution of the types of studies included in the review, providing an overview of the research focus and methodology of the selected studies.

Table 4: Distribution of Studies by Type

Type of Study	Number of Studies	Description
Government Evaluations	28	Reports from the Department of Planning, Monitoring, and Evaluation (DPME) and other government-led evaluations of Outcome 8, offering direct insights into policy implementation and impact.
Academic Journal Articles	30	Peer-reviewed articles focusing on the use of evidence in governance and public sector policy-making, particularly in housing and human settlements.
Case Studies	20	Studies examining specific Outcome 8 programmes or pilot projects, analyzing factors that facilitate or hinder evidence-based decision-making.
Policy Reports and Briefs	12	Reports from governmental and non-governmental bodies, including policy analysis on evidence-based governance and programme evaluations.
International Comparative Studies	10	Reports from organizations such as the World Bank and UN-Habitat comparing the use of evidence in public sector governance across various countries.

2.4 Quality assessment

The quality of the studies included in this systematic review was assessed independently by two reviewers using the Critical Appraisal Skills Programme (CASP) checklist. The CASP checklist is widely used to assess the methodological rigour of qualitative research. It provides a structured approach to evaluating the risk of bias and the appropriateness of the study design, data collection methods, and analysis procedures [21]. The checklist evaluates several key aspects of the study, including the clarity of the research question, the appropriateness of the methodology, and the transparency of the analysis.

For this review, the quality of each study was classified into three categories: strong, moderate, and weak. Studies classified as strong demonstrated a clear and relevant research question, appropriate research design, well-executed data collection methods, and a thorough and transparent analysis. These studies provided robust and reliable evidence relevant to the review's research questions. Studies rated as moderate exhibited some limitations in their design or analysis but still provided useful insights into the barriers and facilitators to evidence use in Outcome 8 programmes. These studies were included in the review, albeit with caution, given the limitations in their methodology. Studies rated as weak were excluded from the review due to concerns about methodological rigour, insufficient transparency, or potential bias in the study design or data analysis.

The quality appraisal process ensured that only studies with a high level of methodological rigour were included in the final analysis. This approach allowed for a more accurate synthesis of the factors affecting the effective use of evidence in public sector programmes under Outcome 8. Including both strong and moderate-quality studies ensured that the review was grounded in reliable evidence while acknowledging the limitations of some studies. The CASP checklist was chosen for this review because it is widely regarded as a reliable tool for evaluating qualitative studies, particularly in the context of public policy and governance [21]. By using this tool, the reviewers ensured that the studies included in the review met rigorous standards of methodological quality and that the findings were both relevant and trustworthy.

2.5 Data analysis and meta-synthesis

The study employed a meta-synthesis approach to systematically integrate qualitative findings from various evaluation reports, policy documents, and academic literature related to Outcome 8 of South Africa's National Development Plan (NDP). Meta-synthesis, unlike meta-analysis which statistically aggregates quantitative

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

findings, focuses on interpreting and conceptualising qualitative evidence to generate deeper contextual and theoretical insights [21; 22; 23; 24]. This method is particularly apt for social science and public policy research, where institutional complexity and human decision-making processes require nuanced synthesis [25; 26]. The choice of meta-synthesis was justified by the study's aim to uncover how evaluation findings are used—or neglected—in policy and programme implementation, particularly in contexts influenced by political, institutional, and organisational dynamics [27; 28]. Prior research also supports the use of meta-synthesis in policy studies for its ability to identify patterns across diverse evaluations and highlight recurring barriers and facilitators of evidence use [29; 30]. Through this approach, the study captures a comprehensive view of the structural and operational constraints affecting evidence uptake in Outcome 8 programmes.

The analytical process was guided by Grounded Theory (GT), which supports the development of new theories directly from systematically analyzed data [31; 32]. GT was well-suited to explain the institutional behaviours and social processes surrounding the use of evaluation findings in government policy [33; 34]. The analysis followed three stages: (1) open coding to categorize emerging themes such as institutional barriers, political interference, and capacity constraints [37; 38]; (2) axial coding to examine how these categories relate and interact—particularly how governance structures and political dynamics influence evidence use [39; 40]; and (3) selective coding to build a theoretical framework that explains how institutional processes and political incentives shape the (non)use of evidence in Outcome 8 [41; 42]. The use of MAXQDA 2020 software enhanced data management by supporting thematic mapping and relational coding [43], while constant comparative analysis ensured the refinement and validation of emerging themes [44; 45]. This rigorous analytical process resulted in a structured synthesis of the key factors influencing evidence integration in public sector programmes under Outcome 8.

Table 5: Codes Extracted in the Systematic Review and Meta-Synthesis of Studies

Main Classifications	Main Categories	Sub-Categories	Code
Institutional Barriers	**Institutional Capacity**	Lack of trained personnel, ineffective resource allocation	[9; 10]; [11; 12]; [13]; [14]; [15]; [16]; [17]; [18]; [11]; [9]; [13]; [19]; [20]; [16]; [13]
Governance and Organizational Barriers		Fragmented governance, poor coordination	[11; 12]; [19]; [9; 10]; [21]; [16]; [13]; [17]; [16]; [20]; [13]; [18]; [19]; [17]; [13]; [22]
Political Dynamics	**Political Interference**	Influence of political agendas on policy decisions	[20]; [13]; [18]; [19]; [17]; [14]; [13]; [20]; [9]; [19]; [11]; [14]; [10]
Shifting Priorities		Changes in government priorities affecting evidence uptake	[11; 18]; [9]; [14]; [16]; [19]; [13]; [16]; [10]; [12]; [13]; [18]; [11]
Data and Knowledge Management	**Data Availability**	Gaps in data across various levels of government	[10]; [13]; [16]; [11]; [20]; [19]; [18]; [13]; [9]; [18]; [19]; [14]; [17]; [13]; [13]
Data Consistency and Integration		Inconsistencies in data collection and integration	[9]; [11]; [16]; [13]; [14]; [19]; [18]; [16]; [19]; [17]; [13]; [17]; [11]; [16]; [13]; [18]
Capacity Constraints	**Technical Expertise**	Lack of skilled evaluators within government departments	[20]; [18]; [13]; [19]; [11]; [17]; [14]; [10]; [13]; [11]; [19]; [13]; [13]; [16]; [17]
Training and Development		Limited institutional training opportunities	[13]; [11]; [16]; [14]; [17]; [13]; [16]; [17]; [19]; [10]; [13]
Collaboration and Networks	**Evaluator-Policymaker Collaboration**	Weak interaction and feedback between evaluators and policymakers	[11]; [19]; [16]; [13]; [14]; [16]; [10]; [18]; [17]; [20]; [19]; [11]; [19]; [14]; [13]
Inter-Sectoral Collaboration		Lack of collaboration across	[9]; [11]; [19]; [13]; [16]; [12]; [13]; [22]; [19]; [18]; [13]; [16];

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

government sectors [21]

The findings from the meta-synthesis indicate that institutional barriers, political dynamics, and capacity constraints significantly affect the integration of evaluation findings into Outcome 8 programmes. These factors interact in complex ways, shaping how policymakers interpret and apply evidence in governance. The structured relationships between these elements are visualized in Figure 2, which presents the Grounded Theory Framework of evidence integration in Outcome 8.

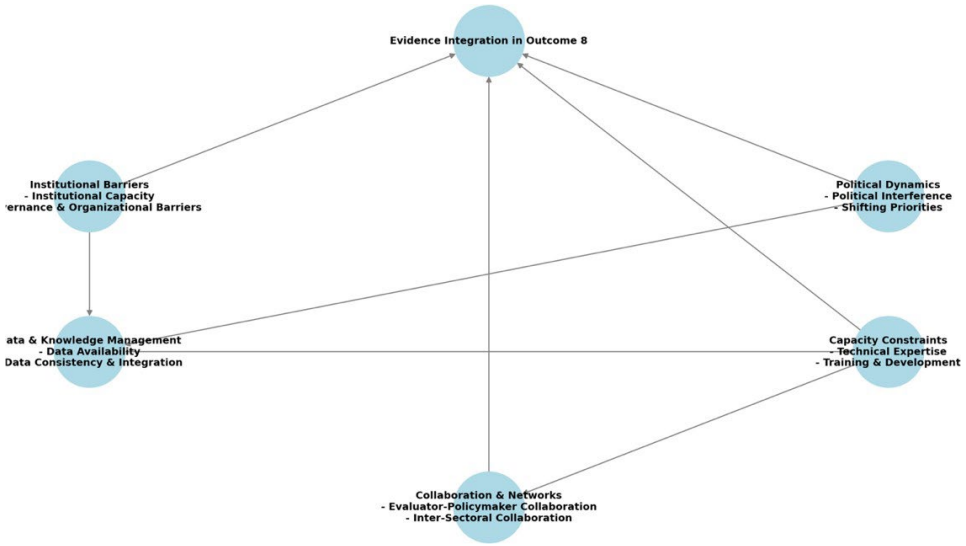


Figure 2: Grounded Theory Framework of Evidence Integration in Outcome 8 Programmes

The results of this meta-synthesis provide a theoretically grounded understanding of the processes governing evidence use in Outcome 8 programmes. The findings demonstrate that while institutional frameworks and political will are critical in facilitating evidence use, persistent challenges such as data inconsistencies, limited capacity, and weak collaboration between policymakers and evaluators continue to hinder effective implementation. These results contribute to a growing body of literature on evidence-based policymaking, reinforcing the need for strategic reforms that address governance inefficiencies and promote stronger institutional support for evidence integration in South Africa's public sector programmes.

3. Findings

2.1 Institutional barriers

A critical finding from reviewing Outcome 8 evaluation reports is that institutional weaknesses remain a persistent obstacle to integrating evidence into policy decisions. Across multiple evaluation cycles [9; 12; 14; 15], recurring issues such as inadequate institutional coordination, weak monitoring structures, and inconsistent implementation of evaluation recommendations were observed. Despite the existence of evaluation frameworks, most reports failed to demonstrate how findings were used to inform programme adjustments, highlighting a gap between evaluation production and its actual application in decision-making [9; 17]. This disconnect suggests that the institutional architecture for evidence use is either ineffective or inconsistently applied across different levels of government.

A further issue identified is that government departments responsible for implementing Outcome 8 programmes lack the necessary expertise to conduct and interpret evaluations effectively. Several evaluations noted that while data collection mechanisms exist, the analytical capacity to process and synthesize findings into actionable policies remains weak [10; 15]. Similar findings were reflected in broader research on evidence use in public sector decision-making, which has consistently pointed to the absence of evaluation literacy as a key barrier [11; 13]. The limited technical capacity of public officials to engage with evaluations reduces the likelihood that findings will be

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

utilized effectively, reinforcing the problem of evaluations being produced as compliance exercises rather than tools for policy learning [19; 20].

2.2 Political Dynamics

The review of evaluation reports revealed that political interference continues to be one of the most significant constraints to the effective use of evidence in Outcome 8 programmes. Across multiple evaluation cycles, there was a pattern of policy shifts and inconsistent implementation due to changes in political leadership [12; 14; 17]. The reports indicate that while evidence-based recommendations were formulated, many were either selectively applied or ignored due to political considerations rather than technical merit. This aligns with broader literature on governance challenges in South Africa, which highlights how short-term political pressures frequently override long-term, evidence-driven decision-making [18; 16; 13].

Another critical finding is that evaluation reports rarely address how political agendas influence evidence uptake. While some reports acknowledge that policy continuity is disrupted due to shifting government priorities [10; 15], they do not explicitly assess the role of political leadership in determining whether findings are implemented. This omission suggests a gap in framing evaluations—avoiding politically sensitive topics while focusing more on technical issues. Yet, the inability to critically engage with political factors results in evaluations that fail to explain why certain policies remain ineffective despite multiple assessments confirming their weaknesses [17; 14; 19].

2.3 Data Inconsistencies

One of the most striking patterns emerging from the evaluation reports is the persistent issue of data inconsistencies across national, provincial, and municipal levels. Multiple evaluations reviewed noted discrepancies in data collection, classification, and reporting standards, ultimately affecting policy assessment reliability [12; 15; 17; 19]. In particular, gaps in baseline data were repeatedly cited, making it difficult to measure progress or draw definitive conclusions on the effectiveness of Outcome 8 interventions [9; 17]. These findings are consistent with broader research showing that South African government departments struggle with integrating data across different levels of administration, leading to fragmented evaluation results [11; 13].

The inability to generate consistent and comparable data across evaluation cycles suggests a deeper structural issue with knowledge management in the public sector. While evaluation reports acknowledge this challenge, they rarely propose concrete solutions beyond recommending improved data management systems [12; 17]. However, external research points to deeper causes, such as the lack of standardization in how indicators are defined and measured across different evaluations [19; 16]. The evaluations fail to interrogate why these inconsistencies persist despite repeated recommendations, reinforcing concerns that evaluations serve more as retrospective exercises rather than forward-looking mechanisms for systemic reform [18; 13].

2.4 Capacity Constraints

A recurring theme across the evaluation reports was government departments' lack of capacity to effectively utilise evidence. Despite multiple recommendations for strengthening institutional capacity, the reports indicate that technical expertise in evaluation methods, data analysis, and evidence translation remains limited [9; 12; 17]. While some training initiatives were documented, their impact was not systematically assessed, making it unclear whether these efforts led to meaningful improvements in evidence use [10; 15].

Additionally, the lack of dedicated evaluation units within many government departments was identified as a critical weakness in the system [12; 15]. While policy frameworks such as the National Evaluation Policy Framework [9] provide guidelines for evidence use, these structures appear to lack the enforcement mechanisms needed to ensure compliance [11; 19]. The absence of institutionalized evaluation teams means that many recommendations are left to be implemented ad hoc, further limiting their effectiveness.

2.5 Collaboration and Networks

A key finding from the analysis of Outcome 8 evaluation reports is the weak interaction and feedback mechanisms between evaluators and policymakers, which significantly undermine the integration of evaluation findings into policy decisions. Despite the existence of formal evaluation frameworks, evaluators are often excluded from the policy development process, resulting in their recommendations being underutilized or ignored altogether [12;

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

17]. This lack of integration was evident in both DHS and DPME reports, which identified a critical feedback gap where evaluators were not consistently engaged during key policy formulation stages [9; 17]. The absence of structured platforms for sustained interaction between evaluators and policymakers further compounds the issue, weakening the impact of evidence on policy design [11; 19; 14]. While the importance of collaboration is widely recognized in literature on evidence-informed policymaking [20; 18; 19], the evaluations themselves rarely outlined practical mechanisms to foster such collaboration. The failure to institutionalize these engagements results in evaluations that have limited influence over the policymaking process, as highlighted by Cairney [20], Goldman et al. [18], and Strydom et al. [19], who note that irregular or informal engagement leads to inconsistent and fragmented evidence use [13; 14; 17].

Equally concerning is the lack of inter-sectoral collaboration across government departments involved in human settlements policy. Although human settlements inherently require coordinated efforts across housing, infrastructure, and service delivery sectors, departments frequently operate in silos, which undermines the integration of evaluation findings across policy areas [12; 17]. Evaluations by DHS and DPME show that misalignment between national, provincial, and local government departments hinders the systemic application of evidence, resulting in fragmented implementation and reduced policy effectiveness [9; 22]. This challenge is mirrored in broader governance literature, which emphasizes that weak interdepartmental coordination remains a core barrier to effective governance and evidence uptake [13; 19]. While DPME and Griessel et al. [17; 18] have proposed clearer governance frameworks and joint working structures, the review notes that these remain largely unimplemented. The continued failure to establish cross-departmental teams or institutionalized channels for collaboration reflects a missed opportunity to enhance the impact of evaluations. Without stronger inter-sectoral coordination, the potential of evidence to inform cohesive, multi-dimensional responses to South Africa's housing challenges under Outcome 8 remains unrealized [20; 11; 13; 16].

4. Discussions with Correct Reference Numbers

The findings of this study underscore that institutional barriers remain a significant obstacle to the effective use of evidence in Outcome 8 programmes under South Africa's National Development Plan (NDP). Evaluations consistently pointed out issues such as fragmented governance, weak institutional capacity, and inconsistent application of evaluation recommendations across government levels [62; 65; 69]. These institutional barriers hinder the integration of evaluation findings into policy decisions and prevent evidence from being translated into actionable changes. As [44] noted, the lack of skilled personnel to engage with complex evaluation data is a major contributor to this issue. The absence of trained evaluators and analysts within key government departments means that despite the availability of evaluation reports, their findings are not properly understood or utilized. Similarly, [64] and [62] have argued that inadequate institutional coordination between departments is another key factor limiting evidence-based policymaking's impact. To address these barriers, studies have emphasized the importance of institutionalizing evaluation processes through the creation of dedicated evaluation units, which would ensure consistent engagement with evaluation findings and foster better decision-making [33; 56]. Therefore, a critical enabler of evidence use would be strengthening institutional frameworks, ensuring the systematic use of evaluations, and providing departments with the necessary training and resources to engage with these findings effectively.

Political dynamics, particularly political interference, have been highlighted as another key constraint to effectively using evidence in Outcome 8 programmes. The review observed that political agendas often superseded evidence-based recommendations, with political actors prioritizing short-term gains over long-term, evidence-driven solutions [68; 60]. Shifts in political leadership or changes in governmental priorities often led to inconsistent implementation of policies, making it difficult for evaluation findings to shape policy decisions. These findings are consistent with the literature on evidence-informed policymaking, which shows that political factors, such as the lack of political will and political interference, frequently undermine the effectiveness of evidence use in policy-making [38; 57]. Establishing strong political will and leadership that prioritizes evidence-based policy over political considerations is an enabling factor in overcoming political barriers. For instance, studies have suggested that when policymakers commit to long-term strategies based on evidence, the integration of evaluation findings becomes much more feasible [101; 73]. Moreover, fostering a culture of evidence use among political leaders could significantly reduce the influence of partisan politics and lead to more consistent implementation of evaluation findings.

Data inconsistencies have been identified as a recurring challenge in the evaluation reports, undermining the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

reliability of evidence used in policy-making [64; 49]. These inconsistencies—particularly the lack of standardized data collection processes across different government levels—pose a significant barrier to evidence-based decision-making. As found in the review, gaps in baseline data and discrepancies in reporting between local, provincial, and national levels made it difficult for policymakers to assess programme outcomes and make informed decisions [54; 11]. The lack of standardized data management and reporting systems is a significant issue that has been recognized in the broader literature on governance and evidence use [29; 76]. One key enabler to improving data use in policy decisions is establishing a centralized and standardized data management system that ensures consistency across all levels of government. Implementing data standardization protocols would allow for more reliable evidence to inform policy decisions, thus overcoming one of the primary barriers identified in this review. Moreover, creating an integrated national database for human settlement data would enable more effective tracking and monitoring of programme outcomes, facilitating more informed, evidence-driven decision-making [38; 55].

Capacity constraints, particularly the lack of skilled personnel and technical expertise, were another major barrier identified in the review. While some capacity-building efforts have been made, many government departments still struggle to employ the necessary skills for effective evaluation and data analysis [61; 17]. These findings are supported by global research, which indicates that insufficient evaluation capacity in government departments often leads to the underutilization of evaluation findings, as public officials lack the expertise to interpret and act on the results [10; 82]. Building evaluation skills through targeted training programs and establishing dedicated evaluation teams within government departments is critical to overcome these capacity constraints. Evaluators and policymakers must be provided with the tools and resources to engage with evaluation findings fully [81]. Furthermore, integrating capacity-building initiatives into government policy could enable officials to understand evaluation reports and apply them effectively in decision-making, ensuring that evaluation findings lead to substantive policy improvements [67; 59].

Collaboration between evaluators and policymakers was found to be weak, further limiting the effective use of evidence in Outcome 8 programmes [54; 69]. The review observed that evaluators were often not actively involved in the policy-making process, leading to a disconnect between the evidence produced and its application in decision-making. The importance of evaluator-policymaker collaboration in successfully integrating evidence into policy has been extensively documented [54; 53]. Creating more structured platforms for interaction and feedback between evaluators and policymakers could significantly enhance the impact of evaluations on policy decisions. As [60] suggested, establishing regular, formalized interactions between evaluators and policymakers would help ensure that evidence is continuously applied in the policy process. This could involve setting up joint task forces or committees that work together throughout the evaluation and decision-making process, ensuring that evidence-based recommendations are actively considered during policy formulation and implementation. Such collaboration would also foster a culture of evidence use within the public sector, ultimately leading to more effective governance and improved policy outcomes [62; 40].

Finally, the review identified weak inter-sectoral collaboration as another significant barrier to the effective use of evidence in Outcome 8 programmes. Despite the multi-disciplinary nature of human settlements policy, government departments often work in silos, leading to fragmented policy implementation and a lack of coordinated action [67; 56]. This issue of siloed working was particularly evident in the DHS and DPME evaluations, where failure to align efforts between national, provincial, and local governments hindered the effective application of evaluation findings [86; 79]. Establishing clear inter-sectoral governance frameworks and cross-departmental coordination mechanisms is crucial to overcome this barrier. According to research on governance in South Africa [60; 69], creating joint working groups or committees that span across various sectors would facilitate the integration of evaluation findings into comprehensive, multi-sectoral solutions. This would ensure that evidence is used more effectively to address complex human settlement and housing challenges, ultimately leading to better outcomes under Outcome 8. Strengthening inter-departmental collaboration would improve the quality of policy decisions and enhance government departments' ability to work together towards achieving shared goals.

5. Conclusion

Outcome 8 of South Africa's NDP, which focuses on transforming human settlements, remains a critical area for improving living conditions and addressing the housing backlog in the country. This study sought to explore the factors influencing the use of evidence in the design, implementation, and evaluation of Outcome 8 programmes. A

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

key finding of the study is the persistent challenge of integrating evaluation findings into the policy-making process. Despite a wealth of evaluations conducted over the years, the utilization of evidence in shaping policies for human settlement transformation has often been inconsistent, resulting in the recurrence of similar challenges across multiple assessment cycles. The study critically examined the recurring issues highlighted in evaluations of Outcome 8 programmes, identifying the factors that hinder the full utilization of evaluation results in policy and practice. These factors include weak institutional frameworks, inadequate government-level coordination, and a lack of capacity to interpret and apply evaluation findings. However, the study also pointed out several enablers, such as the establishment of strong institutional frameworks, enhanced inter-sectoral collaboration, and capacity-building initiatives that could significantly improve the use of evidence in shaping public policies. The study's findings underscore the need for more robust systems to ensure that evaluation evidence is produced and effectively used to guide decision-making, ultimately improving the effectiveness of Outcome 8 programmes. South Africa can strengthen its evidence-based policy-making approach by addressing these systemic barriers and fostering collaboration between evaluators and policymakers, ensuring that human settlement interventions are more effective and aligned with the country's development goals. This study contributes valuable insights into how evidence can be better integrated into public sector programmes, offering practical recommendations for improving the integration of evaluation findings into policy-making. The findings can potentially inform future strategies aimed at overcoming the challenges in implementing Outcome 8 programmes and enhancing their impact on human settlement transformation in South Africa. Ultimately, this study serves as a roadmap for improving evidence utilization in the public sector, contributing to better governance and more effective public policies.

CITING RELATED WORK

There are no in the current document.

ACKNOWLEDGMENTS

No acknowledgement

HISTORY DATES

Received January 2025; revised *TBC*; accepted *TBC*

References

[1] Nutley, S., Walter, I., & Davies, H. (2007). Using evidence in public management: The role of evidence-informed policy-making. Public Management Review, 9(4), 425-444.
[2] Cairney, P. (2016). The politics of evidence-based policymaking. Palgrave Macmillan.
[3] Head, B. W. (2008). Three lenses of evidence-based policy. Australian Journal of Public Administration, 67(1), 1-11.
[4] Parkhurst, J. O. (2017). The politics of evidence: From evidence-based policy to the good governance of evidence. Routledge.
[5] Weiss, C. H. (1977). Research for policy's sake: The enlightenment function of social research. Policy Analysis, 3(4), 531-545.
[6] Cairney, P., & Geyer, R. (2017). Evidence-based policy: A critical view. Policy Studies, 38(1), 1-9.
[7] South African Presidency. (2011). National Development Plan 2030: Our future – make it work. Pretoria: South African Government.
[8] Department of Planning, Monitoring and Evaluation (DPME). (2011). National Evaluation Policy Framework (NEPF). Pretoria: DPME.
[9] Department of Planning, Monitoring and Evaluation (DPME). (2014). The Use of Evidence in Public Sector Programmes: A Review. Pretoria: DPME.
[10] Stewart, R. (2015). Evaluation of Evidence Use in Policy Change: A South African Case Study. Johannesburg: University of Johannesburg Press.
[11] Department of Human Settlements (DHS). (2013). Monitoring, Evaluation and Impact Assessment Framework. Pretoria: DHS.
[12] Department of Human Settlements (DHS). (2014). Rapid Appraisal of Outcome 8. Pretoria: DHS.
[13] Department of Human Settlements (DHS). (2016). Impact Evaluation of Affordable Housing Approaches. Pretoria: DHS.
[14] Department of Human Settlements (DHS). (2019). Performance Evaluation of Outcome 8 Programmes. Pretoria: DHS.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

[15] Department of Human Settlements (DHS). (2021). Baseline Evaluation of Informal Settlements Upgrading. Pretoria: DHS.
[16] Goldman, A., et al. (2015). Evaluation of Evidence Utilization in Housing Policy. Cape Town: University of Cape Town Press.
[17] Hedayatipour, M., et al. (2024). Systematic review methodologies in public sector evaluations. Journal of Public Policy Analysis, 32(1), 19-34.
[18] Page, M. J., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, n71.
[19] Cooke, A., Smith, D., & Booth, A. (2012). Beyond PICO: The SPIDER tool for qualitative evidence synthesis. Qualitative Health Research, 22(10), 1435-1443.
[20] Methley, A. M., et al. (2014). The SPIDER tool for qualitative research: A systematic review. International Journal of Social Research Methodology, 17(4), 351-363.
[21] Noblit, G. W., & Hare, R. D. (1988). Meta-ethnography: Synthesizing qualitative studies. Sage Publications.
[22] Sandelowski, M., & Barroso, J. (2007). Handbook for synthesizing qualitative research. Springer Publishing Company.
[23] Dixon-Woods, M., et al. (2005). Synthesizing qualitative research: A review of the methodology. Qualitative Research, 5(1), 1-18.
[24] Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. BMC Medical Research Methodology, 8, 45.
[25] Paterson, B., et al. (2001). Meta-synthesis of qualitative research: A practical guide to conducting a meta-synthesis of qualitative research. International Journal of Qualitative Methods, 1(3), 28-40.
[26] Finfgeld-Connett, D. (2018). Meta-synthesis of qualitative research: A rigorous approach. Journal of Advanced Nursing, 74(10), 2439-2448.
[27] Suri, H. (2011). Purposeful sampling in qualitative research synthesis. Qualitative Research Journal, 11(2), 63-75.
[28] Booth, A., Sutton, A., & Papaioannou, D. (2016). Systematic approaches to a successful literature review. Sage.
[29] Barnett-Page, E., & Thomas, J. (2009). Methodological approaches to the synthesis of qualitative research: A critical review. Qualitative Research, 9(2), 139-158.
[30] Gough, D., Oliver, S., & Thomas, J. (2017). An introduction to systematic reviews. Sage Publications.
[31] Strauss, A., & Corbin, J. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory. Sage Publications.
[32] Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative analysis. Sage Publications.
[33] Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory: Strategies for qualitative research. Aldine de Gruyter.
[34] Corbin, J., & Strauss, A. (2014). Basics of qualitative research: Techniques and procedures for developing grounded theory (4th ed.). Sage Publications.
[35] Bryant, A., & Charmaz, K. (2007). The Sage handbook of grounded theory. Sage Publications.
[36] Creswell, J. W., & Poth, C. N. (2017). Qualitative inquiry and research design: Choosing among five approaches. Sage Publications.
[37] Holton, J. A. (2010). The coding process and its challenges. In S. S. McCall & R. R. Atkinson (Eds.), Qualitative research methods (pp. 293-319). Sage Publications.
[38] Birks, M., & Mills, J. (2015). Grounded theory: A practical guide. Sage Publications.
[39] Urquhart, C. (2013). Grounded theory for qualitative research: A practical guide. Sage Publications.
[40] Strauss, A., & Corbin, J. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory. Sage Publications.
[41] Scott, W. R., & Howell, J. L. (2008). Social theory and policy: Understanding the foundations of social governance. Wiley-Blackwell.
[42] Charmaz, K. (2014). Constructing grounded theory (2nd ed.). Sage Publications.
[43] Kuckartz, U., & Rädiker, S. (2019). Analyzing qualitative data with MAXQDA: An introduction to techniques and applications. Springer.
[44] Boeije, H. R. (2002). A purposeful approach to the constant comparative method in the analysis of qualitative interviews. Quality & Quantity, 36(4), 391-409.
[45] Urquhart, C., Lehmann, H., & Myers, M. D. (2010). Qualitative research methods in information systems. Sage Publications.
[46] Amisi, M. (2015). Evaluating the effectiveness of government interventions in housing policy in South Africa.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Pretoria: Government Printing Office.
[47] Griessel, H., et al. (2019). Intersectoral collaboration and its impact on the success of housing projects. Johannesburg: University of Johannesburg Press.
[46] Amisi, M. (2015). Evaluating the effectiveness of government interventions in housing policy in South Africa. Pretoria: Government Printing Office.
[47] Griessel, H., et al. (2019). Intersectoral collaboration and its impact on the success of housing projects. Johannesburg: University of Johannesburg Press.
[48] Abrahams, M.A. (2015). 'A review of the growth of monitoring and evaluation in South Africa: Monitoring and evaluation as a profession, an industry and a governance tool', African Evaluation Journal, 3(1), Art. #142, 8 pages.
[49] Bauer, M.S., Damschroder, L., Hagedorn, H., Smith, J., & Kilbourne, A.M. (2015). An introduction to implementation science for the non-specialist. BMC psychology, 3(1), p.32.
[50] Bohnet, I. (2016). What works: Gender equality by design. Cambridge: Belknap Press of Harvard University Press.
[51] Boulle, J., Davids, M., Mabogoane, T., Goldman, I. (2015). Early Childhood Development Evidence-Based Policy Making and Implementation Case Study. DPME: Pretoria, South Africa.
[52] Brinkman, S.A., Johnson, S.E., Codde, J.P., Hart, M.B., Straton, J.A., Mittinty, M.N., & Silburn, S.R. (2016). Efficacy of infant simulator programmes to prevent teenage pregnancy: A school-based cluster randomised controlled trial in Western Australia. The Lancet, 388(10057), 2264–2271.
[53] Bryman, A. (2016). Social Research Methods (5th ed.). Oxford University Press.
[54] Cairney, P. (2016). The politics of evidence-based policy making. Berlin: Springer.
[55] Chalmers, I. (2005). If evidence-informed policy works in practice, does it matter if it doesn't work in theory?. Evidence & Policy: A Journal of Research, Debate and Practice, 1(2), 227–242.
[56] Davids, M., Samuels, M.-L., September, R., Moeng, T.L., Richter, L., Mabogoane, T.W. et al. (2015). 'The pilot evaluation for the National Evaluation System in South Africa – A diagnostic review of early childhood development'. African Evaluation Journal, 3(1), Art. #141, 7 pages.
[57] Dayal D., Langer L. (2016) Policy-relevant Evidence Maps: A departmental guidance note. DPME: Pretoria, South Africa.
[58] Dayal, D. (2018). Introducing Evidence Mapping in the SA Public Sector. Keynote presentation at the Using Evidence in the Public Sector: What Can Rapid Response Services and Evidence Maps Offer Learning Exchange, 1 August, Protea Hotel, Pretoria, South Africa.
[59] Dayal, H. (2016). Using Evidence to Reflect on South Africa's 20 Years of Democracy. Insights From Within the Policy Space. Knowledge Sector Initiative Working Paper No 7. Jakarta: Knowledge Sector Initiative.
[60] Department of Basic Education (DBE). (2017). The Early Grade Reading Study (EGRS): Summary Report: Results of Year 2 Impact Evaluation. DBE: Pretoria, South Africa.
[61] Department of Environmental Affairs (DEA). (2016). National Biodiversity Research & Evidence Strategy (2015-2025). DEA: Pretoria, South Africa.
[62] Department of Human Settlements. (2016). Evaluation of whether the provision of state subsidised housing has addressed asset poverty for households and created assets for Municipalities. Available at: https://www.dhs.gov.za/Evaluation%20Reports (Accessed: 24 January 2024).
[63] Department of Human Settlements. (2017) Evaluation of the Impact of Human Settlements Development Programmes on the Environment during the implementation of the 2nd Edition of the Environmental Implementation. Available at: https://www.dhs.gov.za/Evaluation%20Reports. Accessed: 24 January 2024).
[64] Department of Human Settlements. (2010). Monitoring evaluation and impact assessment 2013/2014–2018/2019: Policy and implementation framework for the human settlements. Pretoria: Department of Human Settlements. Available at: https://www.dhs.gov.za/sites/default/files/documents/MEIA_WEB.pdf.(Accessed: 21 May 2024).
[65] Department of Human Settlements. (2014). MTSF Outcome Number 8: Sustainable Human Settlements and Improved Quality of Household Life. Available at: https://www.dhs.gov.za/sites/default/files/documents/MTSF%202014-2019_web.pdf. (Accessed: 24 January 2024).
[66] Department of Human Settlements. (2014). Rapid appraisal of Outcome 8: Output 1. Pretoria: Department of Human Settlements. Available at: https://www.dhs.gov.za/sites/default/files/documents/RAPID%20APPRAISAL_web.pdf. (Accessed: 21 May 2024).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Triple Transition Ecosystem As Catalyst of Public Value Generation.

Dimitrios Symeonidis [a*], Anastasija Nikiforova [b]
[a] Institute of Computer Science, University of Tartu, Tartu, Estonia, dimitrios.symeonidis@ut.ee ORCID number:0009-0006-0254-4388.

[b] Institute of Computer Science, University of Tartu, Tartu, Estonia, anastasija.nikiforova@ut.ee , ORCID number: 0000-0002-0532-3488

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Digital transformation is increasingly reshaping the public and private sectors by enhancing the efficiency and quality of services. With the integration of emerging technologies such as Artificial Intelligence (AI), blockchain, and Internet of Things (IoT), this transformation is becoming a key driver in achieving the United Nations Sustainable Development Goals (SDGs). This shift has given birth to concept of the "triple transition" emphasizes the interconnected the social, green and digital transitions as part of a systemic approach to achieve the SDGs. However, for these technologies to generate meaningful public value, they must rely on high-quality, accessible, and interoperable data. Public Data Ecosystems (PDEs) , as networks of stakeholders engaging in data exchange across the data lifecycle, provide a foundation for transparency and accountability as elements of public value. Their capacity to create broader societal and economic value remains limited without the synergy of advanced digital technologies. To this end, this study proposes the concept of Triple Transition Ecosystems (TTEs) networks of actors leveraging both PDEs and the four-intelligence (4I) paradigm (Data, Artificial, Collective, and Embodied Intelligence) to generate multidimensional public value aligned with the SDGs. Using a systematic literature review that includes thematic analysis informed by public value frameworks, we examine the potential of TTEs across various policy domains. Our findings indicate that TTEs have the potential to generate public value in terms of better service quality and governance, but also higher societal value. By conceptualizing TTEs, this study offers a novel framework for understanding digital transformation as a systemic enabler of sustainable development and provides actionable insights for researchers and policymakers seeking to design triple transition–oriented policies.

Keywords. digital ecosystem; public data ecosystem; public sector; SDG; triple transition; triple transition ecosystem
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1008

1. Introduction

Digital transformation refers tothe adoption and integration of new technologies by stakeholders across both public and private sectors (Gong & Ribiere, 2021). This transformation is widely recognized for improving operational efficiency (Wujarso, 2023), as well as enhancing quality of services in diverse institutional settings (Dias et al., 2022). Fueled by the momentum of the Fourth Industrial Revolution, emerging technologies are now playing an increasingly pivotal role in reshaping organizational processes and governance models. In this context, the so-called four intelligence paradigm (4I) was introduced by Verhulst (2021) constituted by (1) Data Intelligence (DI) - technologies that process and analyze large datasets (e.g., IoT, blockchain) to inform decisions, (2) Artificial Intelligence (AI) - algorithms, including machine learning and expert models, that automate processes and enhance decision-making, (3) Collective Intelligence (CI) that refers to citizen participation via co-creation, crowdsourcing, or digital assemblies, empowering diverse input and democratized governance and (4) Embodied Intelligence (EI) that stands for physical devices and systems that interact with their environment, such as robotics and sensors, driving real-world applications of digital insights.The adoption of 4I technologies not only enhances operational efficiency and service quality but also offers transformative potential for advancing broader societal goals. These technologies contribute directly to the achievement of the Sustainable Development Goals (SDGs) by enabling more sustainable, inclusive, and responsive governance and service delivery.. E.g., AI can enhance energy efficiency by analyzing historical consumption data and identifying optimal patterns, such as aligning energy use with renewable energy surpluses (Farzaneh et al., 2021), blockchain can ensure secure and transparent data

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

transactions, verifying the performance of public and private organizations in achieving SDG targets (Muheidat et al., 2022). Additionally, open data combined with citizen science initiatives amplifies diverse perspectives, fosters inclusivity, and supports informed decision-making to reduce inequalities and enhance societal outcomes (Moedas, 2018). The majority of the SDGs, such as those targeting climate action, poverty alleviation and gender equality are inherently linked to public value generation. This aligns closely with the emerging notion of the triple transition, the concept of the triple transition, which integrates digital, green, and social transformations into a unified framework for sustainable development. According to the OECD (2023), triple transition stands for "a systemic approach that places the interlinkages and interconnections of the environmental, digital, and social aspects of development at the core", while the EU (2023) refers to it as the social, green and digital transition, connecting it with the 17 SDGs. In this context, public value creation is multifaceted. Drawing on Meynhardt's (2009) framework, it can be understood across four dimensions, namely moral-ethical, hedonistic-aesthetical, political-societal and utilitarian-economic, each representing a critical aspect of how digital innovation can enhance collective well-being.

While all artifacts of the 4I paradigm have the potential of generating public value contributing to the achievement of the SDGs, their effectiveness is contingent upon the the availability of high-quality data. Accurate, complete, and reliable datasets are essential for trainingAI models that support informed decision-making, personalize user experience and improve service outcomes and customer satisfaction (Daneshjou et al., 2021; Deekshith, 2021).

In this context, Public Data Ecosystems (PDEs) emerge as foundational systems composed of data and diverse stakeholders ranging from public institutions and private sector to academia and citizens, interacting dynamically across the data lifecycle. PDEs facilitate the flexible exchange and management of data, enabling stakeholders to collaborate in data-driven decision-making. These ecosystems contribute to public value by promoting transparency and accountability through accessible information, such as fiscal records or environmental indicators, and by encouraging broad participation in data governance. While transparency and accountability align with moral-ethical and political-social values (Meynhardt, 2009), PDEs also have the potential to generate utilitarian and economic value – two types of values often disregarded by research. For instance, sustained growth in the data economy can drive innovation and long-term economic benefits, however, for such outcomes to be achieved, it is stipulated that PDEs are leveraged by emerging technologies (Farboodi & Veldkamp, 2022; Nikiforova et al., 2024), such as constituents of the 4I paradigm.

However, realizing this potential requires synergy between PDEs and 4I technologies. PDEs need technological enablers to unlock their full value, while 4I technologies rely on robust data ecosystems to function effectively.Addressing this interdependence by drawing upon the literature on PDEs, 4I and the triple transition (Pincheira et al., 2021; Farboodi & Veldkamp, 2022; Lnenicka et al., 2024; Nikiforova et al., 2024), we propose the concept of Triple Transition Ecosystem (TTE) that we define as a collaborative network of public and private actors, civil society, citizens and academia, in which stakeholders engage in data transactions and leverage 4I technologies to co-create public value and support the social, digital, and green transitions integral to achieving the SDGs. As TTE is built upon PDE, 4I, and triple transition, it is important to explore and conceptualize their convergence and potential for public value generation, which motivates this study.This study aims to conceptualize the TTE and explore its capacity to generate multidimensional public value by examining the convergence of PDEs and 4I artifacts. Specifically, we examine the roles of its key components - artifacts of the 4I paradigm and PDE. By investigating how these components contribute to public value creation, the study seeks to provide a deeper understanding of their interplay in fostering collaboration between public and private sector and civil society, driving innovation, and addressing societal challenges in the digital age. This research employs a systematic literature review (SLR), whose results are analyzed through thematic analysis, where to distinguish between types of public value being generated by TTE, a public value model inspired by the models of Meynhardt (2009) and Tweyzyimana & Andersson (2019) is used for code generation.

The results show that TTE has the potential to generate public value in a wide spectrum of policies, including land, tax, environmental, urban policy, as well as policies on cultural heritage, human rights, health and freight transport. Citizen participation, transparency, operational efficiency and sustainability are key elements of public value that can be generated by TTE. With this research we make a call for a discussion on the new concept of TTE and how public policy can promote their development in a manner that can spur the generation of public value.

The rest of the paper is organized as follows. In the second section, we provide a background on PDEs and the 4I paradigm, their potential to generate public value and their limitations and introduce the concept of TTE. The third section presents the methodology. In the fourth section, we present the results of the analysis with the fifth section constituting a discussion of the findings. The final section concludes the study.

2. Background

The process of digital transformation has become increasingly significant globally during the past decade, as both public and private services rely heavily on digital practices and processes (Alvarenga et al., 2020; Brunetti et al.,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2020; Dener et al., 2021).

A parallel shift observed over the past decade is the global commitment of the United Nations (UN) members to the SDG agenda (Biermann et al., 2019). Countries worldwide are setting ambitious targets to address critical challenges, such as mitigating climate change, eradicating poverty and inequality, and fostering sustainable economic growth.

Digital technologies play a pivotal role in advancing SDGs (Mandejar et al., 2021), Jones et al., 2017). For instance, AI models can be trained on historical energy consumption data to identify consumption patterns that maximize energy efficiency. Examples include using energy when there is renewable energy surplus, recommending using appliances in the most efficient manner or finding the optimal time to use Vehicle to Grid (V2G) or Vehicle to Home (V2H) technologies (Farzaneh et al., 2021). Blockchain, in the form of a complex hashing algorithm, can be used for key and signature matching to verify data transactions, which can be helpful to avoid fraud during data exchanges that might be relevant to show the performance of public and private sector organizations with regards to achieving the aforementioned SDGs (Muheidat et al., 2022). Open data can also have an impact on SDGs. When effectively coupled with citizen science initiatives (as part of CI), it has the potential to amplify diverse perspectives and contribute to reducing inequalities by increasing transparency, inclusivity, and informed decision-making (Moedas, 2018), although yet to be improved.

Moreover, to monitor and evaluate the performance of public and private sector organizations against SDGs, coordinated data collection and analysis strategy, combined with robust digital governance frameworks (incl. data governance frameworks) are paramount. While data collection strategies focus on ensuring high-quality data collection in a cost-effective manner, while addressing concerns related to data privacy and anonymity concerns (Johnson & Turner, 2003), data governance frameworks encompass the entire data lifecycle—collection, storage, processing, and disposal (Abraham et al., 2019). This data collection is expected to be conducted in a manner that ensures the representativeness of samples from all affected groups, while also guaranteeing the quality and accessibility of data. Emerging technologies, such as IoT, drones, AI-driven tools and intelligent devices can enhance data collection from diverse sources (Plageras et al., 2018), thereby increasing representativeness of data and informing decision-making (Asghari et al., 2019; Plageras et al., 2018). Additionally, CI can significantly contribute to the data collection process. Initiatives such as living labs and crowdsourcing are effective in gathering data and public opinions on societal and environmental topics. These approaches not only enhance data diversity but also have the potential to democratize political decision-making (Hossain & Kauranen, 2015)—provided there are effective communication channels between citizens (that will participate in these collective initiatives) and decision-makers, and these channels are used actively and effectively (Hossain & Kauranen, 2015; Lnenicka et al., 2024).

PDEs, facilitating dynamic data exchange among diverse stakeholders (e.g., government, private sector, citizens, academia), possess the potential to significantly enhance data availability and contribute to the achievement of the SDGs by generating substantial public value.

PDEs can enhance transparency and accountability by increasing data accessibility for all stakeholders. Citizens, for instance, can readily access publicly generated data, such as fiscal, demographic, and socio-environmental indicators (e.g., unemployment, poverty, equality, environmental pollution), empowering them to engage more effectively in SDG-related initiatives. Moreover, increased transparency in data transactions fosters accountability by clearly delineating the contributions of each stakeholder within the ecosystem, ensuring data quality and completeness from all participating entities.

However, the concept of public value extends beyond trust and institutional legitimacy associated with accountability and transparency. Following Meynhardt (2009), public value encompasses the multifaceted relationships between individuals and the broader "society," encompassing all entities with which an individual interacts, including both public and private sector actors. Meynhardt (2009) categorizes these relationships as: (1) moral-ethical, (2) hedonistic-aesthetical, (3) political-social, and (4) utilitarian-instrumental. While accountability and transparency primarily align with moral-ethical and political-social values, a notable gap exists in the current discourse regarding the contribution of PDEs to other facets of public value, particularly the utilitarian-instrumental domain. This gap is exemplified by the limited exploration of strategies for operationalizing the data economy (Hilbert, 2016).

Regarding the utilitarian and economic value of data, it has been argued that a thriving data economy necessitates the conceptualization of data as a long-lived, depreciating, and tradable asset. To sustain long-term data value -and possibly it growth- it is imperative to integrate data into research and development activities, enabling continuous innovation and the accumulation of new knowledge (Farboodi & Veldkamp, 2022). Consequently, the effective utilization of data through emerging technologies to foster novel innovations can significantly enhance the societal value of PDEs. To this end, a new so-called four intelligence paradigm (4I) encompassing AI, DI, CI and EI (Verhulst, 2021)) seems reasonable to be addressed and integrated into the current landscape.

According to 4I (Verhulst, 2021), DI encompasses technologies and methodologies that enable the analysis and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

processing of large datasets generated from diverse sources, including devices, sensors, and operations within both public and private sectors. The processing and analysis of such data within the DI framework hold significant potential for enhancing decision-making processes. Three key components constitute DI:

1. **open data** that refers to data systems, where all stakeholders within a data ecosystem have consistent access to datasets, enabling them to analyze, utilize, and redistribute databased on their specific interests and motivations;

2. **data collaboratives** resembling living labs and citizen science projects that are typically led by private sector entities in collaboration with civil society, through which data is exchanged to generate public value;

3. **IoT** that facilitate the real-time extraction and availability of data generated by devices, with common applications including household electronic appliances and sensors strategically placed within infrastructure grids, such as water or energy systems;

4. **Distributed Ledger Technologies (DLT)/blockchain** technologies that contribute to DI by employing advanced cryptographic techniques to ensure data storage and distribution in a transparent manner, while addressing privacy concerns through mechanisms like “smart contracts.”

Artificial Intelligence

AI within 4I is defined as computational processes designed to perform tasks traditionally carried out by humans (Verhulst, 2021). AI has evolved to include models capable of informing decision-making processes. Two primary artifacts of AI relevant to the intelligence paradigm are:

1. **Machine Learning (ML)** that leverage data to "learn" and generate actionable insights, thus informing decision-making processes;

2. **expert models** specifically designed to replicate human cognitive processes, with their application restricted to decision-making tasks.

Collective Intelligence (CI)

CI, in turn, shares similarities with data collaboratives but focuses on engaging individuals, irrespective of their stakeholder group, to foster citizen participation (Verhulst et al., 2021). CI manifests in several forms, with individuals contributing via smart devices or participating in physical events, such as citizen assemblies, with key artifacts of:

1. **participatory co-creation** involving the use of technological tools to gather data from stakeholders across an ecosystem, which is particularly relevant to geospatial data, where mapping tools integrate individual contributions with spatial datasets;

2. **(smart) crowdsourcing** that, while similar to participatory co-creation, focuses on collecting qualitative data, such as community improvement ideas or problem identification, from stakeholders;

3. **(digital) citizen assemblies** that combine networking opportunities with digital tools in physical settings to enable citizens to co-create policies. Unlike crowdsourcing, citizen assemblies operate with a defined agenda centered on local policies, leading to the designation of these initiatives as "crowdlaw."

Embodied Intelligence (EI)

Finally, EI encompasses AI components that are used in the physical world (Verhulst et al., 2021). The main purposes include automation of industrial processes such as manufacturing, as well as providing real-world, and real-time information on matters such as air quality and health, with EI artifacts entailing:

1. **robots as** reprogrammable machines that can harness the power of AI software to perform automated tasks that have mostly been deployed in the manufacturing sector, with other applications being at a nascent stage;

2. **drones** (also known as unmanned aerial vehicles (UAVs)) - aerial vehicles that are either controlled by remote pilots or by AI software.

According to Verhulst et al. (2021), the interconnected paradigms of DI, AI, CI and EI with its unique artifacts and methodologies collectively enhance data-driven decision-making and citizen engagement. According to this intelligence paradigm, emerging technologies generate novel forms of intelligence that, either independently or in

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

combination, can enhance governance and drive innovation, contributing to addressing multiple SDGs.
However, the different types of intelligence have a similar gap ought to be addressed. They rely on high-quality, reusable data, which remains a critical gap. E.g., AI does not yield the expected results in sectors like healthcare because of the lack of adequate data availability with, radiology and nuclear medicine research and development entities requiring data to train AI models that can help more easily detect suspicious diseases based on X-ray scans (Kocak et al., 2019). However, there are no (public/open) data ecosystems yet developed that can help increase data availability, rendering the utility and potential for public value of AI in this sector rather limited. Similarly, DI artifacts require synergies with PDEs to increase their potential for public value generation. As an example, open data or data sharing initiatives in the horticulture industry can bring benefits to local farmers, who will have larger data availability that will help them make better investment decisions on their infrastructure (Cazacu et al., 2023). Data sharing can also help them make other types of decisions, such as switching crops (De Prieelle et al., 2020). Such examples are evidence for the need for data availability covering the different artifacts of the 4I paradigm that would facilitate generation of expected public value.

This, however, creates a certain controversy. On one hand, PDEs require synergies with artifacts of the 4I paradigm to generate forms of public value beyond transparency, accountability and openness. On the other hand, these technologies require data availability to have meaningful impact for the stakeholders that utilize them. To tackle this controversy, we introduce the concept of TTEs. We define a TTE as *an extensive network of actors, including public, private sector, civil society and citizens, which are actively involved in data transactions and by leveraging artifacts of the four intelligence paradigm facilitates maximization of public value, based on their own personal interests, primarily, but also for the public good*. This definition is informed by academic discourse about PDE and its subsets (such as ODE) and how they can operationalize the data economy (Lnenicka et al., 2024), as well as practical challenges associated with data availability for unlocking the application of artifacts of the 4I paradigm, such as AI (Daneshjou et al., 2021) and blockchain.

Whilst there has been research on the utilization of emerging technologies to generate different elements of public value (Madan & Ashok, 2023), such as increase efficiency of services or make operations more sustainable (Nishant et al., 2020), as well as the potential of PDEs to generate public value through transparency, openness and accountability (Reggi & Dawes, 2016; Lnenicka et al., 2022), there is lack of clarity on the holistic public value that their synergy -or what we refer to as TTEs- can create. Even though evidence from literature demonstrates that artifacts of the 4I paradigm require data availability to increase their impact, but also that PDEs alone have limited public value, there is a lack in studies examining the relationship between artifacts of the 4I paradigm and PDEs in the context of creating public value, which is the gap we address.

As such, the main objective of this study is to conceptualize a TTE comprising artifacts of the 4I paradigm and PDE, and explore its potential for supporting data-driven and evidence-based policymaking that results in public value generation. This will inform the exploration of the types of public value that TTE can create, in terms of societal, ethical, utilitarian and aesthetic value (Meynhard, 2006).

3. Methodology

To attain the set objective, a systematic literature review (SLR), followed by a thematic analysis to generate codes based on the potential of TTEs to generate public value is conducted. Code generation was informed by a meta-synthesis of the e-government public value framework introduced by Tweziyimana & Andersson (2019) and the public value framework by Meynhard (2006). Our SLR followed guidelines proposed by Kitchenham (2004), namely identification of research objectives, selection of primary studies, study quality assessment, data extraction and monitoring and data synthesis. The first step includes familiarization with the existing research, through preliminary research. As a second step, we identified keywords for the query, namely on the convergence between PDEs and artifacts of the four intelligence paradigm.The search query was defined as a combination of "public" and "data ecosystem" terms, where the latter was accompanied with alternative resulting in*("data ecosystem" OR "data infrastructure" OR "data space" OR "data system" OR "data collection ecosystem" OR "dataset* ecosystem" OR "data set* ecosystem" OR "data on the web ecosystem") AND ("public"),* which was used to query Scopus, WoS and Google Scholar.

The selection of the keywords with regards to PDE is justified by the multiple structures of data ecosystems that have been described or introduced by scholars (Lnenicka et al., 2024), which includes data infrastructure (Maretti et al., 2021), data ecosystem (Schade et al., 2015), data system (Formosa, 2014), as well as data space (McKenna, 2017). To make the connection to the 4I paradigm, the protocol was developed to document analysis of researched studies that examined the convergence of PDE with at least one of the 4I paradigm artifacts.

During the identification process, a total of 1,121 research papers were identified. After the screening process, 573 papers were excluded as sector-specific. Only studies pertaining to the fields of computer science, information technology, public administration, and engineering were retained as most relevant to TTEs, which are inherently linked to computer science, information technology, and engineering, with a public value component aligned with

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

public administration and management. Only studies published in the period between 2014 and 2024 were retained to render the most relevant to this study, with older studies seen as less pertinent to TTE due to the rapid pace of technological advancements. Furthermore, the inclusion criteria encompassed conference proceedings, book reviews, and publications in scientific journals.
Subsequently, an eligibility analysis was conducted. During this stage, all studies in language other than English were excluded, reducing the pool to 370 studies. An eligibility check involved the manual exclusion of studies deemed irrelevant to the research topic based on title and abstract, as well as studies with only titles and abstract in English. As a result, only 152 research papers were selected for analysis (see Figure 1).

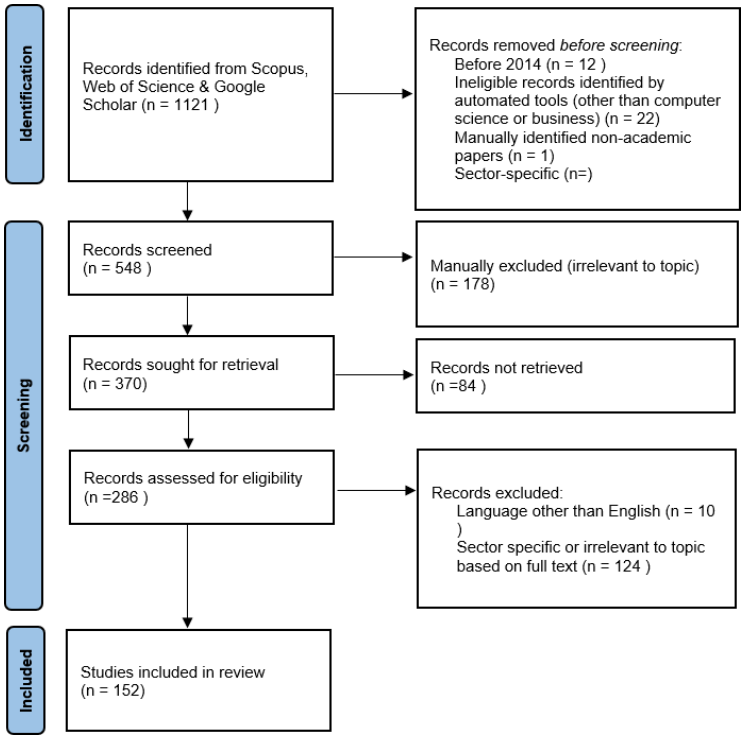


Fig. 1. Systematic Literature Review Process

The analysis of these studies was documented in a protocol developed by Lnenicka et al. (2024) to assess literature on PDEs. Following that, the final selection of studies was assessed based on this protocol that was developed as part of this research. The protocol consists of a series of questions that are presented in Table 1.

Tab. 1: Part of the protocol used in the SLR. The protocol will be disclosed in full in Zenodo upon paper acceptance.

Question Sector	Question
PDE-Specific	PDE/ODE Involved?
	Other terms related to ODE/PDE or other types of data ecosystems?
	If openness is not explicitly mentioned, does the study incorporate public and/or private components?
	- If yes, what is the structure of the ecosystem proposed?
	What stakeholders are involved in the ecosystem proposed?
	Which stakeholders are highlighted as most important?
	What types of data are involved in the ecosystem proposed?
4I-Specific	Is DI covered?
	Is AI covered?
	Is CI covered?
	Is EI covered?
	What are the artifacts it consists of/contains?
	Who are the stakeholders associated with the research on these types of intelligence and what roles do they fulfill?
	How is each type of intelligence affecting/what is its role in PDE/ODE?
	Is there any convergence of multiple intelligence paradigms?
	If so, what types of intelligence and what artifacts are involved?
	What artifacts are being integrated and through which methods/processes?

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The next step included thematic analysis, which was conducted according to the six-step approach by Braun and Clarke (2006) extended by Maguire and Delahunt (2017). This approach suggests starting with familiarization with data, which is initiated after the SLR, followed by generation of the first set of codes that are then converted into themes. These themes are then reviewed and assigned final names and definitions, which we present in Results section.

Several public value frameworks informed development of the codes and themes. For example, the widely used public value scorecard proposed by Moore (2012) is used to assess the application of existing technological artifacts and systems and is not applicable for conceptual models, with the model by O'Flynn (2007) facing the same issues and targeting solely public managers. This comes in contrast with the theme of this study, which aims at conceptualizing the introduced term, encompassing stakeholders including private sector and citizens. Taking this into account, a meta-synthesis of frameworks took place. The initial framework that was used as a reference model for our integrated model is the model developed by Meynhardt (2006). Even though it is only conceptual framework, this framework can also be used for operational purposes and converted into a scorecard. As the framework is not directly related to assessing the public value of technology, the dimensions of public value are not broken down into the four categories provided by the author in his follow-up work (Meynhardt, 2009). Instead, the e-government public value framework, developed by Twizeyimana & Andersson (2019) is being adapted. According to this model, the dimensions of public value for e-government are improved public services, improved administration and improved societal value. The main categories of the e-government public value model are relevant for all digital technologies and all sectors (public and private), however the sub-categories are only relevant to the e-government sector. Hence, these categories are being reshaped and merged with the Meynhardt (2009) model into a framework as presented in Figure 2. All pillars from the model by Meynhardt (2009) were integrated into the category of the model by Twizeyimana & Andersson (2019) considering their individual suitability. For example, transparency and accountability fit most governance, whilst reliability and efficiency of services - improved service quality.



Fig. 2: Public Value Framework for TTE SLR

Based on this framework, the themes and codes that have been identified above as elements of public value are used to understand the type of public value that each instance of the TTE (PDE, four intelligence paradigm) can create. In addition, as part of the conducted SLR, we seek for identifying sectors/types of policy where the (potential) value of what we call TTE was studied.

4. Results

The results of our SLR show the convergence of PDEs and artifacts of the 4I paradigm as identified in literature can act as catalysts to generate public value in various policies. This convergence was found to have the potential to inform land, tax, environmental, urban, health, human rights, cultural heritage and freight transport policy, which we elaborate on in more detail below.

Land policy

TTEs in land registries hold promise to enhance operational efficiency in the public sector, even if the first attempts were not met with success. This is evidenced by Denmark in 2009, which was successful in reducing the time intensity of land registry procedures, but also faced deficiencies, such as the lack of mechanisms to verify land-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

related data, such as geographic data (Naghavi et al., 2022), which is suggested to be tackled by blockchain systems that harness PDEs. More specifically, Voluntary Geographic Information (VGI) systems constitute a new way of crowdsourcing of geospatial data (**CI** artifact), increasing **citizen involvement** (Naghavi et al., 2022). Combined with blockchain to verify and secure data transactions (**DI** artifact), they can be used by land registries and then visualized to improve **efficiency** and simplify the service itself (Kliment et al., 2016). This can be in a form of a private/restricted blockchain based on majority consensus, where the users can use hashing algorithms such as SHA256 or Proof-of-Work (PoW) algorithms to ensure the validity of geospatial data entered that are related to a piece of land, so that the land registry can update all the characteristics of different assets (Krishnapriya & Greeshna, 2020).

Tax policy/Compliance

The aforementioned use of blockchain (**DI**) and VGI (**CI**) systems extends to tax policy. Firstly, this combination can serve as a proof for the tax obligations that stem from land property. Secondly, other artifacts combinations with blockchain can support provision of tax obligations for other assets. As an example, images of assets (such as land property, houses) generated through citizens' devices can then be processed by **AI** for their categorization to understand the type of asset and their value (Petersen et al., 2019). The "cleaned" data can then be validated by blockchain, which can be converted into proof of assets for citizens, which can then be taxed accordingly, further improving **operational efficiency** for the departments of finance at local, regional and national governance level. Similarly, this can be used for whistleblowing cases, where illegal buildings or other assets are not registered and, through this digitized process and using citizen-generated data from PDEs changes in taxation or recompenses can be administered financially for **citizen participation** and **transparency** purposes. Finally, TTEs can increase efficiency, when Generative **AI** harnesses publicly available financial reports of firms and checks them against existing tax policies and regulatory frameworks (Chen et al., 2024).

Urban Planning

The transformative effect of TTE is also foreseen in urban planning. An example includes the proposition of PFLOW (Kashiyama et al., 2017), which proposes an open data system, where data inputs by citizens can be provided voluntarily about their movements, either within their vehicles, public transportation or on foot, to understand traffic patterns (**CI**). Such a system, complemented by a GIS system, has the potential to support urban planning through **citizen participation**. As the voluntary data generated and provided might require cleaning or verification, **AI** and blockchain (**DI**) can find their use in this context and, following that phase, the final datasets can be harnessed by urban planners to help making cities more livable, reducing traffic and improving **sustainability**.

Environmental policy

There is some evidence that environmental policy is a potential beneficiary of TTE. Environmental monitoring is one of the cases where TTEs can have added value. Open government data portals can enhance **transparency** of governments, increasing the availability of environmental data, such as CO2 emissions (Misra et al., 2017). However, this data should be provided in a clear format being easy to understand by diverse stakeholders, with every stakeholder having a suitable data literacy level (Hintz et al., 2023). For that to occur, **AI**'s data curation, cleaning, alignment, sketching and processing potential can make data clearer, understandable and reusable (Purawat et al., 2021), whilst data collaboratives (**CI**) can, in the long term, improve environmental data literacy among citizens (Verhulst et al., 2023). According to Shusha et al. (2023), developing an open data ecosystem (**DI**), where space data are deposited increasing **citizen participation**, has been largely beneficial for actors such as the Swedish Forestry Agency and other governmental entities that work on the environment in Sweden. While this research focuses on open data ecosystems, the concept can be expanded to a broader concept of PDEs OGD is a subset of, having the benefit of larger data availability due to the participation of more stakeholders in the ecosystem. Providing clean space data can support these agencies, as they can introduce them into their AI models (**AI** artifacts) and generate insights of expected environmental degradation under different environmental policy scenarios, thereby supporting **sustainability**. Other cases include smart cities, where sensors and IoT technologies (**DI**) are deployed within a city context referred to as "urban tech" and allow cars, buses, bicycles, and citizens to collect data about air quality, noise pollution, and the urban environment at large, through sensors installed in the vehicles, as well as devices operated by citizens (Zerza & Park, 2020). These types of data can be then leveraged by municipalities to understand the level of environmental degradation in real time, shaping policy accordingly and reducing the response time.

Another case where TTEs can be useful for environmental policy is energy and resource efficiency. Resource efficiency and overall environmental conservation requires even larger amounts of diverse data. E.g., while datasets with overall or even per region energy consumption can help inform policy making at a macro level, combination with geodata provides information on the energy consumption for individual buildings, which can result in a spatial visualization of energy consumption patterns and, thus, make interventions in

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

buildings/neighborhoods where, for example, high energy usage is being observed. Other examples include using geodata to estimate the solar rooftop potential of each neighborhood and install photovoltaic panels where this potential is the highest (Mainzer et al., 2017). This, in turn, can take place using satellite imagery and drones (**EI**). Moreover, due to the large amounts of data processed by **AI**, there is the issue of sustainability that ought to be addressed, with green computing being one of emerging solutions to the sustainability conundrum, which includes e-waste minimization, as well as innovations such as energy efficient hardware, virtualization software and green algorithms, that result in the minimized use of energy during their runtime (Lannelongue et al., 2021).

Health Policy

Health policy can also largely benefit from a TTE. Ahmad et al. (2022) provide an overview of how healthcare can be transformed from this convergence in a smart city context. There are four models that can be used for digital transformation of healthcare. In healthcare 1.0, stakeholder participation in PDEs is very low, with no 4I artifacts and no public value associated with this model. In healthcare 2.0, there is slightly higher participation of stakeholders in PDEs, however, 4I artifacts are still not used and the only public value-related benefit is an increased efficiency. In healthcare 3.0, there is a high level of **citizen involvement** in PDEs, with EI artifacts such as wearables and artificially intelligent devices, resulting in **citizen participation** and **reliability** of results. Finally, in healthcare 4.0, there is a very high involvement of stakeholders and, in addition to **EI**, **DI** artifacts such as blockchain can be observed, as well as **CI** artifacts, such as citizen science (termed as big medical data) to ensure privacy, in addition to the foregoing public values.

Human Rights

A convergence of PDEs and artifacts of the four intelligence paradigm can be of use also for the human rights policy, in two manners. First, in relation to digital rights. Calzada & Almirall (2020) propose the development of GovTech labs in cities, using global examples and applying them to the case of Barcelona. These ecosystems employ public AI and public analytics, powered by blockchain (**DI**) to ensure anonymization processes and privacy-preserving procedures during co-creation in citizen science structures (**CI**), which include data commons. This is a dynamic type of infrastructure, whereby citizens actively provide their inputs in the data commons, which then are used to inform legislation around digital rights, leading to increased **citizen participation**. Human rights policy in general can be informed in a similar way. Nelson & Zanti (2020) propose a framework, where PDEs are complemented by data collaboratives (**CI**) and the use of machine learning tools (**AI**) to understand whether racial equality principles are respected in certain areas within a country. This is largely useful to inform policies relevant to minorities and indigenous communities in countries that have these populations, indirectly related to **human dignity**.

Cultural Heritage

In addition, policy around cultural heritage can be affected. E.g., Vahidnia (2023) explored how open data ecosystems can help inform urban decay through the support of VGI (**CI**), proposing a framework, where municipalities, civil society organizations and the private sector working on tourism develop a spatial data infrastructure (SDI), combined with a collection of other data, such as images, being crowdsourced by stakeholders and then introduced into a living lab (**CI**). These data are then processed within living labs and, following a co-creation process, policy recommendations are used to help preserve buildings of importance for **cultural heritage**.

Freight and Long-Distance Transport Policy

Lastly, the possibility of informing long-distance transport policy emerged as a pattern, with freight logistics in focus, in particular. Horizontal collaboration among stakeholders through smart contracts, using blockchain (**DI**), that harness open data and using **AI** to develop emission scenarios for different policies based on the aforementioned data is considered an efficient measure to track CO2 emissions in freight transportation from the governance side (Larsson et al, 2024). Environmental monitoring is deemed as the main reason for the utilization of this convergence in this case, resulting in enhanced **sustainability**.

Thus, TTEs have a role to play in several different policies as summarized in Figure 3.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

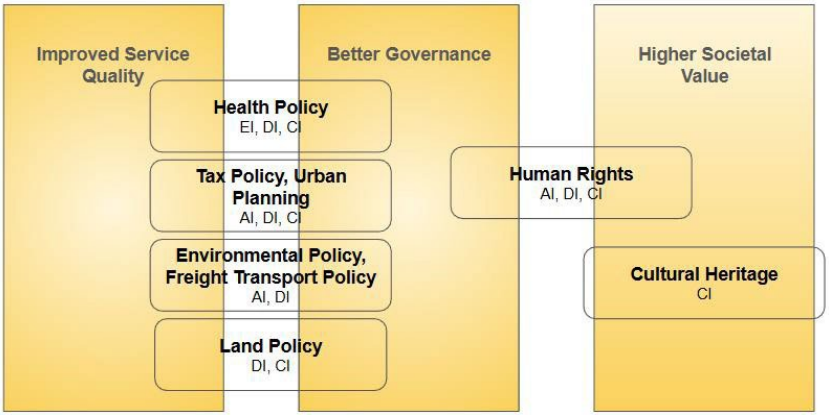


Fig. 3: Impact on TTEs in generating public value in policies

5. Discussion

The results show that TTEs hold promise to generate public value in various sectors and through several different means. Its approach can have benefits for policies in several sectors of the government. It can improve sustainability through energy efficiency in the built environment, which is a public value important in the smart cities sector. Local governments are increasingly implementing smart city initiatives and, according to the definition by the European Commission (n.d), upgrading energy and water infrastructure, as well as the built environment to become more efficient and sustainable is one of the key aspects of a smart city. Hence, TTEs have the potential to generate public value in the form of sustainability for the smart city realm.

Another sector where TTEs are a promising solution to generate public value is cultural heritage. This requires collaboration between macro and micro levels, namely national and local governments. The use of VGI and combination with AI can contribute to comprehending the level of decay that different cultural and historical heritage sites have undergone. Citizens' role can be instrumental in this application and, if organized as a crowdsourcing initiative, it can be an example of CI application for cultural heritage purposes. However, the majority of cultural heritage preservation projects involve the financial and operational capacity of the relevant responsible bodies such as ministries. The public value that can be created, apart from preservation of cultural heritage, is also aesthetic, since cultural heritage sites are usually considered to be visually and aesthetically appealing.

The potential to generate public value at both a micro and a macro level is also significant in tax and land policy. VGI has been portrayed as a means to increase data availability on land and other assets that individuals possess. This informs both local and national governments with regards to the assets of each individual for two purposes - first, to develop social policies such as social housing and the second - to tax individuals, so that less cases of tax evasion occur. Correspondingly, this implicates data that are collected at a local level, usually applying citizen science methodology. Data collected through citizen science are then transferred to the Ministry of Finance. The public values associated with the use of TTEs in this policy are efficiency, as well as accountability.

The last policy that is applicable to coordination between micro and macro level of governance as identified by this study encompasses human rights. CI and open data, in the form of citizen science initiatives such as data commons, can be used both to understand how citizens perceive the adoption of technology from the public sector and to what extent it ensures their personal dignity, but also how emerging technologies such as AI and machine learning are addressing (or not) diversity, equity and justice aspects of our society. Hence, TTEs have the potential to also generate public value related to humanitarian/societal causes.

Finally, there is a policy that covers only the macro level. This is the freight and long-distance transport policy. Tracking emissions using open data on the emissions of the different transport routes and exchanging data between governmental agencies through blockchain can help increase transparency and understand the bigger picture with regards to the contribution of long-distance and freight transport in the overall environmental pollution. This is related also to sustainability.

6. Limitations

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This study has several limitations. The first is related to the choice of public value frameworks used in this study to explore the potential of TTE for public value generation. Several frameworks exist, having elements going beyond those covered by used framework, some of which could be useful to assess public value generation potential of TTEs, e.g., recreational or historical values as comes from (Zhang et al., 2024). These values, however, seem to have a low probability of being generated by TTEs and, thus, were not taken into account in this study.

Another limitation lies in the applicability of the results. The majority of the cases found in literature, where a convergence of PDEs and 4I artifacts has the potential to generate public value, are conceptual. Hence, it is recommended that different case studies are developed. Case studies should include interviews with relevant stakeholders to explore how the concept of triple transition ecosystems could be operationalized, what its actual potential to generate public value is, and what the main obstacles are.

Finally, there are public values that are not distinguished in literature, such as accountability and transparency. Accountability focuses on the ownership and responsible behavior and, in the context of open data, is related to ensuring that data privacy regulations are being taken into consideration. In some cases, this is rather challenging, as datasets possess sensitive data, such as personal information of citizens, but also data that is important for reusability services, such as health-related epidemiological data that are crucial to inform decision-making. To this end, blockchain technologies can be used in combination with PDEs to ensure anonymity and respect towards data privacy, however, so far literature has not addressed accountability alone.

7. Conclusion

In this study we introduce a concept of TTE that builds upon two complementary concepts of PDEs and the 4I paradigm, the call for which has been made by previous research. As a new concept, knowledge on the potential of TTEs as a combination of the above for the use in the public sector, types of policies it can affect and the kind of public value it can create is limited. The results of this study reveals that there is potential for the TTE to generate public value across ministries and agencies generating public value ranging from sustainability to transparency, accountability, efficiency and innovation. Nonetheless, development of pilot projects and operationalization of TTEs is essential to comprehend whether the conceptual cases found in literature can have the expected impact.

Acknowledgement

- **Funding or Grant** : This work was supported by the Estonian Research Council grant "Developing human-centric digital solutions" (TEM-TA120) and the Mobility Grant of the Estonian Doctoral School.
- **Contributor Statement***: Describe properly all author contributions and all types of contributions) see Policies (tudelft.nl)
- **Use of AI***: During the preparation of this work, the authors used ChatGPT to adjust the text for language and tone. After using this tool/service, the authors reviewed, edited and validated the outcome, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Abraham, R., Schneider, J., & Vom Brocke, J. (2019). Data governance: A conceptual framework, structured review, and research agenda. *International journal of information management*, *49*, 424-438.

Alvarenga, A., Matos, F., Godina, R., & CO Matias, J. (2020). Digital transformation and knowledge management in the public sector. *Sustainability*, *12*(14), 5824.

Asghari, P., Rahmani, A. M., & Javadi, H. H. S. (2019). Internet of Things applications: A systematic review. *Computer Networks*, *148*, 241-261.

Biermann, F., Kanie, N., & Kim, R. E. (2017). Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals. *Current Opinion in Environmental Sustainability*, *26*, 26-31.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Brunetti, F., Matt, D. T., Bonfanti, A., De Longhi, A., Pedrini, G., & Orzes, G. (2020). Digital transformation challenges: strategies emerging from a multi-stakeholder approach. *The TQM Journal*, *32*(4), 697-724.

Cazacu, S., Mulder, I., Vande Moere, A., & Steenberghen, T. (2023, May). Revealing the role of values in developing a garden data ecosystem through a reflective participatory design approach. In Proceedings of the 11th International Conference on Communities and Technologies (pp. 156-162).

Chen, C., Howe, J., Kariotis, T., & Jackson, S. (2024). Open data, workplace relations law compliance, and digital regulation. *Data & Policy*, *6*, e26.

Daneshjou, R., Smith, M. P., Sun, M. D., Rotemberg, V., & Zou, J. (2021). Lack of transparency and potential bias in artificial intelligence data sets and algorithms: a scoping review. *JAMA dermatology*, *157*(11), 1362-1369.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

De Prieëlle, F., De Reuver, M., & Rezaei, J. (2020). The role of ecosystem data governance in adoption of data platforms by Internet-of-Things data providers: Case of Dutch horticulture industry. *IEEE Transactions on Engineering Management*, *69*(4), 940-950.
Dener, C., Nii-Aponsah, H., Ghunney, L. E., & Johns, K. D. (2021). *GovTech maturity index: The state of public sector digital transformation*. World Bank Publications.
Dias, A. M., Carvalho, A. M., & Sampaio, P. (2022). Quality 4.0: literature review analysis, definition and impacts of the digital transformation process on quality. *International Journal of Quality & Reliability Management*, *39*(6), 1312-1335
European Council. (2023). The Council approves conclusions on a social, green and digital transition. Council of the European Union.
Farboodi, M., & Veldkamp, L. (2021). *A model of the data economy* (No. w28427). Cambridge, MA, USA: National Bureau of Economic Research.
Farzaneh, H., Malehmirchegini, L., Bejan, A., Afolabi, T., Mulumba, A., & Daka, P. P. (2021). Artificial intelligence evolution in smart buildings for energy efficiency. *Applied Sciences*, *11*(2), 763.
Formosa, S. (2014). If Appleseed had an open portal: making sense of data, SEIS and integrated systems for the Maltese Islands. In *Computational Science and Its Applications–ICCSA 2014: 14th International Conference, Guimarães, Portugal, June 30–July 3, 2014, Proceedings, Part II 14* (pp. 709-722). Springer International Publishing.
Gong, C., & Ribiere, V. (2021). Developing a unified definition of digital transformation. *Technovation*, *102*, 102217.
Hilbert, M. (2016). Big data for development: A review of promises and challenges. *Development Policy Review*, *34*(1), 135-174.
Hintz, A., Dencik, L., Redden, J., & Trere, E. (2023). Civic participation in the datafied society| civic participation in the datafied society—introduction. *International Journal of Communication*, *17*, 13.
Hossain, M., & Kauranen, I. (2015). Crowdsourcing: a comprehensive literature review. *Strategic Outsourcing: An International Journal*, *8*(1), 2-22.
Johnson, B., & Turner, F. (2003). Data collection strategies. *Handbook of mixed methods in social and behavioural research. Thousand Oaks: Sage*, 297-315.
Jones, P., Wynn, M., Hillier, D., & Comfort, D. (2017). The sustainable development goals and information and communication technologies. *Indonesian Journal of Sustainability Accounting and Management*, *1*(1), 1â-15.
Kliment, T., Cetl, V., Tomič, H., Lisiak, J., & Kliment, M. (2016). Using participatory approach to improve availability of spatial data for local government. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *4*, 139-144.
Krishnapriya, S., & Sarath, G. (2020). Securing land registration using blockchain. *Procedia computer science*, *171*, 1708-1715.
Lannelongue, L., Grealey, J., & Inouye, M. (2021). Green algorithms: quantifying the carbon footprint of computation. *Advanced science*, *8*(12), 2100707.
Lnenicka, M., Nikiforova, A., Luterek, M., Milic, P., Rudmark, D., Neumaier, S., ... & Bolívar, M. P. R. (2024). Understanding the development of public data ecosystems: From a conceptual model to a six-generation model of the evolution of public data ecosystems. *Telematics and informatics*, 102190.
Lnenicka, M., Nikiforova, A., Clarinval, A., Luterek, M., Rudmark, D., Neumaier, S., ... & Bolívar, M. P. R. (2024). Sustainable open data ecosystems in smart cities: A platform theory-based analysis of 19 European cities. *Cities*, *148*, 104851.
Madan, R., & Ashok, M. (2023). AI adoption and diffusion in public administration: A systematic literature review and future research agenda. *Government Information Quarterly*, *40*(1), 101774.
Maretti, M., Russo, V., & Del Gobbo, E. (2021). Open data governance: civic hacking movement, topics and opinions in digital space. *Quality & Quantity*, *55*(3), 1133-1154.
McKenna, H. P. (2017). Civic tech and ambient data in the public realm: challenges and opportunities for learning cities and smart cities. In *Distributed, Ambient and Pervasive Interactions: 5th International Conference, DAPI 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9–14, 2017, Proceedings 5* (pp. 312-331). Springer International Publishing.
Meynhardt, T. (2009). Public value inside: What is public value creation?. *Intl Journal of Public Administration*, *32*(3-4), 192-219.
Misra, D., Mishra, A., Babbar, S., & Gupta, V. (2017, March). Open government data policy and Indian ecosystems. In *Proceedings of the 10th International Conference on Theory and Practice of Electronic Governance* (pp. 218-227).
Moedas, C. (2018). *Citizen science: innovation in open science, society and policy*. Ucl Press.
Muheidat, F., Patel, D., Tammisetty, S., Lo'ai, A. T., & Tawalbeh, M. (2022). Emerging concepts using blockchain and big data. *Procedia Computer Science*, *198*, 15-22.
Naghavi, M., Alesheikh, A. A., Hakimpour, F., Vahidnia, M. H., & Vafaeinejad, A. (2022). VGI-based spatial data infrastructure for land administration. *Land Use Policy*, *114*, 105969.
Nishant, R., Kennedy, M., & Corbett, J. (2020). Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda. *International Journal of Information Management*, *53*, 102104.
Petersen, S. A., Pourzolfaghar, Z., Alloush, I., Ahlers, D., Krogstie, J., & Helfert, M. (2019). Value-added services, virtual enterprises and data spaces inspired Enterprise architecture for smart cities. In *Collaborative Networks and Digital Transformation: 20th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2019, Turin, Italy, September 23–25, 2019, Proceedings 20* (pp. 393-402). Springer International Publishing

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Pincheira, M., Vecchio, M., Giaffreda, R., & Kanhere, S. S. (2021). Cost-effective IoT devices as trustworthy data sources for a blockchain-based water management system in precision agriculture. *Computers and Electronics in Agriculture*, *180*, 105889.
Plageras, A. P., Psannis, K. E., Stergiou, C., Wang, H., & Gupta, B. B. (2018). Efficient IoT-based sensor BIG Data collection–processing and analysis in smart buildings. Future Generation Computer Systems, 82, 349-357.
Reggi, L., & Dawes, S. (2016). Open government data ecosystems: Linking transparency for innovation with transparency for participation and accountability. In *Electronic Government: 15th IFIP WG 8.5 International Conference, EGOV 2016, Guimarães, Portugal, September 5-8, 2016, Proceedings 15* (pp. 74-86). Springer International Publishing.
Purawat, S., Dasgupta, S., Song, J., Davis, S., Claypool, K. T., Chandra, S., ... & Altintas, I. (2021, December). TemPredict: a big data analytical platform for scalable exploration and monitoring of personalized multimodal data for COVID-19. In *2021 IEEE International Conference on Big Data (Big Data)* (pp. 4411-4420). IEEE.
Schade, S., Granell, C., & Perego, A. (2015). Coupling public sector information and public-funded research data in Europe: a vision of an open data ecosystem. *Information and communication technologies in public administration: innovations from developed countries. CRC Press, London*, 275-298.
Verhulst, S., Addo, P. M., Young, A., Zahuranec, A. J., Baumann, D., & McMurren, J. (2021). Emerging uses of technology for development: a new intelligence paradigm. *Available at SSRN 3937649*.
Verhulst, S. G. (2023). Computational Social Science for the Public Good: Towards a Taxonomy of Governance and Policy Challenges. In *Handbook of Computational Social Science for Policy* (pp. 19-40). Cham: Springer International Publishing.
Wujarso, R. (2023). *Effect of digital transformation on company operational efficiency*. Asadel Publisher.
Zuiderwijk, A., Janssen, M., & Davis, C. (2014). Innovation with open data: Essential elements of open data ecosystems. *Information polity*, *19*(1-2), 17-33.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Improving Public Health Supply Chains: Time Series Techniques for Medication Demand Forecasting.

Ilka Corrêa De Meo[a*], *João Vitor Matos Gonçalves*[b]

[a] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil, imeo@prefeitura.sp.gov.br.

[b] Economics Department, São Paulo University, São Paulo, Brazil.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. The National Pharmaceutical Assistance Policy (PNAF) in Brazil aims to ensure universal access to essential medications through primary care. To achieve this goal and reduce healthcare access inequalities, efficient health system supply chains are crucial. This study evaluates time series forecasting methods, specifically exponential smoothing (ETS) and autoregressive integrated moving average (ARIMA) models, to predict the demand for captopril, a widely used antihypertensive drug, in São Paulo's Basic Health Units. Data on medicine consumption and demand from January 2018 to March 2023 were collected and analyzed to address current inefficiencies in demand prediction, compared through the Mean Absolute Percentage Error (MAPE). Results indicate that the ETS model achieved the best performance in captopril demand forecasting, with a MAPE of 2.26%, significantly improving on the 77.97% MAPE of the existing methodology. Holt-Winters seasonal models and ARIMA also demonstrated robust predictive capabilities, with MAPEs of 3.81% and 3.47%, respectively. This research highlights the potential of data-driven forecasting techniques, such as the ETS model, to optimize resource allocation, ensure medication availability, and improve service quality, providing a framework for future applications in similar contexts.

Keywords: demand forecasting, ARIMA, public health supply chains, exponential smoothing, efficiency improvement.
Policy paper, DOI: https://doi.org/10.59490/dgo.2025.1013

1. Introduction

The National Pharmaceutical Assistance Policy (PNAF), established in 1998 in Brazil, fulfills Article 6 of Law 8,080/90, which mandates comprehensive therapeutic care, including pharmaceutical assistance, within the Unified Health System (SUS) (Brazil, 1990). This policy aligns with the provisions of the World Health Organization, which, has long emphasized that the right to health requires equitable access to essential medicines (WHO, 1978). In this context, the PNAF supports the constitutional principles of universality, comprehensiveness, and equity in health (Brazil, 1988), ensuring essential medicines availability in primary care through municipal supply chains (Oliveira et al., 2010). Lack of access to medicines at this level compromises care delivery (Álvares et al., 2017; Yadav, 2015), therefore, ensuring their efficient distribution is essential to reducing inequalities (Dickman et al., 2017).

However, demand uncertainty poses significant challenges in supply chain management in general (Storey et al., 2006) and is a major issue in healthcare (Subramanian, 2021). Factors like epidemiology and supply shortages are a significant operational barrier for governments managing healthcare supply chains (Dixit et al., 2022). While many causes of medicine shortages are beyond managerial control (Reis & Perini, 2008), better forecasting improves planning and resource use (Subramanian, 2021). Addressing demand distortions is critical, as their effects amplify upstream in the supply chain in a phenomenon known as the bullwhip effect, leading to inefficiency (Lee et al., 1997).

Improving forecasting boosts supply chain efficiency by reducing costs and waste (Al-Zaidi et al., 2018), and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

enhancing healthcare delivery. In this regard, Saha and Rathore (2024) highlight that innovation and digital tools can support sustainable healthcare supply chain performance. Though underexplored, evidence suggests efficiency gains from adopting demand-oriented healthcare supply chains (Bvuchete et al., 2020). Time series analysis, which consists of analyzing a set of observations ordered over time (Morettin & Toloi, 2004), is one such effective method for forecasting demand (Shah et al., 2023). Its application relies on the premise of serial dependence among data, meaning that future observations are influenced by past behaviors (Villani et al., 2017). Thus, it employs a univariate modeling approach, based solely on time as the input variable (Ackermann & Sellitto, 2022). While no single approach applies universally, healthcare demand forecasting relies on time series patterns—trend, seasonality, cycles, and randomness—for accurate estimates (Soyiri & Reidpath, 2013).

Given this context, this study evaluates the use of time series techniques for forecast captopril demand in São Paulo's basic health units, comparing these forecasts with current models to assess potential efficiency gains in service delivery. It aims to address the scarcity of data-driven tools based on real consumption data in public health systems (Tetteh et al., 2025). Given the role of primary care in reducing health disparities (Starfield, 2001), improving forecasting at the local level—as in São Paulo's municipal system—can inform more accurate planning under real-world constraints.

2. Research Methods

According to Gil (2017), this research is quantitative in data nature, applied in purpose, and exploratory in objectives, having its design carried out through literature review and data collection to better understand the problem presented. The methodology used was adapted from the Cross Industry Standard Process for Data Mining (CRISP-DM) framework (Chapman et al., 2000), applying its first five stages—business understanding, data understanding, data preparation, modeling, and evaluation—while omitting the final stage, deployment, which Schroer et al. (2021) observed is often not included in most studies adopting this process.

Data were requested from the São Paulo Municipal Health Department (SMS-SP), in CSV format, covering monthly consumption and demand of the twenty most dispensed medicines. The selection included medicines purchased directly by SMS-SP and identified as the most dispensed based on the average of the first quarter of 2023. The dataset spanned from January 2018 to March 2023 and included information on month, year, health region, health supervision territory, medicine code, name, demand, and average consumption. This selection aimed to ensure at least one viable time series for the study.

To identify the behavioral patterns of the selected series components, a decomposition method based on moving average filters was applied (Barros et al., 2017). This procedure allows isolating trend, seasonality, and random effects components for graphical visualization. The series were then split into training (January 2018–September 2022) and test (October 2022–March 2023) sets, with predictions evaluated on the last six observations.

According to Choudhary et al. (2022), although machine learning models are increasingly popular for forecasting purposes, classical univariate time series methods, such as exponential smoothing and autoregressive integrated moving average (ARIMA), the two most widely used approaches in time series forecasting (Hyndman & Athanasopoulos, 2021), generally present good results. The use of both model classes was chosen because, although exponential smoothing models perform well for short-term forecasts and for series that do not show severe changes in their behavior, their performance worsens considerably for long-term forecasts, making it interesting to resort to alternatives, such as Box-Jenkins models (Thomaz et al., 2018).

The analysis began with simple exponential smoothing (SES), suitable for stationary series, followed by the Holt-Winters model with linear trend. Additive (HWAS) and multiplicative (HWMS) seasonal Holt-Winters models were then applied to capture both trend and seasonality (Barros et al., 2017). The Error-Trend-Seasonality (ETS) model was also tested using an R function that automatically selects the most appropriate model based on the combination of error (additive or multiplicative), trend (none, additive or multiplicative, with or without damping), and seasonality (none, additive, or multiplicative) (Hyndman et al., 2008; Hyndman & Khandakar, 2008). Finally, the Box-Jenkins methodology was applied using ARIMA models (Ingle et al., 2021), which combine three components: autoregressive (based on past values), integrated (reflecting accumulated effects over time), and moving average (accounting for past forecast errors) (Fattah et al., 2018).

To develop Box-Jenkins models, it is first necessary to assess seasonality and stationarity, applying differencing if required, then identify and estimate the appropriate ARIMA model and evaluate its fit (Wang, 2011). In this study, these steps were performed automatically to identify the optimal ARIMA model based on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) (Hyndman et al., 2008), which balance model fit and complexity. The lower these values, the better the combination of parameters p, d, and q, corresponding respectively to the order of the autoregressive component, the order of differentiation, and the order of the moving average component (Choudhary et al., 2022).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

After generating the models, accuracy was assessed using the Mean Absolute Percentage Error (MAPE), which is used to measure the accuracy of forecasting models, through the average of absolute percentage differences between forecasts and actual values (Hyndman & Koehler, 2005). It is calculated as follows:

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right| \times 100$$

where: Yt is the actual value at time t; Ŷt is the forecasted value at time t; Yt - Ŷt is the forecast error, $\sum_{t=1}^{n}\left|\frac{Y_t - \hat{Y}_t}{Y_t}\right|$ represents the sum of absolute errors for each observation divided by the actual values, transforming them into a proportion relative to the actual values which, multiplied by 100, is converted into a percentage error relative to the actual values and $\frac{1}{n}$ indicates the division by the total number of observations n, providing a measure of the mean error in percentage terms.

As all time series values were positive and well above zero, the MAPE was preferred for its simplicity. The model with the lowest MAPE was selected as the most accurate for the case under study.

3. Results

The results will be presented following the CRISP-DM methodology stages.

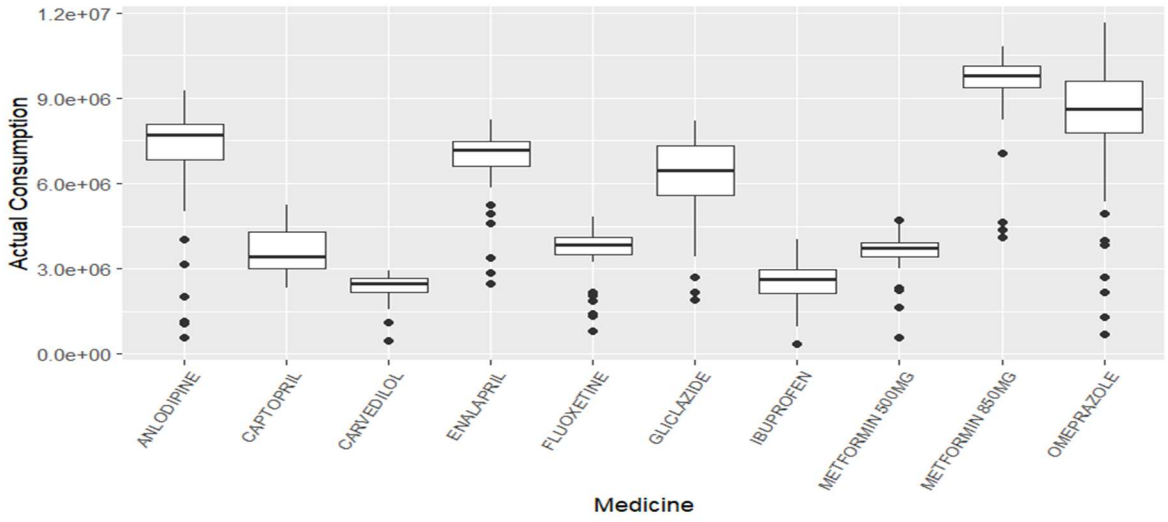
3.1 Business Understanding

Medicines purchased directly by SMS-SP are distributed from a central warehouse to primary health care units, based on monthly demand values recorded in the inventory system—referred to in this study as *informed consumption*. Although a manual defines this value as the average of consumption over a set number of months (Prodam-SP, 2008), this method is not consistently applied in practice, and the actual calculation remains unclear. Nonetheless, this value is used for supply planning under the current SMS-SP methodology.

Dispensation to patients is also recorded in the system, and the monthly output is referred to here as *actual consumption*. Based on these definitions, the study aims to assess the accuracy of SMS-SP's current demand forecasting approach and compare it with time series forecasting methods using the same data. Considering the scale of São Paulo's operation—over 450 health units across 27, health supervision territories in 6 health regions—the requested data were structured at the health supervision territory level to enable better tracking of discrepancies and support the study's objectives.

3.2 Data Understanding and Preparation

The data request was submitted to SMS-SP on May 4, 2023, and they were provided on June 24, 2023. The file contained consumption and demand data for 20 medicines (January 2018 to March 2023) from 472 primary health care units, organized by territories. These were aggregated by health supervision territory, resulting in a dataset imported into RStudio with information from 27 territories. During data exploration, medicines with fewer than 1,701 observations—due to missing data across 27 territories and 63 months—were excluded to avoid distortions. For the remaining 10 medicines, boxplots (Figure 1) were used to detect outliers and assess pandemic-related impacts on their time series.



Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Fig. 1 - Boxplot of actual medication consumption from January 2018 to March 2023. Source: Original research results.

Since captopril was the only medication without outliers and showed no significant pandemic-related changes, it was selected for modeling and prediction. The dataset was then limited to this medication. Figure 2 shows the time series of its actual consumption (dispensed quantity) and informed consumption (reported demand).

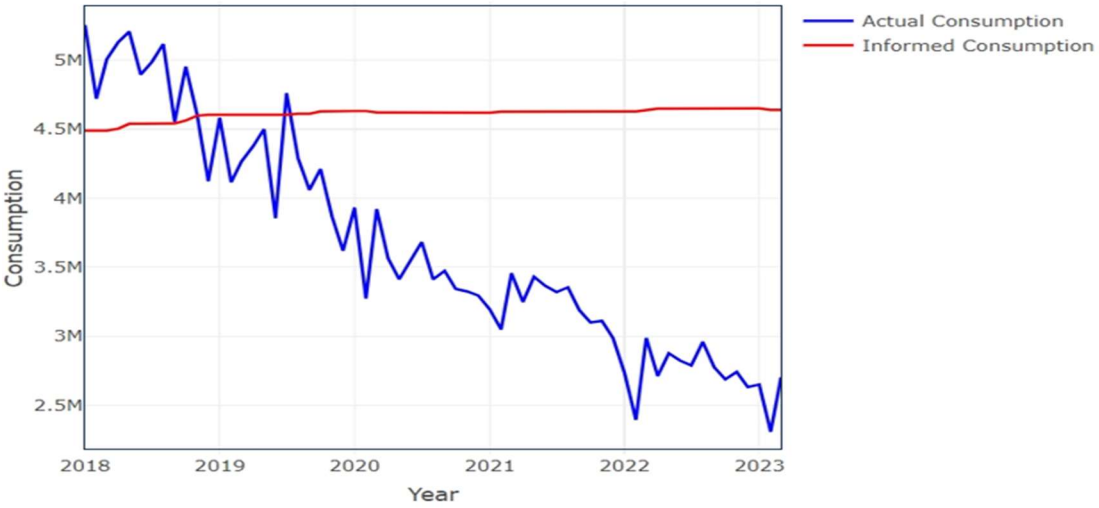


Fig. 2 - Actual Consumption and Informed Consumption of Captopril from January 2018 to March 2023. Source: Original research results

Actual consumption shows a strong downward trend, while informed consumption (forecasted demand) remains more stable. To analyze the components of the time series under study, an additive decomposition method was applied (Hyndman & Athanasopoulos, 2021). Seasonality and a decreasing linear trend can be seen in Figure 3 below.

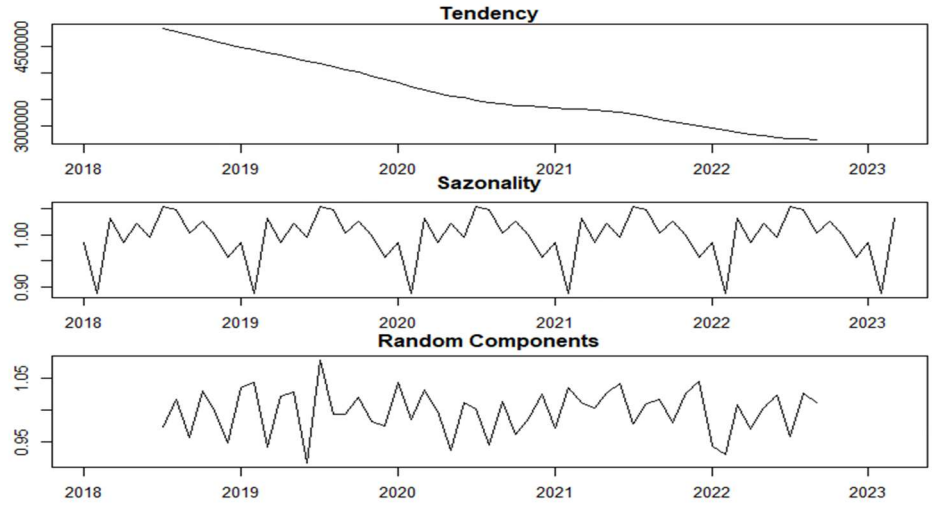


Fig. 3 - Additive Decomposition of the Captopril Actual Consumption Series. Source: Original research results

3.3 Modeling

Modeling started by splitting the data into training (January 2018–September 2022) and test sets (last 6 points: October 2022–March 2023), as shown in Figure 4.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

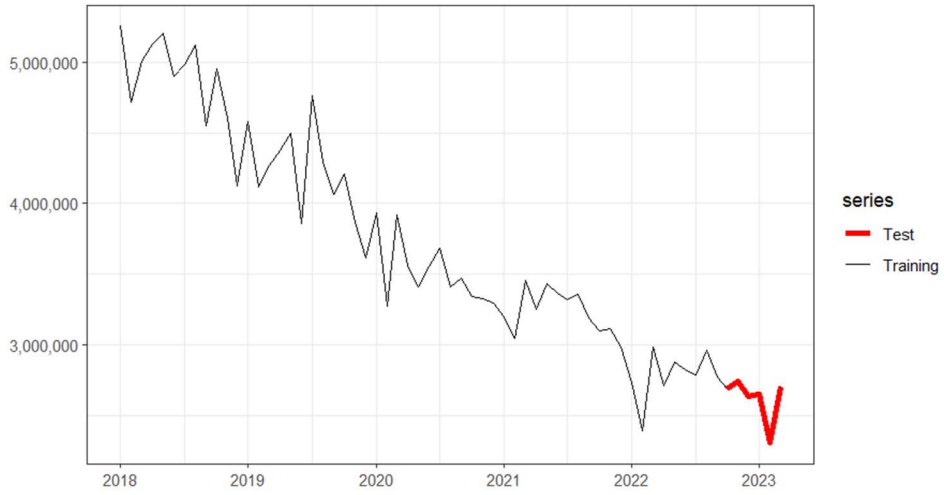


Fig. 4 - Separation of the Captopril Actual Consumption Time Series into Training and Test Data. Source: Original research results.

The MAPE for the original forecast (informed consumption) over the last 6 points was 77.97%, indicating a high average error compared to actual consumption.

The predictions made using exponential smoothing techniques are shown in Figures 5 to 9 below. Figure 5 shows the simple exponential smoothing model; Figure 6, the Holt-Winters trend model; Figure 7, the additive seasonal Holt-Winters model; Figure 8, the multiplicative seasonal Holt-Winters model; and Figure 9, the ETS model.

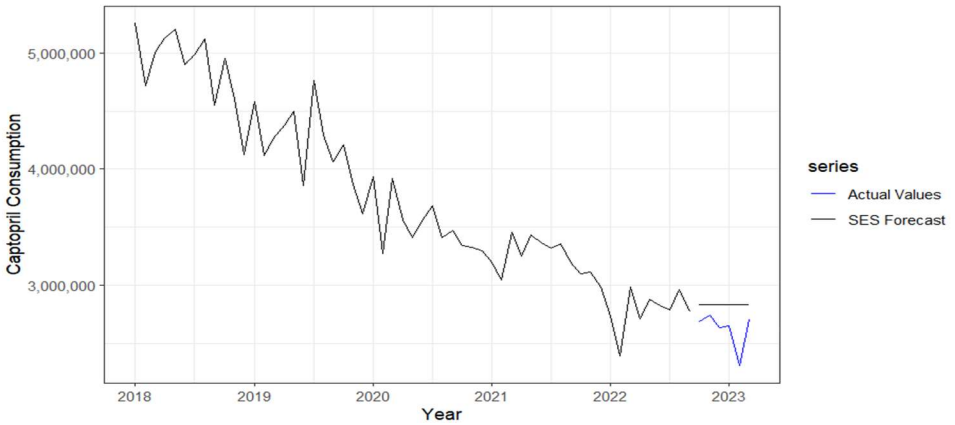


Fig. 5 - Comparison of forecast using the exponential smoothing method with actual values. Source: Original research results.

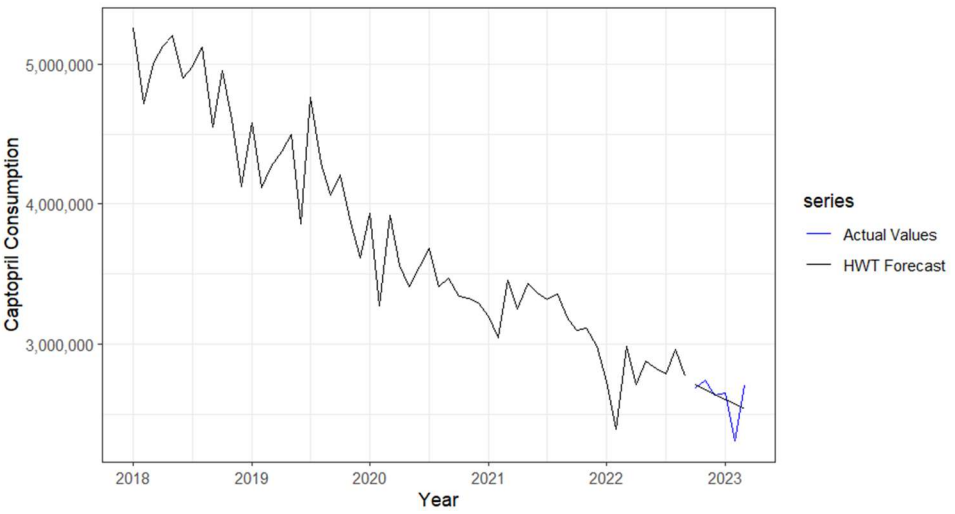


Fig. 6 - Comparison of forecast using the Holt-Winters method with trend and actual values. Source: Original

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

research results.

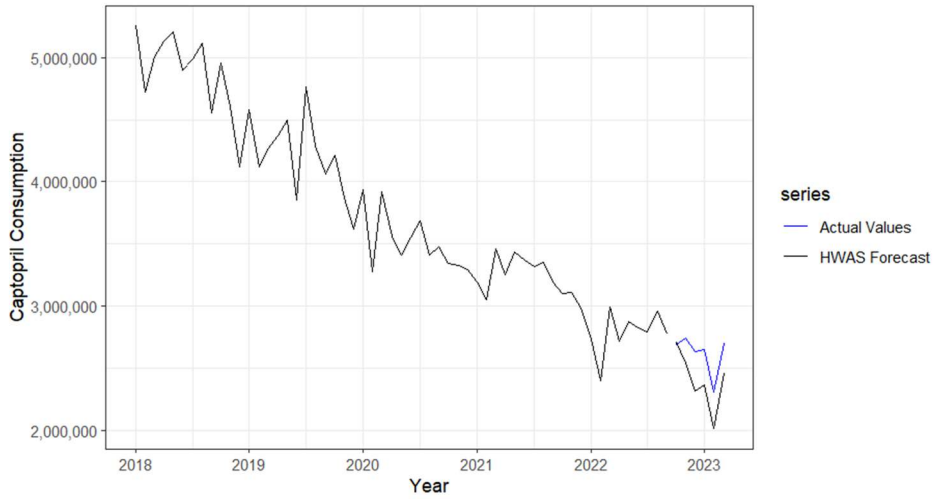


Fig. 7 - Comparison of forecast using the Holt-Winters additive seasonal method with actual values. Source: Original research results.

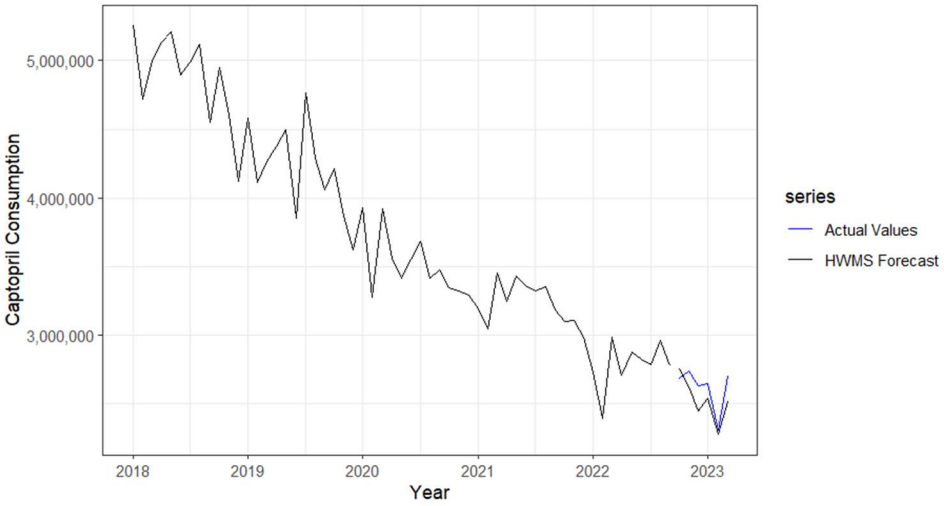


Fig. 8 - Comparison of forecast using the Holt-Winters multiplicative seasonal method with actual values. Source: Original research results.

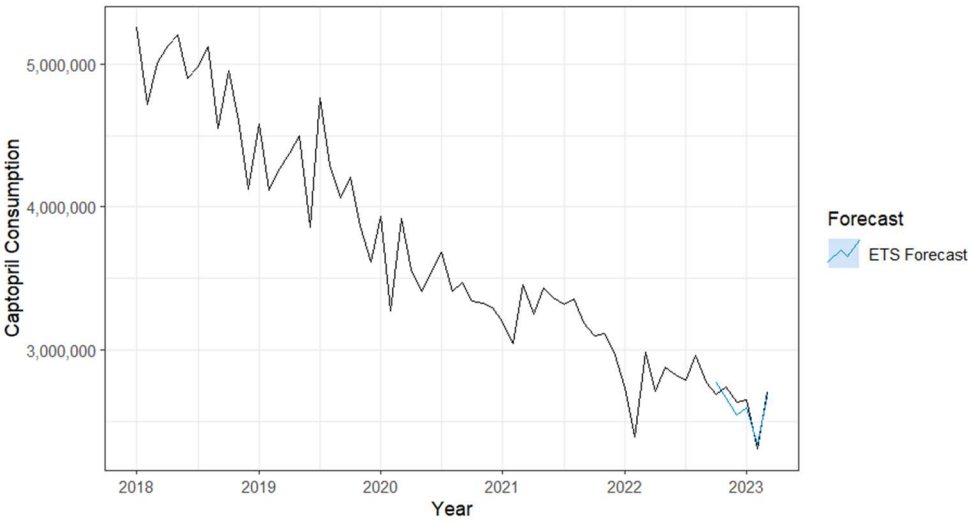


Fig. 9 - Forecast using the ETS model compared to actual consumption data. Source: Original research results.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The last class of models applied was ARIMA. Among these, the most accurate was ARIMA(2,1,0)(1,0,0)(12) with drift, selected based on the AIC criterion, where the lowest value indicates the model with the best balance between fit and complexity (Choudhary et al., 2022). This model includes two autoregressive terms, one differencing, no moving average terms, and a seasonal autoregressive component of order one with a 12-month period. The "drift" term indicates the presence of a linear trend.

Forecasts for the next six months using this model are shown in Figure 10.

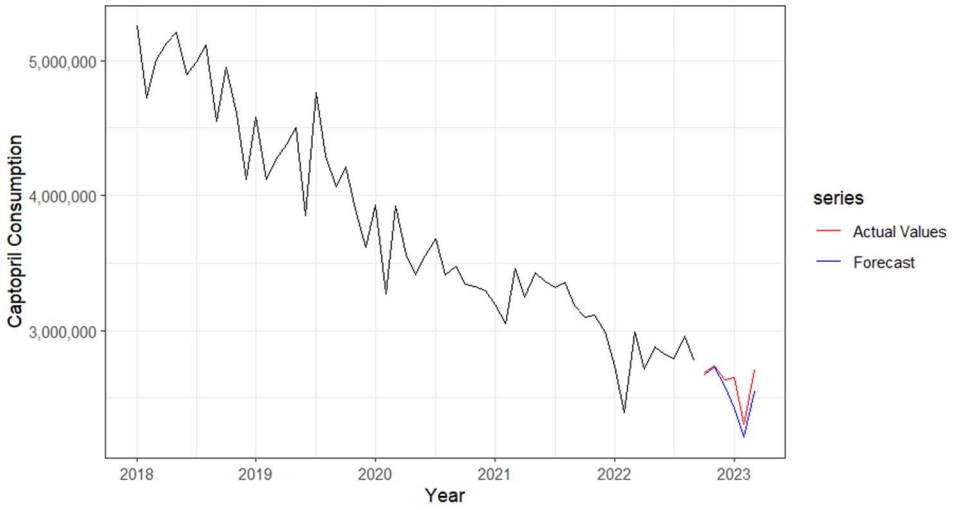


Fig. 10 - ARIMA Model Forecast Compared to Actual Consumption Data. Source: Original research results.

3.4 Evaluation

After applying all models, MAPE was used to identify the best performer. MAPE's simplicity allows direct interpretation without further comparison (Chen et al., 2017). Table 1 shows that the model with the highest predictive capacity for the time series under study was the ETS.

Tab. 1 - MAPEs of Models.

Modelos	MAPE
Previsão atual	77,97
Holt-Winters aditivo sazonal	8,84
Suavização exponencial simples	8,36
Holt-Winters multiplicativo sazonal	4,33
Holt-Winters com tendência	3,81
ARIMA	3,47
ETS	2,26

Source: Original research results

After identifying ETS as the best model, its residuals' autocorrelation was tested using the Ljung-Box test, indicating whether the autocorrelations found are more significant than expected in a random series (Hyndman & Athanasopoulos, 2021). Table 2 shows a p-value of 0.1381, indicating no significant autocorrelation at the 0.05 level. Thus, the residuals are independent, confirming a good model fit. This result indicates the ETS model fits well and outperforms the current model based on MAPE.

Tab. 2 - Ljung-Box Test Result.

Elementos	Valor
X-squared	21.995
df	1
p-value	0,1381

Source: Original research results.

4. Discussion

The results show that time series methods can effectively improve forecast accuracy for captopril consumption in São Paulo's health units, though dataset and modeling limitations should be considered. While this study focused on a stable, complete series, predictive methods can also be applied to series with irregularities, requiring contextual analysis to address anomalies caused by supply shortages or reporting errors—common in public

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

sector supply chains.

This issue is critical in the public sector, where inconsistent operations and stockouts lead to suppressed demand not reflected in the actual consumption data, thereby potentially distorting the time series. Infante and Santos (2007) found that automatic replenishment based on historical consumption is biased by frequent stockouts, while replenishment driven by subjective requests introduces significant errors—findings that align with this study and highlight structural challenges in public supply chains.

Structural constraints—such as limited personnel, bureaucracy, and low local autonomy—continue to hinder public supply chain management. Although Supply Chain Risk Management (SCRM) is essential to mitigate disruptions, its application in Brazil remains limited. Senna et al. (2022) noted that centralized, risk-insensitive decision-making often leads to reactive and fragmented actions, a pattern reflected in this study. This highlights the importance of integrating predictive models with broader institutional strategies to build resilience and coordination.

While univariate models used here improved forecast accuracy, they overlook key drivers of demand such as demographics, disease patterns, policy shifts, and supply issues. Given the growing pressures on Brazil's SUS from epidemiological and technological changes (Elias, 2013), future studies would benefit from adopting multivariate models that incorporate these factors to strengthen planning and responsiveness.

Bhat et al. (2024) highlight the potential of integrating stochastic, causal, and projective forecasting—combined with machine learning and inventory optimization—to improve access, reduce stockouts, and optimize resources in public primary care. These hybrid approaches are promising for decentralized systems, especially when adapted to institutional constraints.

This study reinforces that applying forecasting techniques and digital tools can improve demand prediction, public spending, service efficiency, and equity in access to essential medicines. Beyond practical contributions, the findings add to the theoretical understanding of forecasting in decentralized public supply chains with limited autonomy. While structural barriers are well documented (Yadav, 2015; Dixit et al., 2022), this study offers empirical evidence that even simple models can enhance decision-making in resource-constrained settings.

5. Conclusions

Beyond its practical contributions, this study also provides important theoretical implications for public administration and health policy. It reinforces the relevance of evidence-based decision-making frameworks in public logistics and the need to strengthen institutional capacity to operationalize predictive analytics in decentralized health systems. Moreover, the findings support the view that supply chain transparency and forecasting accuracy are not only technical challenges but also governance issues, requiring alignment between data infrastructure, managerial autonomy, and policy objectives.

From a theoretical standpoint, the study reinforces the role of local-level data analytics as a governance instrument in health policy. It suggests that forecasting is not merely a technical function, but also a strategic capability that shapes how public administrations manage uncertainty and allocate resources. In this context, the results point to the need for public policies that improve access to medications dispensed at the primary care level within the SUS, as shortages can lead to treatment discontinuity and, consequently, an increase in the number of hospitalizations. Failing to address this issue may further burden the health system with avoidable inpatient care resulting from gaps in outpatient treatment (Oliveira et al., 2021).

6. Acknowledgements

- **Data/Software Access Statement:** Data were obtained from the São Paulo Municipal Health Department via formal request and are not publicly available due to institutional restrictions. Analyses and forecasts were performed using RStudio (v2023.12.1+402) with R (v4.3.3) and relevant packages.
- **Contributor Statement:**
  - **Ilka De Meo:** Conceptualization, Methodology, Data Curation, Formal Analysis, Software, Visualization, Writing – Original Draft, Writing – Review and Editing.
  - **João Gonçalves:** Supervision, Validation, Writing – Review.
- **Use of AI:** The authors used ChatGPT (OpenAI) to support R code development for time series modeling and to enhance the clarity and academic tone of the text. All content was critically reviewed, edited, and validated by the authors, who take full responsibility for the final version.
- **Conflict of Interest:** There is no conflict of interest.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

Ackermann, A. E. F., & Sellitto, M. A. (2022). Métodos de previsão de demanda: uma revisão da literatura. *Innovar, 32*(85), 83-89. https://doi.org/10.15446/innovar.v32n85.100979

Álvares, J., Guerra Junior, A. A., Araújo, V. E., Almeida, A. M., & Dias, C. Z. (2017). Acesso aos medicamentos pelos usuários da atenção primária no Sistema Único de Saúde. *Revista de Saúde Pública, 51*(Sup), 1-10. https://doi.org/10.11606/S1518-8787.2017051007139

Al-Zaidi, W. A., Al-Karawi, A. J., & Al-Zuhairi, A. Kh. (2018). Role of demand forecasting and lead time on waste in supply chain: a case study in Diyala health sector-Iraq. *Journal of Advanced Management Science, 6*(3), 155-160. https://doi.org/10.18178/joams.6.3.155-160

Barros, A. C., Mattos, D. M., Oliveira, I. C. L., Ferreira, P. G. C., & Duca, V. E. L. A. (2017). *Análise de Séries Temporais em R: Curso Introdutório.* (1ª ed.). Grupo GEN.

Bhat, S. S., Srihari, V. R., Prabhune, A., Satheesh, S. S., & Bidrohi, A. B. (2024). Optimizing medication access in public healthcare centers: a machine learning stochastic model for inventory management and demand forecasting in primary health services. In *2024 International Conference on Intelligent and Innovative Technologies in Computing, Electrical and Electronics (IITCEE)* (pp. 1-5). IEEE.

Brazil. (1988). *Constituição da República Federativa do Brasil de 1988* (Federal Constitution of Brazil, 1988). Brasília, DF: Presidência da República. Retrieved March 21, 2023, from https://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm

Brazil. (1990). Lei n. 8080, de 19 de setembro de 1990. Dispõe sobre as condições para a promoção, proteção e recuperação da saúde, a organização e o funcionamento dos serviços correspondentes e dá outras providências. Diário Oficial da União. Retrieved March 21, 2023, from https://conselho.saude.gov.br/web_confmundial/docs/l8080.pdf.

Bvuchete, M., Grobbelaar, S. S., & Eeden, J. van. (2020). Best practices for demand-driven supply chain management in public healthcare sector: A systematic literature review. *South African Journal of Industrial Engineering, 31*(2), 11-27. Retrieved June 05, 2023, from https://hdl.handle.net/10520/EJC-2012932bcb

Chapman, J., Clinton, R., Kerber, T., Khabaza, T., Reinartz, C., & Wirth, R. (2000). *CRISP-DM 1.0 step-by-step data mining guide* (1st ed.). Morgan Kaufmann.

Chen, C., Twycross, J., & Garibaldi, J. M. (2017). A new accuracy measure based on bounded relative error for time series forecasting. *PloS One, 12*(3), 1-23. https://doi.org/10.1371/journal.pone.0174202

Choudhary, A., Kumar, S., Sharma, M., & Sharma, K. P. (2022). A framework for data prediction and forecasting in WSN with Auto ARIMA. *Wireless Personal Communications, 123*, 2245–2259. https://doi.org/10.1007/s11277-021-09237-x

Dickman, S. L., Himmelstein, D. U., & Woolhandler, S. (2017). Inequality and the health-care system in the USA. *Lancet, 389* (10077), 1437-1441. https://doi.org/10.1016/S0140-6736(17)30398-7

Dixit, A., Routroy, S., & Dubey, S. (2022). Analyzing the operational barriers of government-supported healthcare supply chain. *International Journal of Productivity and Performance Management, 71*(8), 3766-3791. https://doi.org/10.1108/IJPPM-09-2020-0493

Elias, F. T. S. (2013). A importância da avaliação de tecnologias para o Sistema Único de Saúde. *Boletim do Instituto de Saúde-BIS*, 14(2), 143-150. Retrieved April 20, 2025, from https://periodicos.saude.sp.gov.br/bis/article/download/34155/32907

Fattah, J., Ezzine, L., Aman, Z., & El Moussami, H. (2018). Forecasting of demand using ARIMA model. *International Journal of Engineering Business Management,* 10, 1-9. https://doi.org/10.1177/1847979018808673

Gil, A. C. (2017). *Como elaborar projetos de pesquisa* (6ª ed.). Atlas.

Hyndman, R. J., & Khandakar, Y. (2008). Automatic time series forecasting: The forecast package for R. *Journal of Statistical Software, 27*(3), 1-22. https://doi.org/10.18637/jss.v027.i03

Hyndman, R. J., & Koehler, A. B. (2005). Another look at measures of forecast accuracy. *International Journal of Forecasting, 22*(4), 679-688. https://doi.org/10.1016/j.ijforecast.2006.03.001

Hyndman, R. J., Koehler, A. B., Ord, J. K., & Snyder, R. D. (2008). Forecasting with exponential smoothing: The state space approach (1st ed.). *Springer Science & Business Media*.

Hyndman, R. J., & Athanasopoulos, G. (2021). Forecasting: Principles and practice (3rd ed.). *OTexts.*

Infante, M., & Santos, M. A. B. D. (2007). A organização do abastecimento do hospital público a partir da cadeia produtiva: uma abordagem logística para a área de saúde. *Ciência & Saúde Coletiva*, 12, 945-954. Retrieved April 20, 2025 from https://www.scielosp.org/article/ssm/content/raw/?resource_ssm_path=/media/assets/csc/v12n4/13.pdf

Ingle, C., Bakliwal, D., Jain, J., Singh, P., Kale, P., & Chhajed, V. (2021). Demand forecasting: Literature review on various methodologies. In *Proceedings of the 12th International Conference on Computing Communication and Networking Technologies* (pp. 1-7). Kharagpur, India. http://doi.org/10.1109/ICCCNT51525.2021.9580139

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Lee, H. L., Padmanabhan, V., & Whang, S. (1997). The bullwhip effect in supply chains. *Sloan Management Review, 38*(3), 92-102. Retrieved January 24, 2025, from https://rzabdulaziz.wordpress.com/wp-content/uploads/2021/01/bahan-bacaan-the-bullwhip-effect.pdf

Morettin, P. A., & Toloi, C. M. (2004). *Análise de séries temporais: Modelos lineares univariados* (3ª ed.). Edgar Blucher.

Oliveira, L. C. F., Assis, M. M. A., & Barboni, A. R. (2010). Assistência farmacêutica no Sistema Único de Saúde: Da Política Nacional de Medicamentos à Atenção Básica à Saúde. *Ciência & Saúde Coletiva, 15*(3), 3561-3567. Retrieved January 24, 2025, from https://www.scielo.br/j/csc/a/qjZTpTXRDfzqcVwv6yJy6PR/?format=pdf&lang=pt

Oliveira, T. L., Santos, C. M., Miranda, L. P., Nery, M. L. F., & Caldeira, A. P. (2021). Fatores associados ao custo das internações hospitalares por doenças sensíveis à Atenção Primária no Sistema Único de Saúde. *Ciência & Saúde Coletiva, 26*(10), 4541-4552. Retrieved April 20, 2025, from https://www.scielosp.org/pdf/csc/2021.v26n10/4541-4552/pt

PRODAM-SP. (2008). *Manual GSS2 para unidades de saúde* (Versão 2.3). Secretaria Municipal da Saúde de São Paulo.

Reis, A. M. M., & Perini, E. (2008). Desabastecimento de medicamentos: Determinantes, consequências e gerenciamento. *Ciência & Saúde Coletiva, 13*(Sup), 603-610. Retrieved January 24, 2025, from https://www.scielosp.org/pdf/csc/2008.v13suppl0/603-610/pt

Shah, V., Gupta, V., Gandhi, T., & Gupta, R. K. (2023). Efficient medical supply chain forecasting using time series analysis. In *Proceedings of the International Conference on Computer Vision and Machine Intelligence* (pp. 1-6). Paris, France. https://doi.org/10.1109/CVMI59935.2023.10465213

Saha, E., & Rathore, P. (2024). The impact of healthcare 4.0 technologies on healthcare supply chain performance: Extending the organizational information processing theory. *Technological Forecasting & Social Change, 201*, 1-16. https://doi.org/10.1016/j.techfore.2024.123256

Schroer, C., Kruse, F., & Gómez, J. M. (2021). A systematic literature review on applying the CRISP-DM process model. *Procedia Computer Science, 181*, 526–534. https://doi.org/10.1016/j.procs.2021.01.199

Senna, P., Reis, A. D. C., Leão Santos, I., & Dias, A. C. (2022). Healthcare supply chain risk management in Rio de Janeiro, Brazil: What is the current situation?. *Work*, *72*(2), 511-527. https://doi.org/10.3233/WOR-205216

Soyiri, I. N., & Reidpath, D. D. (2013). An overview of health forecasting. *Environmental Health and Preventive Medicine, 18*, 1-9. https://doi.org/10.1007/s12199-012-0294-6

Starfield, B. (2001). New paradigms for quality in primary care. *The British Journal of General Practice*, 51(465), 303. Retrieved April 21, 2025, from https://pmc.ncbi.nlm.nih.gov/articles/PMC1313982/pdf/11458485.pdf

Storey, J., Emberson, C., Godsell, J., & Harrison, A. (2006). Supply chain management: Theory, practice and future challenges. *International Journal of Operations & Production Management, 26*(7), 754-774. https://doi.org/10.1108/01443570610672220

Subramanian, L. (2021). Effective demand forecasting in health supply chains: Emerging trend, enablers, and blockers. *Logistics, 5*(12), 1-21. https://doi.org/10.3390/logistics5010012

Tetteh, F. K., Amoako, D. K., Kyeremeh, A., Atiki, G., Degbe, F. D., & Nyame, P. E. D. (2025). Unraveling the interplay between supply chain analytics and healthcare supply chain performance: establishing an underlying mechanism and a boundary condition. *International Journal of Quality & Reliability Management*, *42*(2), 752-783. https://doi.org/10.1108/IJQRM-12-2023-0400

Thomaz, P. S., Mattos, V. L. D., Nakamura, L. R., Nunes, G. S., & Konrath, A. C. (2018). O uso de métodos de suavização exponencial na modelagem de séries temporais sem sazonalidade. *RETEC – Revista de Tecnologias, 11*(3), 17-27. Retrieved January 24, 2025, from https://www.fatecourinhos.edu.br/retec/index.php/retec/article/view/315

Villani, M., Earnest, A., Nanayakkara, N., Smith, K., Courten, B., & Zoungas, S. (2017). Time series modelling to forecast prehospital EMS demand for diabetic emergencies. *Health Services Research, 17*(332), 1-9. https://doi.org/10.1186/s12913-017-2280-6

Wang, C. C. (2011). A comparison study between fuzzy time series model and ARIMA model for forecasting Taiwan export. *Expert Systems with Applications, 38*(8), 9296–9304. https://doi.org/10.1016/j.eswa.2011.01.015

World Health Organization (WHO). (1978). International Conference on Primary Health Care - Alma-Ata Declaration. Retrieved March 22, 2023, from https://bvsms.saude.gov.br/bvs/publicacoes/declaracao_alma_ata.pdf

Yadav, P. (2015). Health product supply chains in developing countries: Diagnosis of the root causes of underperformance and an agenda for reform. *Health Systems & Reform, 1*(2), 142-154. https://doi.org/10.4161/23288604.2014.968005

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 4: Digital Democracy & AI

Track Description

AI technologies have significantly expanded the potential to improve democratic services, enhance communication quality, and support data-driven decision-making. By integrating AI in government, the aim ought to be to improve citizen-government collaboration, smart city planning, and other key initiatives that foster informed policy-making. The Digital Democracy & AI track aimed to explore how advancements in AI can enhance democratic processes through collaborative human-machine interactions. More specifically, the goal of this track was to gather insights into how AI can support more inclusive, transparent, and responsive democratic systems, addressing both opportunities and challenges. Beyond diverse topics under the theme, the track chairs also encouraged research exploring the regulation of technology platforms and the ethical use of AI-driven tools in shaping democratic governance.

Track Chairs

J. Haqbeen, Kyoto University, Japan
T. Ito, Kyoto University, Japan
S. Sahab, Kyoto University, Japan

Contents

Assessment of the LLM-Based Chatbots on Student Engagement and Learning Outcomes in Afghanistan 321
J. A. Haqbeen, S. Sahab, and T. Ito

GoViz: A Visualization Tool for Empowering Transparency in Government Speech.....331
L. Guder, J. P. Aires, I. H. Manssour, and D. Griebler

Not only *what*, but also *when*: Understanding Brazilian political comments on legislative bills over time through Stance Detection and Topic Modeling.....343
M. Cerqueira, N. F. F. da Silva, E. Souza, H. O. Albuquerque, M. de S. Dias, and A. C. P. L. F. de Carvalho

Assessment of the LLM-based Chatbots on Student Engagement and Learning Outcomes in Afghanistan.

Jawad Ahmad Haqbeen*, *Sofia* Sahab, *Takayuki* Ito

Graduate School of Informatics, Kyoto University, Kyoto, Japan, email address: jawad.haqbeen@i.kyoto-u.ac.jp, ORCID 0000-0002-0481-0196

Graduate School of Informatics, Kyoto University, Kyoto, Japan, email address: sahab.sofia@i.kyoto-u.ac.jp, ORCID 0000-0002-5822-5021

Graduate School of Informatics, Kyoto University, Kyoto, Japan, email address: ito@i.kyoto-u.ac.jp, ORCID 0000-0001-5093-3886

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. The integration of Generative AI (GenAI) technologies, such as ChatGPT, into online education is accelerating; however, their effectiveness in under-resourced contexts remains insufficiently studied. This paper investigates the impact of a Large Language Model (LLM)-based conversational agent on student engagement and learning outcomes in Afghanistan, where access to formal education—particularly for women—is severely restricted or banned. We conducted an experimental study involving 80 undergraduate computer science students (40 male, 40 female) in Afghanistan, randomly assigned to control and treatment groups. All participants attended identical 50-minute online lectures followed by 40-minute post-lecture discussions moderated by a human instructor, and completed a follow-up self-report questionnaire. The treatment group additionally engaged in AI-facilitated discussions using a GPT-4-based chatbot during post-lecture discussion. Analysis of discussion logs and post-intervention surveys revealed that the treatment group demonstrated significantly higher participation rates, with more posts and replies, during post-lecture discussion and reported greater confidence in their understanding of the course material. These findings highlight the potential of LLM-based chatbots to enhance interactive learning and foster educational inclusion, particularly for marginalized populations in low-resource environments.

Keywords. Conversational AI, online deliberation, online learning, GPT-4, LLMs, AI, ethnographic studies, learning outcomes, women, Afghanistan
Research paper, DOI: https://doi.org/10.59490/dgo.2025.956

1. Introduction

The demand for online learning has surged globally due to limited classroom capacity, rising educational costs, and the need for flexible learning options (Hart et al., 2018) External disruptions such as the COVID-19 pandemic (Szopiński & Bachnik, 2022) and internal political and cultural restrictions in such war-ravaged countries as Afghanistan have further accelerated the shift toward online education (Haqbeen et al., 2023). Afghanistan is currently the only country where women and girls are systematically banned from accessing secondary and higher education due to political and cultural restrictions imposed by the ruling Taliban regime (Haqbeen et al., 2023). Recent surveys in Afghanistan highlight the severe impact of these restrictions on women's educational attainment, with females significantly lagging behind males in learning and academic achievement (Lyons, 2023). This disparity reflects the longstanding gender inequality in access to education in Afghanistan (Shayan, 2015), where

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

women and religious minorities are frequently excluded from male-dominated spheres such as education, politics, commerce, and even public life (Haqbeen et al., 2021).

In response, many Afghan women now rely on online learning opportunities provided by non-profit organizations as their primary avenue for education (Haqbeen et al., 2023). Despite the promise of online education, virtual learning environments often suffer from limited interactivity and student engagement (Singh & Meena, 2022). A lack of meaningful student–student, student–instructor, and student–content interaction during online course is a major drawback, leading to passive learning experiences (Haleem et al., 2022). Large class sizes (sometimes with hundreds of participants) pose additional challenges for maintaining engagement and personalized interaction. Studies have found that increasing online class size can negatively impact instructor–student interaction quality (Sorensen, 2015), and reduce student satisfaction (Russell & Curtis, 2013). Indeed, research shows that interactivity—especially between students and instructors—is a key factor influencing student satisfaction and learning outcomes (Espasa & Meneses, 2010). Active teaching strategies that promote engagement have been shown to improve participation (Deslauriers et al., 2019). Facilitating peer-to-peer learning is considered crucial for the next wave of online education innovation (Chandra & Palvia, 2021). However, in large online classes it is difficult for instructors alone to manage and simulate rich post-lecture discussions among students (student–student, student–instructor, and student–content interaction).

Recently, advances in Generative Artificial Intelligence (GenAI) (e.g., OpenAI's ChatGPT) have opened new possibilities for enhancing online interactivity (Kasneci et al., 2023). Large Language Models (LLMs), such as GPT-4 (Achiam et al., 2023) have demonstrated remarkable abilities in understanding and generating text, quickly establishing themselves as foundational components of many AI-powered applications, particularly in education domain. This technology supported the initiative of LLMapps, which refer to the type of software that uses LLMs as one of its building blocks, have been developed (Yan et al., 2024) in different downstream domains. Downstream refers to application-specific tasks where pre-trained LLMs are used or fine-tuned. For example, using GPT-4 to build an app that helps students write essays. Particulary in LLM-assisted apps in education like, Khanmigo, a GPT-4-based virtual tutor and classroom aide by Khan Academy to help student in their learning process (Anand, 2023).

The LLM-assisted apps can engage learners in dialogue, answer questions, and provide tailored feedback, potentially stimulating student engagement even in the absence of direct human instructors. While such AI tutors and facilitators are increasingly being integrated into educational settings (Kasneci et al. 2023), their effectiveness in low-resource contexts like Afghanistan remains under-studied.

Our work addresses these gaps by introducing an LLM-based conversational agent into online class discussions for Afghan students. We investigate whether a GPT-based powered chatbot, acting as a discussion facilitator alongside a human instructor, can enhance student engagement and improve learning outcomes. We conducted a randomized controlled trial to evaluate the chatbot's impact. We hypothesized that AI-facilitated discussions would lead to higher student participation (more frequent and longer contributions) and greater learning outcome experience compared to discussions led only by a human tutor. The study's focus on Afghan learners (including female students facing educational barriers) provides insight into AI's role in supporting equitable access to interactive learning.

The structure of the paper is as follows: Section 2 presents relevant studies. In Section 3, we detail the methodology, experimental settings, sample and sampling, and implementation of our social experiment. Section 4 presents the results, followed by discussions. Finally, we summarize our work and highlight future directions in section 5.

2. Related Work

Prior research emphasizes that a lack of interaction in virtual classrooms leads to diminished student engagement (Haleem et al., 2022). Another study found that larger online class sizes correlate with lower instructor performance in fostering interaction (Sorensen, 2015). Russell and Curtis, reported that students and teachers perceive less meaningful engagement in large-scale online language courses than in smaller ones (Russell & Curtis, 2013). Espasa and Meneses highlighted the importance of feedback processes in online environments, linking interactive feedback to better learning outcomes (Espasa & Meneses, 2010). Overall, ensuring interactivity in online education is critical to prevent passive learning during online educational course.

To address engagement challenges, various technology-mediated solutions have been explored. Deslauriers et al. demonstrated that actively engaging students in class (e.g., through interactive activities) yields greater actual learning, even if students subjectively feel they learned less (Deslauriers et al., 2019)—underscoring the importance of interactive engagement. Chandra and Palvia discussed the emerging paradigm of peer-to-peer learning in online education, suggesting that enabling students to interact with each other is key to improving outcomes (Chandra & Palvia, 2021). One promising approach to facilitate such interaction in online interaction is the use of conversational AI agents as a facilitator to support online activities (Ito et al., 2022).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Generative artificial intelligence (AI) is poised to revolutionize how humans work, and has already demonstrated promise in significantly improving human productivity (Bastani et al., 2024). LLMs, such as GPT-4 have demonstrated remarkable abilities in understanding and generating text, quickly establishing themselves as foundational components of many AI-powered applications, particularly in education domain (Achiam et al., 2023). For example, Bastani et al., conducted a field experiment with nearly 1,000 high school students to assess the impact of GPT-4 on math learning. They compared two AI tutors: GPT Base (standard ChatGPT interface) and GPT Tutor (prompt-engineered for learning support), integrated into 15% of the curriculum. While both improved short-term performance (48% and 127%, respectively), the study also found that students who later lost access to the AI performed worse than those who never used it, suggesting potential long-term dependency risks (Bastani et al., 2024).

Our study builds on this work from conservative lenses by applying GPT-4 as a conversational agent in an educational context to support downstream domains such as education. In line with this, we use GPT-based chatbot as facilitator to enhnace student enagement and learning outcome in online education. We rely on mainstream LLMs like GPT-4 as foundational model and tailored for specific post-lecture facilitation task. GPT-4 is a much-improved model compared to GPT-3.5, which is the large language model that powers the now infamous ChatGPT (Achiam et al., 2023).

Our work inspired by prior research on the efficacy of conversational agent in enhancing online discussion performance. Prior research on human-conversational agents behaviour studies suggests conversational agents can improve user interactions, enhance discussion and support minorities in online discussion. For example, Ito et al. developed an agent to facilitate crowd discussions in large groups (Ito et al., 2022). Conversational agents have been shown to increase women's contributions in online debates (Hadfi et al., 2023) and to improve overall engagement and problem-solving in discussion activities (Sahab et al., 2024). Argumentative chatbots can scaffold debates in online forums (Hadfi et al. 2021), and AI facilitators have demonstrated benefits for critical thinking in social media discussions (Tanprasert et al., 2024).

These studies indicate the potential of AI-driven agents to enrich online learning interactions. However, it is unclear how such tools perform in unique online education environments like Afghanistan, where resource limitations differ from typical settings (Haqbeen et al, 2023) can work. Our work addresses this gap by introducing an LLM-based conversational agent into online class discussions for Afghan students to empirically study how a Large Language Model (LLM)-based chatbot influences student engagement and learning outcomes in online courses in a low-resource educational setting like Afghanistan.

3. Methodology

3.1 Research design

The study recruited 80 undergraduate computer science students (40 female, 40 male; aged 18–26) from a pool of 3,432 qualified applicants (out of 3,761 who initially registered) from Afghanistan via local subjects' recruitment agency (Sahab et al., 2024b). A priori power analysis was conducted using G*Power v3.1 (Faul et al., 2009) to assess the adequacy of the sample size for an independent samples t-test comparing two groups (treatment vs. control). With a total of 80 participants (40 per group), the study is adequately powered (power ≈ 0.80) to detect large effect sizes (Cohen's $d \geq 0.65$) at a significance level of $\alpha = .05$.

We conducted a randomized controlled trial (RCT), and participants were randomly assigned to either a control or treatment condition (Sahab et al., 2024b). Each condition had 40 students during online lectures via Zoom, and subdivided into four discussion groups of 10 students each during post-lecture discussion via Discourse. All participants attended identical 50-minute online lectures followed by 40-minute post-lecture discussions moderated by a human instructor, and completed a follow-up self-report questionnaire. The treatment group additionally engaged in AI-facilitated discussions using a GPT-4-based chatbot during post-lecture discussion.

Figure 1 illustrates the recruitment and grouping process. Selected students were randomly assigned into two conditions (control vs. treatment, 40 each). To facilitate post-lecture discussions, each condition was further divided into four smaller discussion groups of 10 students (labeled A1–A4 for control and B1–B4 for treatment). We used stratified random sampling to ensure each discussion group had an equal gender mix (5 female, 5 male per group). All participants provided informed consent and then took part in study.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

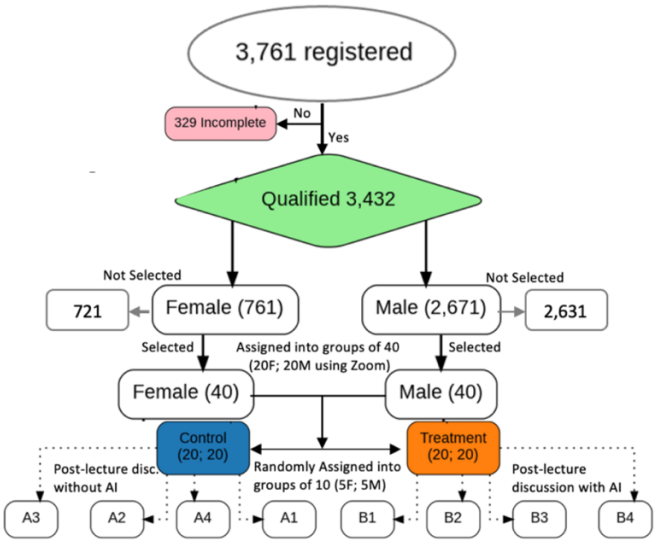


Figure 1. Provides an illustration of the recruitment process and the experimental pipeline.

3.1 Online lecture with follow-up discussion

At the beginning of experiment, both the control and treatment groups (n=80) attended an identical 50 minutes live lecture via Zoom, a videotelephone application which is used for online learning courses. The lecture content was the same for all students and was delivered by an experienced instructor (a Ph.D. in CS with >2 years online teaching experience). To maintain consistency across conditions, the lecture topic and materials were fixed: a lesson on "The Role of Information in Society." The instructor used the same slide presentation and script on both days to minimize any variability in instruction. Each lecture lasted approximately 50 minutes. By controlling all instructional content and delivery, we ensured that any differences observed between conditions could be attributed to the discussion facilitation method (with vs. without the AI chatbot) rather than differences in teaching.

Following the lecture, students were divided into groups of ten (5 female, 5 male per group), resulting in four discussion groups per condition (treatment and control) and engaged in a 40 minutes post-lecture discussion session conducted via an online customized discussion forum called Hyper-Democracy platform, which is built on the open-source Discourse system (Ito et al., 2024; Discourse, 2025). Each group's discussion space was supervised randomly by the same course instructor, who served as the human facilitator across both conditions.

In each condition group (n = 40), a single instructor was assigned to facilitate both conduct the Zoom lectures and interact (moderate) the subsequent post-lecture discussions. These discussions were conducted in smaller breakout groups, with 10 students per group across four subgroups. The instructor rotated between these groups at random intervals. This setup was designed to reflect the practical challenges instructors face in large-scale online courses, particularly the difficulty of independently managing and stimulating meaningful discussions across multiple simultaneous groups.

In the treatment condition, an AI chatbot facilitator was integrated alongside the instructor to support and stimulate the conversation. In contrast, the control condition relied solely on human facilitation by the instructor. This setup ensured that all participants took part in an online discussion following the lecture, with the key distinction being the presence or absence of AI facilitation.

The discussion session was structured to prompt reflective engagement around the guiding question: "What are the key takeaways from today's lecture?" To facilitate meaningful post-lecture discussion, the session was divided into three clearly defined phases:

1. Key Point Generation (15 minutes): Participants were encouraged—by the human facilitator (instructor) and/or the AI agent—to identify and articulate the most significant concepts presented in the lecture.

2. Bridging Theory with Practice (15 minutes): Participants were encouraged—by the facilitator and/or the AI agent—to connect lecture content with real-world contexts or personal experiences.

3. Summary and Forward Reflection (10 minutes): Participants were encouraged—by the facilitator and/or the AI agent—to summarize the discussion, extract key insights, and offer feedback or suggestions for future topics.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This structured format was designed to ensure consistency across conditions and to allow systematic analysis of the AI facilitator's impact. The overall experimental procedure is summarized in Figure 2.

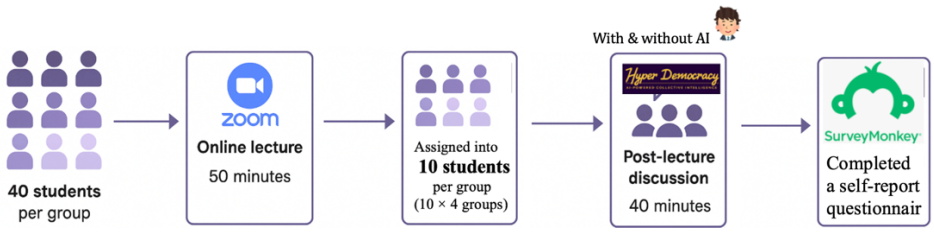


Figure 2. The main experimental pipeline.

3.2 Chatbot Design and Deployment

The conversational agent used in the treatment condition was implemented using the OpenAI's GPT-4 (Achiam et al., 2023). To ensure the chatbot's interventions were relevant and pedagogically useful, we employed a few-shot learning and prompting approach (Tunstall et al., 2022) during its development. We used the GPT-4 model behavior by providing several example question-answer pairs related to the lecture content and discussion guidelines. To ensure both coherence and contextual appropriateness in agent responses, we implemented a predefined prompt adaptation and learning strategy (Liu et al., 2023). Instead of prompting GPT to generate sentences from scratch, we curated a structured set of facilitation messages (a set of 17 human-authored facilitation messages) in advance for post-lecture discussion session while adopting three clearly defined phases explained in section 3.1. During interactions, the agent leverages GPT to post exact facilitated messages which pre-defined by human author or dynamically modify these predefined sentences to better align with the ongoing discussion. This indicates that the chatbot does not always generate messages autonomously; rather, it draws on previously authored human facilitation posts as references. In Figure 3, red-bordered box shows the chatbot's posted previously written human-authored facilitated message, and blue-bordered box a conversation between a student and the chatbot, where chatbot posted a facilitated message entirely created on its own based on posted examples. This design balances the need for consistency in facilitation objectives with the flexibility required to respond to context-specific dialogue. In essence, GPT is not tasked with creating new content but with adapting existing prompts to fit the evolving conversational context. We adjusted the phases for chabtot facilitation described in section 3.1 based on time.

To integrate user (students) interactions with AI agent during post-lecture discussion, we deployed the chatbot into the Discourse (Ito et al., 2024), so the participant could post messages and replies in the discussion threads. On the backend, the chatbot listened to the discussion in real time via the forum's API and decided to intervene once it sees posted messages. On the frontend, the chatbot's profile name was explicitly set as "Facilitator", and the chatbot's profile picture was set similar to those from the popular Japanese "Irasutoya" site (Irastutoya, 2025), which is often used for free educational or presentation illustrations.

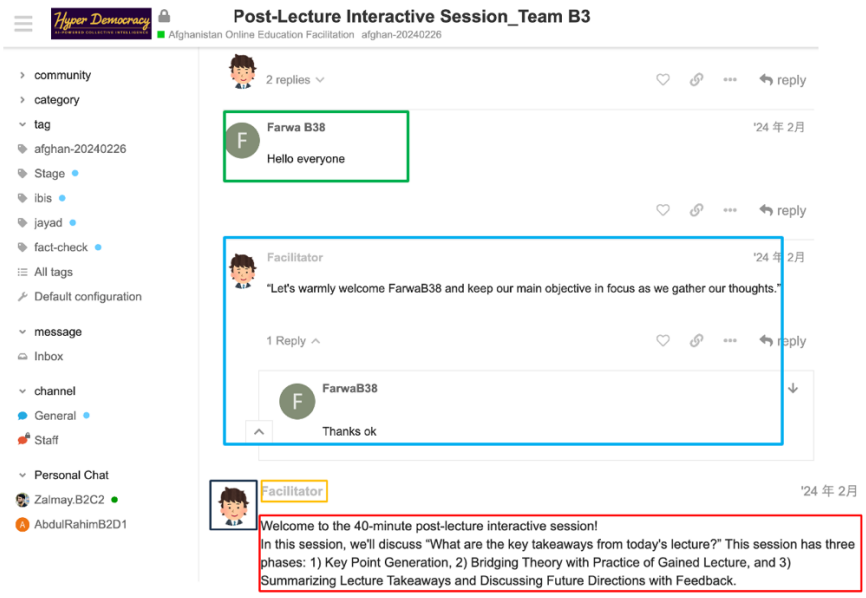


Figure 3. The main user interface of the post-lecture discussion website featuring AI-facilitated interaction (Treatment).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In Figure 3, the interface illustrates a structured online discussion session conducted with treatment group. The green-bordered box at the top shows a message posted by a human participant. Below, the blue-bordered section represents a human–chatbot interaction, in which the AI facilitator acknowledges the participant and encourages focus. On the left, the dark blue-circled avatar depicts a cartoon-style profile image similar to those from the popular Japanese "Irasutoya" site representing the AI facilitator. The orange-highlighted label indicates the chatbot's displayed role "Facilitator". Finally, the red-bordered box shows the chatbot's posted human-authored facilitated message.

3.3 Data collection and analysis

We logged all discussion activity on the forum for both conditions. Each student's posts, replies, word-count, and likes were recorded, along with chatbot facilitated messages (treatment groups), timestamps and thread structure. To evaluate student-student engagement and discussion performance, we defined quantitative metrics based on prior research on online discussions (Hadfi et al., 2023; Sahab et al., 2024a): (1) Posts per user – the average number of messages each student posted; (2) Replies per user – the average number of direct replies to others' posts; (3) Word count – the total number of words contributed by each student, and length of posted messages; and (4) Likes received – the number of "likes" each student's posts received from peers. Among these indicators, the number of posts, replies, and total word count reflect active participation and the depth of discussion, whereas likes primarily signal peer appreciation (Gao, 2016; Schreiner & Fischer, 2021) and are therefore considered light contributions. Metrics were computed to observe any changes or learning effects.

In addition to log data, we administered a short post-experiment survey at the end. This survey assessed students' self-reported learning outcomes and perceived confidence in the subject matter. In particular, we asked students to rate their agreement with the statement: "As a result of this class setting, I feel more confident in this area of study." on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree). We used the 5-point Likert scale to determine the attitudes of individuals towards acceptance study setting. The Likert scale, developed by Rensis Likert in 1932, is a reliable and valid method for measuring attitudes (Sullivan & Artino, 2013). The aim was to capture whether the students felt the discussion format (with or without AI) improved their confidence and perceived learning outcome in the subject.

For analysis, we compared the control and treatment groups on the engagement metrics and survey results. We used independent-samples t-tests to assess differences between conditions for each metric, as well as for the self-report ratings. Statistical significance was set at $p < 0.05$. All quantitative analyses were performed using IBM SPSS Statistics (v28). Below, in section 4, we report the results.

4. Results

4.1 post-lecture discussion engagement

Figure 4 summarizes the post-lecture discussion performance metrics for the control vs. treatment groups.

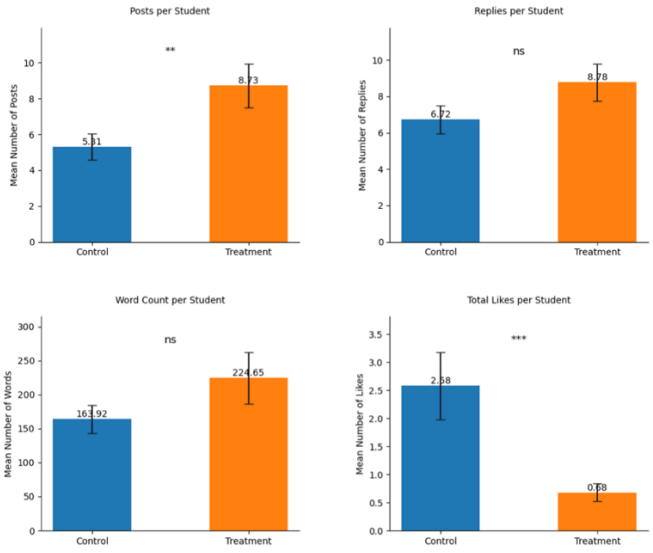


Figure 4. Discussion engagement metrics between control (n=36) and treatment (n=40) groups.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Our finding suggests that treatment group posted significantly more messages per student than the control (p<0.01), while differences in replies and word count were not significant (ns). The control group received more likes per student (*p<0.001). Treatment group students made an average of 8.73 posts each, significantly exceeding the control group's 5.11 posts per student (t test, $p < 0.01$). This indicates that the chatbot's presence stimulated students to contribute more frequently to the discussion. For the other engagement metrics, the treatment group demonstrated a slightly higher mean number of replies per student (8.78) compared to the control group (6.72), as well as a greater average word count per student (224.65 vs. 67.92). However, these differences were not statistically significant. An interesting finding was that control group posts received significantly more "likes" from peers on average than treatment group posts (2.88 vs. 0.78 likes per student, $p < 0.001$).

4.2 Self-reported learning outcome

To assess students' perceptions of their learning experience, we compared the post-experiment survey results between the two conditions. Figure 5 presents the distribution of responses for the control and treatment groups. Overall, students who participated in the AI-facilitated discussions reported higher confidence in their understanding of the course material. The treatment group's average rating was higher than the control groups. An independent t-test confirmed that this difference was statistically significant (t(78) = –2.125, p = 0.037).

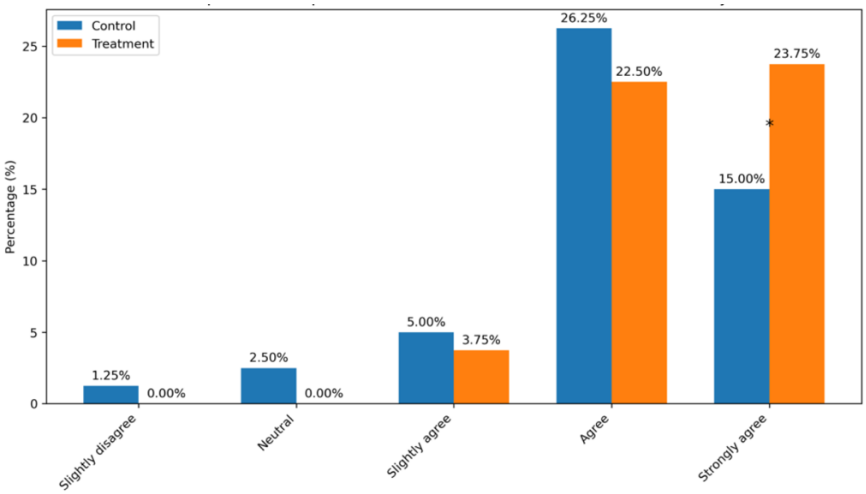


Figure 5. Comparison of post-intervention self-report measurement responses of users between control (n=40) and treatment (n=40) groups.

5. Discussion and Conclusion

In this study, we investigated the impact of an GPT-based AI conversational agent on student engagement and learning outcome in an online course interactive session in Afghanistan. Using a controlled experimental design, we found that embedding a GPT-4-based chatbot facilitator into post-lecture discussions significantly improved multiple facets of student engagement. Analysis of discussion logs and post-intervention surveys revealed that the treatment group (discussion with the AI facilitator) demonstrated significantly higher participation rates, with more posts and replies, during post-lecture discussion and reported greater confidence in their understanding of the course material.

An interesting observation emerged regarding the number of "likes" received across conditions. Posts in the control group (discussion without the AI facilitator) received more likes from peers than those in the treatment group. One possible explanation is that the human-only discussions in the control group resulted in fewer overall posts, allowing students to focus their attention—and consequently their likes—on a smaller number of contributions. In contrast, the higher volume of posts in the treatment groups, facilitated by the chatbot, may have diluted peer attention across more content. This interpretation aligns with the *bandwagon effect* (Schmitt-Beck, 2015), wherein individuals are more likely to endorse content that has already received visible support. In the control condition, where engagement was relatively lower, students may have shown their support through likes rather than additional contributions (*posts* & *replies*). Conversely, in the treatment groups, the chatbot's active facilitation may have encouraged more students to participate directly by posting (*posts* & *replies*), reducing their reliance on passive indicators of engagement such as *likes*.

In this study, our primary focus was on active participation and content engagement, as these measures provide a more meaningful indication of learning involvement (Gao, 2016; Schreiner & Fischer, 2021). Specifically, we emphasized students' efforts to articulate their opinions by posting, rather than merely expressing feelings or

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

offering surface-level reactions by liking. In summary, these results confirm that the chatbot had a strong positive effect on student engagement in the post-lecture discussions.

These finding are further supported by self-reported questionnaire data, which indicated that students who participated in chatbot-facilitated discussions reported higher levels of confidence in the subject matter compared to those in the human-only condition. The higher self-reported confidence in the treatment group on subject matters also merits AI role as a facilitator in discussion. Students in the AI-supported discussions felt more confident about the study material, which is consistent with research showing that interactive and responsive learning environments improve student self-confidence and satisfaction (Pence, 2022). Chatbot likely contributed by promptly addressing confusion and keeping the discussion productive, thus reinforcing students' understanding. Taken together, the survey results reinforce the behavioral data (discussion logs), highlighting the value of AI-assisted facilitation in enhancing student engagement and perceived learning outcomes.

Our findings are in line with emerging evidence that facilitating peer learning can enhance educational experiences (Chandra & Palvia, 2021), interactive and responsive learning environments improve student self-confidence and satisfaction (Pence, 2022), and AI facilitators can amplify the voices and opinions in discussions (Hadfi et al., 2023, Sahab et al., 2024b), and overall support engagement opportunities (Sahab et al., 2024a).

Despite these findings, the study has several limitations and should be addressed in future research. First, while the sample size in our study is adequately powered (power ≈ 0.80) to detect large effect sizes (Cohen's $d \geq 0.65$) at a significance level of $\alpha = .05$. However, it is underpowered to detect medium ($d = 0.50$) and small ($d = 0.20$) effects, for which the estimated power falls below the conventional threshold of 0.80. This limitation should be considered when interpreting non-significant results. Additionally, the study was limited to a single-day intervention with computer science undergraduates considering one environment. Future research should consider replicating the experiment over multiple sessions across different educational programs and areas to examine the consistency and generalizability of the observed effects. Another limitaiton of this study is the chatbot was configured to support multiple facets of engagement: instructor–student interaction (by answering questions or providing prompts), student–student interaction (by encouraging students to respond to each other), and student–content interaction (by bringing in relevant points from the lecture). However, this study focused exclusively on student–student interactions. Future research should explore additional dimensions of interactivity, such as student–instructor and student–content interactions, to assess the consistency and generalizability of the observed effects.

In conclusion, our study provides empirical evidence that AI-powered conversational agents can play a supportive role to enhance student-student interactions in online education. The GPT-based chatbot in our study functioned effectively as a facilitator during post-lecture discussion. These results are among the first to demonstrate such benefits in an Afghan educational setting, suggesting the approach holds promise for other resource-constrained environments. While our study focused on student-to-student interactions, future work will explore the impact of AI facilitation on student–instructor and student–content interactions. We believe integrating AI agents across these dimensions could further optimize online learning experiences. An extended version of this research, including qualitative analysis of discussion content, is in preparation for submission to the IEICE Transactions on Information and Systems.

Acknowledgement

- **Funding or Grant:** This research was partially supported by the JSPS KAKENHI (Grant Number: 23K17164, Japan) and JST CREST (Grant Number: JP- MJCR20D1, Japan) funds.
- **Data/Software Access Statement**: The discussion logs data is available upon reasonable request at https://hyper-democracy.com/tag/afghan-20240226 (accessed date 21 April 2025); and data from the questionnaire are available upon request from the corresponding author.
- **Contributor Statement**: Conceptualization, J.H. and S.S.; methodology, J.H., S.S.; software, J.H. and T.I.; validation, J.H. and S.S.; formal analysis, J.H. and S.S.; investigation, J.H. and S.S.; resources, J.H., S.S. and T.I.; data curation, J.H. and S.S.; writing—original draft preparation, J.H. and S.S.; writing—review and editing, J.H. and S.S.; visualization, J.H. and S.S. supervision, T.I.; project administration, J.H. and S.S.; funding acquisition, J.H. and T.I. All authors have read and agreed to the published version of the manuscript.
- **Conflict Of Interest (COI)**: The authors declare no conflict of interest.

References

Hart, C. M., Friedmann, E., & Hill, M. (2018). Online course-taking and student outcomes in California community colleges. *Education Finance and Policy, 13*(1), 42–71.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Liu, P., Yuan, W., Fu, J., Jiang, Z., Hayashi, H., & Neubig, G. (2023). Pre-train, prompt, and predict: A systematic survey of prompting methods in natural language processing. *ACM Computing Surveys, 55*(9), 1–35. https://doi.org/10.1145/3505244

Salmon, A. K., & Barrera, M. X. (2021). Intentional questioning to promote thinking and learning. *Thinking Skills and Creativity, 40*. https://doi.org/10.1016/j.tsc.2021.100822

Achiam, J., Adler, S., Agarwal, S., Ahmad, L., Akkaya, I., Aleman, F. L., Almeida, D., Altenschmidt, J., Altman, S., Anadkat, S., et al. (2023). *GPT-4 technical report*. arXiv. https://arxiv.org/abs/2303.08774

Yan, C., Ren, R., Meng, M. H., Wan, L., Ooi, T. Y., & Bai, G. (2024). Exploring ChatGPT app ecosystem: Distribution, deployment, and security. In *Proceedings of the 39th IEEE/ACM International Conference on Automated Software Engineering* (pp. 1370–1382).

Anand, P. (2023, March 16). Khan Academy creates GPT-4 based helper Khanmigo marking formal entry of AI into education. *Dataquest*.

Bastani, H., Bastani, O., Sungu, A., Ge, H., Kabakcı, Ö., & Mariman, R. (2024). Generative AI can harm learning. *Research Paper, The Wharton School*. https://doi.org/10.2139/ssrn.4895486

Haqbeen, J., Sahab, S., Ito, T., & Rizzi, P. (2021). Using decision support system to enable crowd identify neighborhood issues and its solutions for policy makers: An online experiment at Kabul municipal level. *Sustainability*, 13(10), 5453. https://doi.org/10.3390/su13105453

Szopiński, T., & Bachnik, K. (2022). Student evaluation of online learning during the COVID-19 pandemic. *Technological Forecasting and Social Change, 174*, 121195.

Haqbeen, J., Sahab, S., & Ito, T. (2023). A digital initiative to address girls' education challenges in collaboration with NPO in post-2021 Afghanistan. *IIAI Letters on Information and Interdisciplinary Research, 4*(1).

Lyons, E. (2023). Household and student survey-based evidence on girls' secondary education in Afghanistan. *Social Sciences & Humanities Open, 8*(1), 100533.

Shayan, Z. (2015). Gender inequality in education in Afghanistan: Access and barriers. *Open Journal of Philosophy, 5*, 277–284.

Singh, A. K., & Meena, M. K. (2022). Challenges of virtual classroom during COVID-19 pandemic: An empirical analysis of Indian higher education. *International Journal of Evaluation and Research in Education, 11*(1), 207–212.

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. S. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275–285.

Sorensen, C. (2015). An examination of the relationship between online class size and instructor performance. *Journal of Educators Online, 12*(1), 140–159.

Russell, V., & Curtis, W. (2013). Comparing a large- and small-scale online language course: An examination of teacher and learner perceptions. *The Internet and Higher Education, 16*, 1–13.

Espasa, A., & Meneses, J. (2010). Analyzing feedback processes in an online teaching and learning environment: An exploratory study. *Higher Education, 59*(3), 277–292.

Deslauriers, L., McCarty, L. S., Miller, K., Callaghan, K., & Kestin, G. (2019). Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Sciences, 116*(39), 19251–19257.

Chandra, S., & Palvia, S. (2021). Online education next wave: Peer to peer learning. *Journal of Information Technology Case & Application Research, 23*(3), 157–172.

Kasneci, E., Sessler, K., Winkel, K., Schmid, U., & Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences, 103*, 102274.

Ito, T., Hadfi, R., & Suzuki, S. (2022). An agent that facilitates crowd discussion. *Group Decision and Negotiation, 31*, 621–647.

Hadfi, R., Okuhara, S., Haqbeen, J., et al. (2023). Conversational agents enhance women's contribution in online debates. *Scientific Reports, 13*, 14534.

Sahab, S., Haqbeen, J., & Ito, T. (2024a). Conversational AI as a facilitator improves participant engagement and problem-solving in online discussion. *IEICE Transactions, E107-D*(4).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Hadfi, R., et al. (2021). Argumentative conversational agents for online discussions. *Journal of Systems Science and Systems Engineering, 30*, 450–464.

Tanprasert, T., Fels, S., Sinnamon, L., & Yoon, D. (2024). Debate chatbots to facilitate critical thinking on YouTube: Social identity and conversational style make a difference. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, Honolulu, HI, USA.

Sahab, S., Haqbeen, J., Hadfi, R., et al. (2024b). E-contact facilitated by conversational agents reduces interethnic prejudice and anxiety in Afghanistan. *Communications Psychology, 2*, 22.

Hyper-Democracy. (2025). *Hyper-Democracy Platform*. https://hyper-democracy.com

Discourse. (2025). *Discourse Platform*. https://www.discourse.org

Ito, T., Dong, Y., Haqbeen, J., Matsuo, T., & Sahab, S. (2024). Multiple AI agents that support crowd discussion. In *Proceedings of the 12th ACM Collective Intelligence Conference*, Northeastern University, Boston, MA.

Sullivan, G. M., & Artino, A. R., Jr. (2013). Analyzing and interpreting data from likert-type scales. *Journal of Graduate Medical Education*, 5(4), 541–542. PubMed. https://doi.org/10.4300/JGME-5-4-18

Tunstall, L., et al. (2022). Efficient few-shot learning without prompts. *arXiv preprint*, arXiv:2209.11055.

Tofade, T., Elsner, J., & Haines, S. T. (2013). Best practice strategies for effective use of questions as a teaching tool. *American Journal of Pharmaceutical Education, 77*(7), 155.

Schmitt-Beck, R. (2015). Bandwagon effect. In *The International Encyclopedia of Political Communication* (pp. 1–5).

Gao, L. (2016). Motives for posting and liking on social media: Comparing differences between Chinese and European users (Master's thesis). University of Twente. https://essay.utwente.nl/69110/

Schreiner, M., Fischer, T., & Riedl, R. (2021). Impact of content characteristics and emotion on behavioral engagement in social media: Literature review and research agenda. *Electronic Commerce Research, 21*, 329–345.

Pence, P. L. (2022). Student satisfaction and self-confidence in learning with virtual simulations. *Teaching and Learning in Nursing, 17*(1), 31–35.

Irasutoya. (2025). *2025 年*. https://www.irasutoya.com/2025/

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

GoViz: A Visualization Tool for Empowering Transparency in Government Speech.

Larissa Guder[a*], *João Paulo* Aires[a], *Isabel H.* Manssour[a], *Dalvan* Griebler[a]

[a]Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil, larissa.guder@edu.pucrs.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Public speech from government figures often describes relevant actions that can impact the population's lives. However, most people do not have time and access to analyze and understand public speech. Such a scenario narrows the participation of the people in the main discussions, which leads to multiple misunderstandings. In this work, we propose GoViz, a tool that automatically produces visual representations to outline governmental speeches regarding the subject, its main actors, and how they connect to the discussion topics. GoViz processes natural language from speech transcriptions in a pipeline that identifies part-of-speech elements, named-entities, and the relation between persons, making speech content more accessible and insightful. Using publicly available data, we evaluate our tool in two different languages (Portuguese and English). The results demonstrate that the visualizations from both data facilitate understanding the speech content. Thus, our main contribution is to encourage the participation of citizens in parliamentary issues, allowing a simplified and visually engaging avenue to access long speeches and fostering improved communication between parliamentarians and the population.

Keywords. natural language processing, data visualization, digital government
Research paper, DOI: https://doi.org/10.59490/dgo.2025.954

1. Introduction

Most representative democracies define and discuss laws and public measures in parliaments. There, politicians elected by the people vote and argue in favor of the interests of their voters. Although these politicians are the ones to accomplish and propose discussions, the public must also follow and question the decisions and which topics must be covered. However, the language used in these discussions and the decisions made are often hard to comprehend, making them inaccessible to the population. In the analysis of Bernardes and Bandeira, 2016 about parliamentary websites in Brazil and the United Kingdom, one of the main problems found is that even though there is a lot of information available, it can be an exhaustive task to explore and understand such information. Thus, although there is information about these discussions, they still cannot reach the population in a way that facilitates understanding.

A simple way to facilitate the understanding of parliament discussions is through visualizations. Generating images and interactive charts showing the main topics in a discussion can make it easier to follow them. Existing approaches (Cantador et al., 2021; Palma et al., 2021) propose generating visualizations from debates that try to explain most of the discussion. However, they often need extra information from someone who already knows about the subject to guide the generation of these visualizations. Considering that most people do not know about the topic, one of the main features of a visualization tool should be the capacity to process information without any previous knowledge about it.

The Global Parliamentary Report (Inter-Parliamentary Union, 2022) defines the parliamentary engagement in five different points: (1) information, (2) education, (3) communication, (4) consultation, and (5) participa-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

tion. The citizens' engagement starts with understanding what is happening in the government. In this work, we introduce GoViz, a visualization tool that automatically processes discourses to provide insightful visualizations that facilitate their analysis. Our main objective with GoViz is to provide a practical application of natural language processing combined with visualization techniques to engage the citizens at the information level. Alternatives like this are necessary because more than making information publicly available is needed. It is necessary to grant that the information is relevant, reliable, timely, and comprehensive, and mainly that it can be understood by everyone in society, regardless of their background, status, or abilities (Inter-Parliamentary Union, 2022).

GoViz uses natural language processing to detect different patterns in speech transcriptions. It can receive structured documents as input and automatically identify columns containing speech and those containing people's names. By connecting people's names with their discourses, GoViz can reveal the main subjects discussed by every speaker and how frequently they talk about other people. Currently, GoViz can work with both English and Portuguese languages, which allows the processing of different types of texts. We evaluate GoViz using two publicly available datasets, one in English and the other in Portuguese. They bring political discussions about sensitive topics that are of people's interest. We perform a series of analyses of the generated visualizations and describe how they connect to the main subject of the datasets and their main limitations.

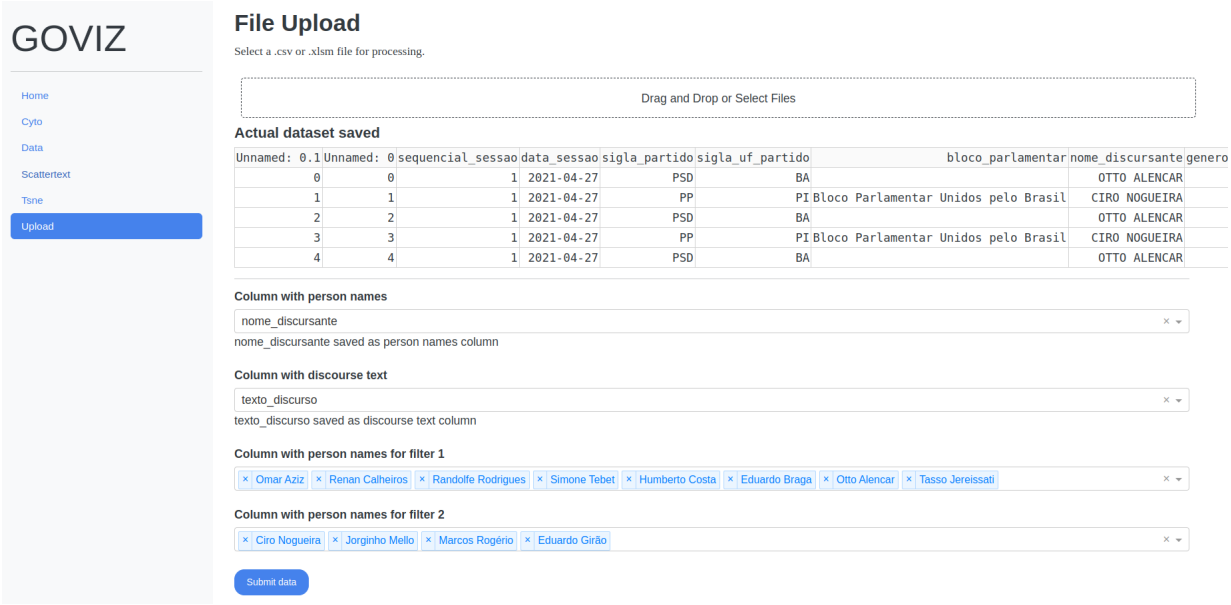


Fig. 1 – Upload screen.

GoViz's contribution is two-fold: first, it increases the direct participation of citizens in parliamentary issues through access to long speeches in a simplified and visual way; and second, GoViz implementation code is publicly available on https://github.com/NLP-PUCRS/GoViz, which allows other people to modify it to work in different contexts and languages. This paper is organized as follows: Section 2 introduces the main concepts concerning this work, such as natural language processing and visualization techniques. We also present some related work that shares some aspects with our approach. Section 3 describes the methods used for building GoViz. Here, we explain how we build GoViz, detailing its different models. In Section 4, we describe the main experiments and the results obtained. We introduce the scenarios and how we extract information from the selected datasets. Given our results, Section 5 discusses the main findings of this work and its limitations. Finally, in Section 6, we summarize our work and bring some perspectives on future work.

2. Background

GoViz is a tool built on two main concepts: Natural Language Processing (NLP) and Data Visualization. From NLP, we leverage the main techniques for extracting textual information. On the other hand, from data visualization, we use existing approaches for summarizing information into visual representations. In this section, we detail the visualization concepts and present related work.

2.1. Text Visualization

When performing data analysis, extracting information from textual data can be difficult. As text can carry relevant information, it is necessary to identify where this information is and how we can summarize it. Text visualization techniques can help with this task. We can consider visualization as a method for communicating information through an image or interactive chart (Ward et al., 2015). Such an image or chart can carry as much information as possible, making it easier for a human to understand the context it is describing. Text visualizations have corpora as a basis and can focus on words, sentences, paragraphs, or entire documents.

One of the first steps to process text is converting it into vector space. In the vector space, we have information about the presence and frequency of words in sentences/documents. There are many ways to obtain a vector that represents a text. Counting the frequency of terms (bag-of-words) in a text is one of the most basic ways to get a vector. Each position in the vector will represent a word with a number indicating the frequency of such a word. With this initial representation, we can already create visualizations that show frequent terms in a text. Other representations can involve the frequency of words in a document weighted by their presence in other documents in a corpus, such as Term-Frequency inverse Document-Frequency (Rajaraman & Ullman, 2011).

A common way to visualize a document is by displaying the frequency of words. Word cloud is a visualization technique that shows the word frequency of a document. It highlights more frequent words by increasing its font size and color darkness (Ward et al., 2015). The result is a cloud-shaped structure containing such words. Similarly, Word Tree is a technique that shows the frequency of words and the context in which they are inserted and allows easy exploration (Wattenberg & Viégas, 2008). Thus, given a document and a target word, it provides a visualization where the target word is the root and the sentences where it appears are the branches.

These techniques demonstrate how we can organize textual information to understand the context without reading it. In addition to Word Cloud and Word Tree, other text visualization techniques can support the representation of connections in the text, such as the arc diagram (Heer et al., 2010), or analyze feature values across the text, such as the literature fingerprinting presented by (Keim & Oelke, 2007).

An alternative to visualize text representations and other high-dimensional elements is using t-SNE (Van der Maaten & Hinton, 2008). This technique allows the visualization of multidimensional points in two or three dimensions. When converting from a multidimensional to a two-dimensional representation, t-SNE can preserve the approximate distance between similar points and non-similar ones. Modifying the concept of Stochastic Neighbor Embedding (SNE) (Hinton & Roweis, 2002), t-SNE proposes a new method to identify the similarity of low-dimensional points using the Student-t distribution. Besides, they propose a new cost function to approximate the real distance between points of low-dimensional representations converted from high-dimensional ones. In this work, we use text visualizations to facilitate people's understanding of speeches from politicians.

2.2. Related Work

Transparency, participation, and collaboration can be considered the principles of the open government (o-government) (Harrison et al., 2011; Quintero-Angulo et al., 2020). Transparency is crucial in making it possible for citizens to participate and collaborate with the government. However, making large datasets publicly available is not enough. This data must be accessible, clear, and easy to understand for citizens. Government data can have different formats and sources. It can be financial values, statistical, and textual, such as speech transcriptions. Manual summarization and information retrieval from textual data are laborious tasks since it is necessary to read everything to understand the subject of the data. Thus, NLP becomes a valuable alternative to extract information from texts automatically.

There are several research initiatives to facilitate the comprehension of a textual dataset, such as chatbots that extract only the desired information (Cantador et al., 2021) and the application of topic mapping from text (Palma et al., 2021). However, these approaches still require prior knowledge of the subject to extract information correctly.

When we refer to speech transcriptions, specifically of debates and public discussions, we can use data visu-

alization techniques to facilitate the understanding of their subjects or to extract key information from these discussions. Khartabil et al., 2021 propose a tool for argument visualization that allows us to determine which points each person is defending. The authors proposed three novel visualizations: Stacked Boxes, Sunburst Pop-Up, and F+C Icicle. Their approach is suitable for deep analyses but requires the user to pass some arguments. Our approach focuses on providing a lean summarization of the content from speech transcriptions.

When analyzing speeches from politicians, it is important to see the agreements and disagreements in political discussions (Volkovskii & Filatova, 2022) and polarization (Diaz et al., 2022). With this information, citizens can use their critical sense and build their vision about the subject in discussion. To facilitate the visualization of different points of view, graphs such as the scatter-text proposed by Kessler, 2017 allow us to compare two groups of people. The scatter-text allows us to clearly see the polarization between two groups and which terms they commonly address. Because of this, we have incorporated this type of graph into our tool. Its use is available when processing documents in Portuguese and English.

Focusing on open government data, Steinbauer et al., 2016 and Bönisch et al., 2023 propose visualizations to explore transcribed parliamentary speeches. Steinbauer et al., 2016 explores Austrian parliament data, proposing a tool to visualize the relationships between politician discourse and parliamentary groups. The authors present the politician's profile and overview through visualizations, including the politician's speech, club, absence, and a politician relation graph in the parliament. While Steinbauer et al., 2016 uses the sentiment expressed in the speech towards topics discussed, we analyze the content of the speech to define the relations. Bönisch et al., 2023 proposes a web application to explore the minutes of plenary proceedings, agenda items, and polls of the German government data. The proposed tool contains a topic analysis, focusing on a specific speaker, party, or fraction on a specific topic. The Deputy Inspector analyzes a speech in conjunction with complementary data from background information, remarks, and poll results. In contrast to Bönisch et al., 2023 tool, which is specific to German government data, our tool is generalist, accepting various sources of data in Portuguese or English.

3. GoViz Description

In this section, we describe the methodology used to develop GoViz. We explain the data input supported, the main techniques used to process the text, and the available visualizations to analyze it. Figure 2 illustrates all the processing stages described in the following sections.

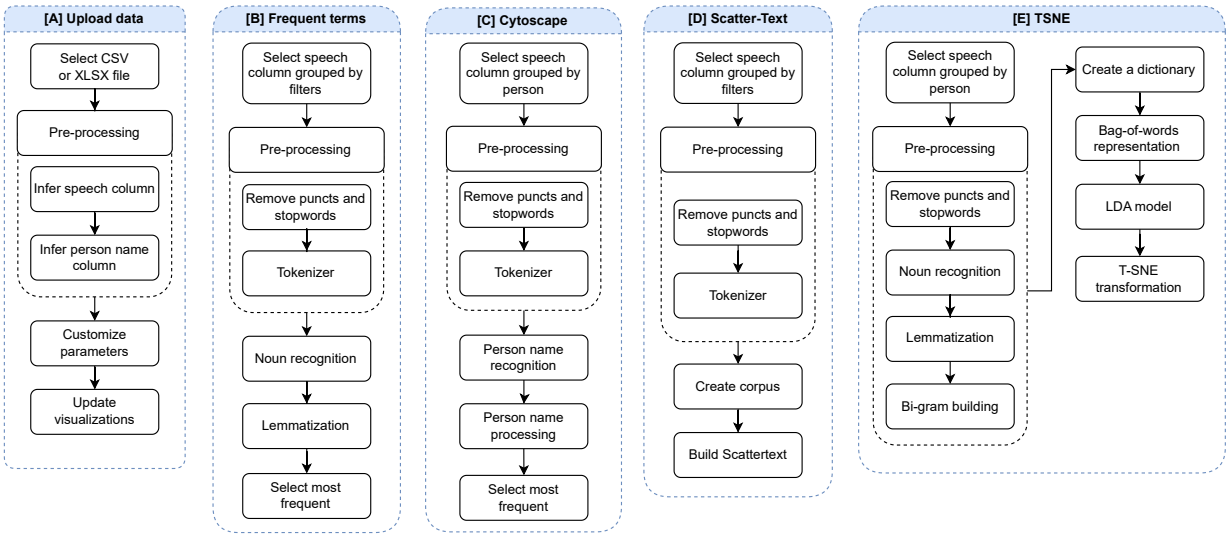


Fig. 2 – Processing stages for chart generation.

3.1. Methodology

For this work, we initially analyzed related work involving the visualization of governmental data. Then, we studied NLP methods and visualization techniques to specify the requirements and functionalities of GoViz.

With this initial study, we defined the type of information we aim to extract from governmental speeches and which NLP models we would employ to obtain them. Finally, given the textual information from the speeches, we selected the best visualization techniques that allowed us to summarize the data.

We process textual data using SpaCy (Montani et al., 2020) and Gensim (Rehurek & Sojka, 2011), while for manipulating the dataset, we use Pandas[1]. For the visualizations, we use the Plotly library[2] to plot the graphs and Dash[3] to build the tool. For this work, we use Spacy for most natural language processing tasks. We selected this library due to its ability to process different languages accurately. Since we want GoViz to work on both Portuguese and English properly, Spacy became a reliable option. Spacy provides the obtained accuracies for each task in different languages. We summarize the results in Table 1. As we can see, both languages have an accuracy higher than 95% for both Tokenization and Part-of-Speech Tagging, while having an F-score higher than 85%. We can see the full results for English[4] and Portuguese[5] in their page. As source for training the models, Spacy uses OntoNotes 5[6], ClearNLP Constituent-to-Dependency Conversion[7], WordNet 3.0[8], and Explosion Vectors (OSCAR 21.09 + Wikipedia + OpenSubtitles + WMT News Crawl)[9]. While for Portuguese, they use UD Portuguese Bosque v2.8[10], WikiNER[11], and Explosion fastText Vectors (cbow, OSCAR Common Crawl + Wikipedia).

Language	Task	Result
English	Tokenization	1.0
	Part-of-Speech	0.97
	Named Entity Recognition	0.85
Portuguese	Tokenization	1.0
	Part-of-Speech	0.97
	Named Entity Recognition	0.89

Tab. 1 – Spacy results for NLP tasks in both English and Portuguese. For both Tokenization and Part-of-Speech Tagging, they provide an accuracy result, while for Named Entity Recognition, they use F-score.

3.2. Input data

The main idea behind the proposed approach is that the user can use different textual datasets to generate visualizations to extract information without the need to read the entire transcription. Textual data can be collected from various sources and stored in different ways. Providing a standard input format is essential to allow a correct visual representation. Thus, GoViz accepts structured data in `csv` and `xlsx` formats. The dataset must contain a column with the person's name and one with textual data. Since our goal is to generate visualizations from speeches, it is important to have information about who is saying the transcribed text. Regarding the textual language, it can be either in Portuguese or English.

To facilitate the use of GoViz by its users, we built an interface, illustrated in Figure 1. It contains an upload function that receives a `csv` or `xlsx` file as input. Once the file is uploaded, we process the textual data using SpaCy and Gensim. Different processing is done for each visualization, as described in Figure 2. We store the processed data in a JSON file that GoViz reads to generate each chart every time the application starts.

3.3. Processing stages

GoViz has five main processing stages. The first one processes the uploaded data. Initially, GoViz pre-processes the uploaded file to infer columns that contain the name of the speaker and the one containing the speech. However, the user can change the automatically selected columns if the inference fails to find them correctly. To

[1]https://pandas.pydata.org/
[2]https://plotly.com/
[3]https://dash.plotly.com/
[4]https://spacy.io/models/en#en_core_web_md-accuracy
[5]https://spacy.io/models/pt#pt_core_news_md-accuracy
[6]https://catalog.ldc.upenn.edu/LDC2013T19
[7]https://github.com/clir/clearnlp-guidelines/blob/master/md/components/dependency_conversion.md
[8]https://wordnet.princeton.edu/
[9]https://github.com/explosion/spacy-vectors-builder
[10]https://github.com/UniversalDependencies/UD_Portuguese-Bosque
[11]https://figshare.com/articles/dataset/Learning_multilingual_named_entity_recognition_from_Wikipedia/5462500

make the inference, we first convert the dataset into a Pandas DataFrame and verify the column type, removing everything with a data type other than text. From the remaining columns, we select the one containing the largest textual length as the speech column. Once selected, we use SpaCy to perform named-entity recognition on the other columns to identify the person's name column. We select the first word from each row in a candidate column and check if it is a named-entity object identified as a person. The column with the highest occurrence of person names is then selected. Before submitting the data for the next stages, the user can define two groups of person names to compare their speeches. Figure 2[A] illustrates the steps from the first processing stage.

A simple way to identify patterns in textual data is by obtaining the frequency of words. We select data from the provided file based on the groups defined in the data upload stage to extract the frequency of terms. If the user did not provide any groups, we consider the top terms from the automatically identified column containing textual data. When defined by the user, we split the text based on the two informed groups. First, we remove stop words and punctuations to pre-process and convert the raw text into tokens to feed the Spacy model that performs part-of-speech tagging. We only consider nouns for counting the term frequency, as they contain more relevant information, such as things, places, and persons. After filtering the terms, we convert them to lemmas and select only the top 20 most frequent nouns. We illustrate this processing stage in Figure 2[B].

We process data for the third processing stage to obtain the person's names mentioned in each speech. First, we group each speech by the speaker. Then, we pre-process the data by removing punctuation and stop-words and convert it into tokens. We feed the named-entity recognizer Spacy model with the cleaned data. From the output, we keep only the tokens recognized as Person entities. Finally, we get the people's names cited by their frequency. Figure 2[C] shows the steps of this processing stage.

To generate the Scatter-text visualization (see Section 3.4), in the fourth processing stage, we need to create a corpus of frequent terms for two separate groups. This process only occurs when the user previously indicates two groups for comparison. The idea is to visually compare the main terms that each group brings into the discussion. Thus, given each group's speeches, we first use the same pre-processing steps described in the previous stages. Then, using the library provided by Kessler, 2017, we create a corpus containing tokens that we will use to create groups of words and the most frequent terms mentioned by the participants of each group. Figure 2[D] shows the steps to perform this processing stage.

Finally, the fifth processing stage manipulates textual data to serve as input to the t-SNE model (see Section 3.4). In this process, the first step is to pre-process speeches by selecting them by their speaker. Then, we remove punctuation and stop words. To obtain the part-of-speech of the terms, we use Spacy. Once we have the part-of-speech, we select only the nouns, convert them into lemmas, and create bi-grams out of them. With the cleaned data, we feed a Latent Dirichlet allocation (LDA) model provided by Gensim. This model tries to identify the topics given a set of documents. For our specific case, we want to identify topics given in the speeches in the dataset. The number of topics to be created is customizable in the script. With the output of LDA, we made the transformations for t-SNE. We illustrate these steps in Figure 2[E].

3.4. Visualizations

GoViz provides four interactive visualizations: treemap, network, scatter text, and t-SNE. Each visualization has a different level of user interaction that facilitates a more detailed analysis of the numbers and terms present in the visualization. To use all GoViz resources, the user must specify two groups of people's names with the aim of comparing the speeches. If not informed, GoViz still brings the treemap and t-SNE visualizations.

Focusing on understanding the main terms mentioned by speakers, we use a treemap to show the top 20 nouns. If the user specifies the two groups of people's names, GoViz shows the top 20 for each group, using two different colors, as exemplified in Figure 3. Otherwise, it shows the general top-20, as presented in Figure 7. The size of each rectangle represents the frequency of the term. For this specific figure, we omitted words that do not fit the rectangle, as we increased the font size for better visualization.

The treemap allows us to overview the main terms, but it is limited to 20 of them. To provide a deeper analysis, we use the scatter text visualization. To build the scatter text, the user must specify two groups of persons that will have their speeches compared, considering the terms they use. Thus, the visualization shows terms



Fig. 3 – Most frequent nouns in the PCI Covid dataset.

used by one group, by the other, and those used by both. As presented in Figure 4, the terms in the center are used by both sides. On the top-left, we have the most used terms by group 2, while on the bottom-right, we have the most used terms by group 1. This is important to show where the discourse can be similar and at which points they diverge.

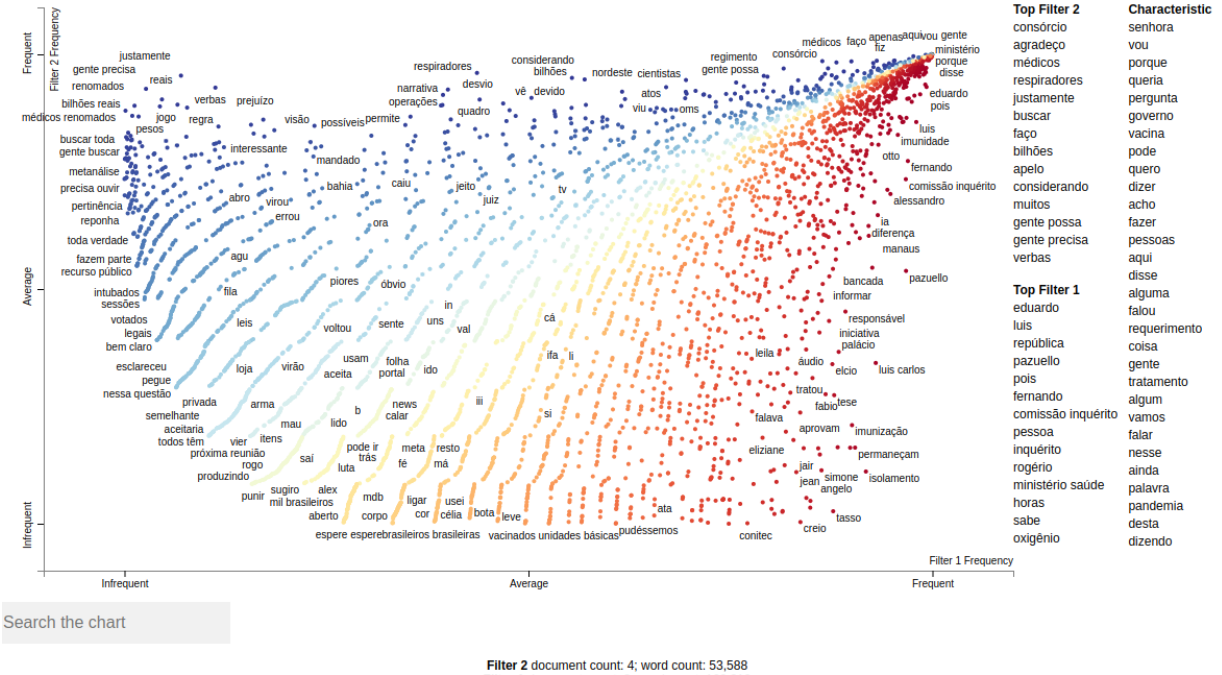


Fig. 4 – Scatter-text visualization with PCI Covid dataset.

To verify which people were cited during the speeches, we used Cytoscape, a network visualization provided by Dash. It shows the relationship between the speaker and the people mentioned. Figure 5 shows an example with the speaker's name in the center and the connections showing how many times he/she mentioned each person.

Finally, the visualization generated by t-SNE (Figure 6) aims to show the relationship between topics and who is talking about them. Each circle represents a speaker, and the size of each circle means how many times that speaker talked about the topic. It is possible to see the speaker's name with a mouse click on the circle or selection. Each color represents a different topic, and their position in the graph means how close each group is to the other. Using t-SNE, we can see a complement from the treemap, where we can focus on each speaker and understand which points they are making during their speech.

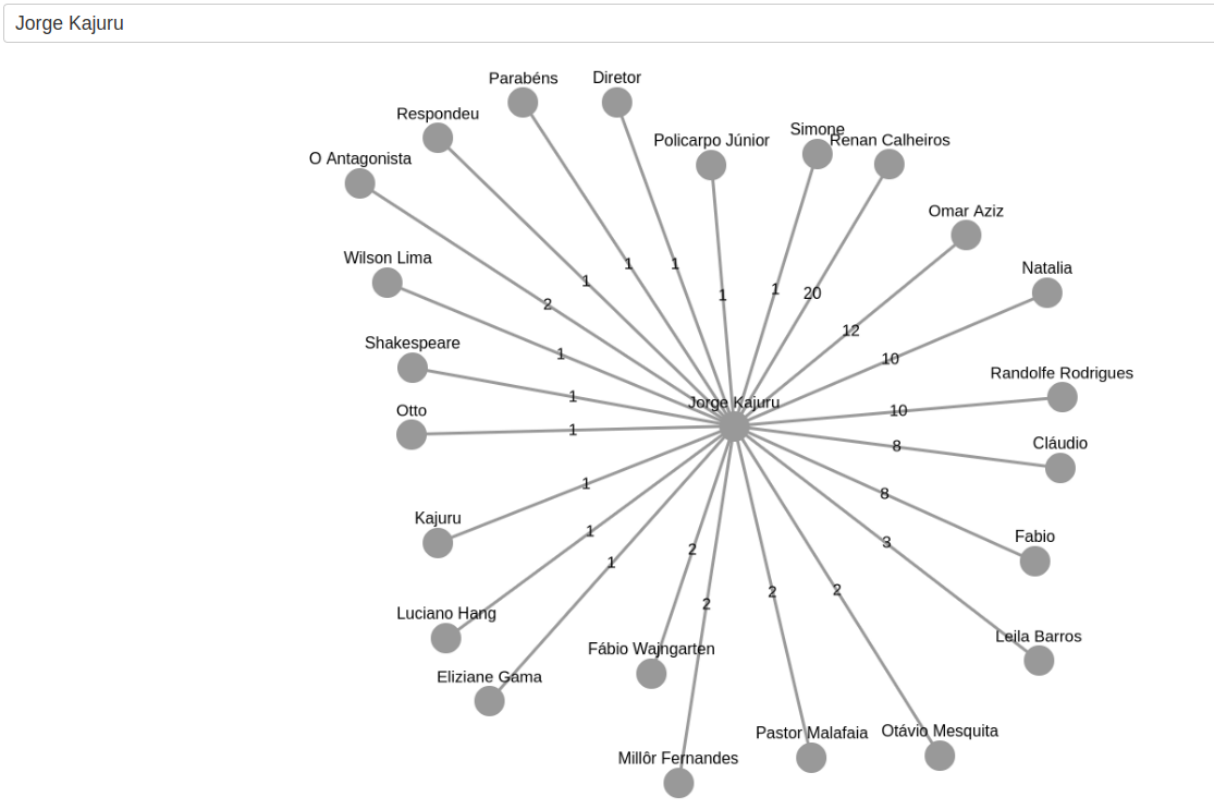


Fig. 5 – Cytoscape visualization with PCI Covid dataset.

4. Case Studies

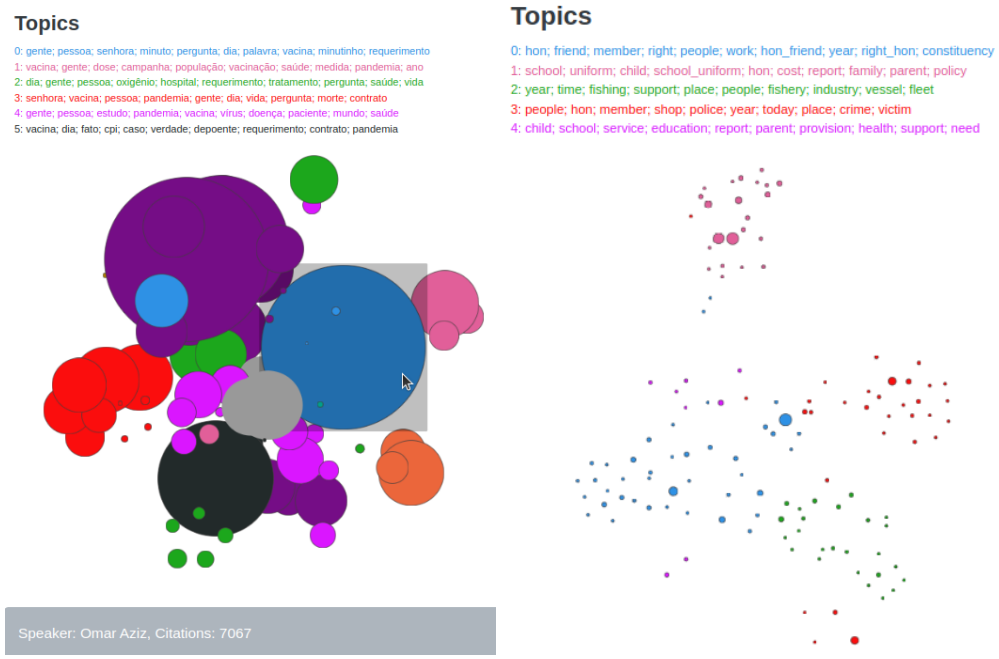
This section presents two case studies using different datasets containing government speeches. We evaluate GoViz on its qualitative aspect, considering two datasets, one in Portuguese and the other in English. The dataset in Portuguese describes the Parliamentary Commission of Inquiry (CPI) dataset about the COVID-19 pandemic. On the other hand, the dataset in English is the ParlSpeech V2 (Rauh & Schwalbach, 2020). Our goal is to show how GoViz can bring the main topics into discussion in both datasets. To validate our goal, we read some of the transcriptions and compared them to what GoViz brings as a result.

4.1. Datasets

The dataset in Portuguese contains the transcriptions from every speech made during the Parliamentary Commission of Inquiry (CPI) of the COVID-19 pandemic in Brazil (see Section 4.2). The dataset was originally made publicly available by the Brazilian federal senate. Later, it was treated and made available by *Base dos Dados*[12], a non-governmental, non-profit, and open-source organization. Besides the speech transcriptions, the entire dataset contains information about the speaker (name, genre, and category; political party acronym; federal unity of Brazil; and the parliamentary bloc) and the speech (besides the text, it has the duration, start, and end time). However, our approach uses only the transcription and the speaker name columns. The transcription column contains a total of 735k words.

The English language dataset we tested is the ParlSpeech V2 (Rauh & Schwalbach, 2020) (see Section 4.3). It contains transcriptions from parliamentary speeches from Austria, the Czech Republic, Germany, Denmark, the Netherlands, New Zealand, Spain, Sweden, and the United Kingdom. For our case, we consider only the House of Commons corpus, which contains data from the United Kingdom. This corpus contains information from 1988 to 2019 about the speech's date, speaker, transcription, political party, and agenda topic. However, for our experiments, we only select data from a single day, the 5^{th} of November 2019, which consists of 114k words.

[12] https://basedosdados.org/dataset/br-senado-cpipandemia



(a) PCI Covid dataset (b) House of Commons corpus

Fig. 6 – t-SNE visualization

4.2. Case Study 1: Parliamentary Commission of Inquiry

A Parliamentary Commission of Inquiry (PCI) often investigates complaints of irregularities carried out by agencies related to the Brazilian government. In 2021, a PCI was instituted to investigate whether there were any crimes of responsibility, possible omissions, and irregularities during the actions promoted in managing the COVID-19 pandemic in Brazil. The discussion on the PCI focused on adopting treatments without scientific evidence, such as using medications like chloroquine and azithromycin. On the other hand, there were campaigns against vaccination and delays in acquiring vaccines. The non-mandatory use of masks and social distancing was also pointed out.

Before the pandemic, Brazil already suffered from intense political polarization (Juvino Santos et al., 2022). Such polarization is reflected directly in the PCI speeches. To show this polarization, we select two groups of senators: the government's base and the opposition. The Government's base comprises: Ciro Nogueira, Jorginho Mello, Marcos Rogério, and Eduardo Girão. The opposition comprises the senators Omar Aziz, Renan Calheiros, Randolfe Rodrigues, Simone Tebet, Humberto Costa, Eduardo Braga, Otto Alencar, and Tasso Jereissati. We selected these names based on their position during PCI.

The treemap present in Figure 3 shows that for the opposition (blue color), the most frequent terms are: *vacina* (vaccine), *contrato* (contract), *requerimento* (application), and *reunião* (meeting). These terms were expected as PCI investigated if there was any irregularity in the vaccine acquisition.

In scatter text visualization (Figure 4), we can see that the opposition uses terms such as "isolation", "immunization", and "accountability" more frequently. From the Government's base, we can see a more financial appeal, with terms such as "funds", "damage", and "public resources". Moreover, the issue of vaccines has been hotly debated on both sides.

In this PCI, there was an effort to define the people responsible for the potential negligence during the pandemic. The network visualization generated by Cytoscape shows the relation between the deponent and the people they mentioned in their speech. In Figure 5, we selected Jorge Kajuro, a Senator who spoke in PCI. His name is in the center of the image. Names cited by Jorge, such as Natalia and Fabio, are from people invited to depose. Fabio, for example, is a former Secretary of Communication of the federal government and has been investigated for possible irregularities. We can also see that names such as Omar Aziz appear multiple times,

as he was the president of this PCI.

Figure 6 shows the main terms of the PCI, grouped by topics of interest. For this visualization, we selected 14 topics. In the figure, we limited the number of topics to six to improve visualization. As we can see, the term *vacina* (vaccine) appears as a topic multiple times because they can be interpreted in different scenarios, such as in a more administrative way in topic 2, or focusing on health in topic 3. Considering the PCI scenario and the identified topics, one can understand that the main focus was on investigating contractual points on vaccine acquisitions (topic 2) and conducting treatments and hospital supplies (topics 3 and 4).

4.3. Case Study 2: House of Commons corpus

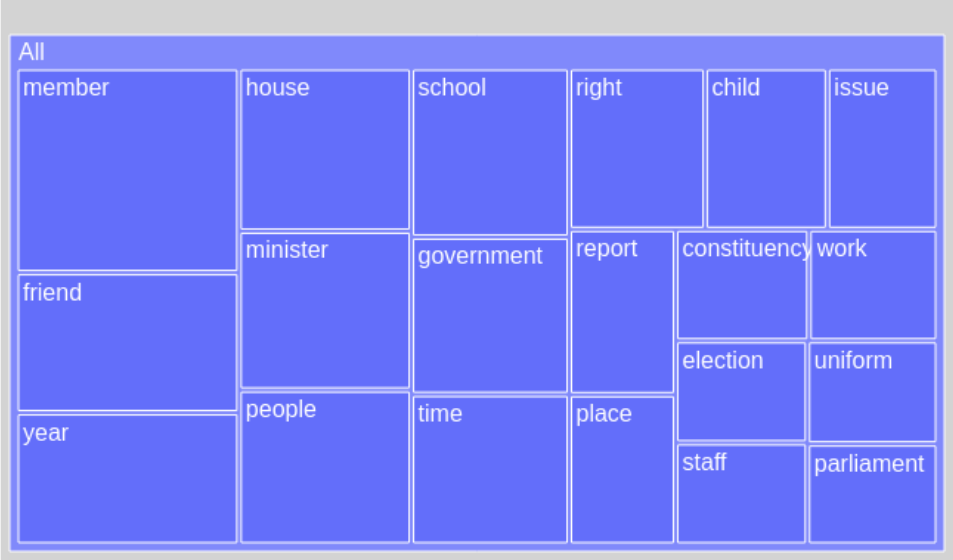


Fig. 7 – Most frequent nouns in House of Commons (ParlSpeech dataset).

Our focus in analyzing the House of Commons corpus was testing whether we could also use GoViz in English documents. The dataset contains information ranging from 1988 to 2019. On this day, the agenda had more than 20 topics involving UK international relations, Human Rights, Climate Change, among others. Thus, considering this scenario without previous knowledge about these topics, we show the most used nouns, without defined groups, in Figure 7. Given the diversified agenda of the day, most terms are more generic. Yet, we can see that some of them indicate the human rights topic as being more frequent, such as 'house', 'right', and 'child'. Figure 6(a) shows the t-SNE visualization for the same day. We can see that the automatically selected topics involve Human Rights and Health (topics 1 and 4), while topic 2 focuses more on the industry. Similar to Figure 6(b), each point in the figure represents a person. The point size indicates the number of times the person mentioned something about the topic (color).

5. Discussion

GoViz is a web-based application that does not require programming skills to use. The main contribution of this work is that it allows extracting information from texts in English or Portuguese without the need to read large amounts of data. With such a feature, GoViz can potentially increase citizens' participation in parliamentary issues. The increase in participation is a consequence of the simplified access to information. In general, our tool brings more interesting results when users provide polarized groups, as shown in Section 4.2. As demonstrated in Section 4, we still obtain an overview of the information presented in the final PCI report without previously knowing the dataset.

Since GoViz is a generic tool capable of handling different datasets, some details were left out. For example, Spacy has excellent accuracy in the named entity recognition task. However, it is not perfect. If we look

carefully at Figure 5, we will see terms, such as *respondeu* (replied), *parabéns* (congratulations), and *diretor* (director) that are not person names. Spacy allows customization, but we did not customize it as we expect GoViz to manipulate any dataset, and it should be as generic as possible to deal with a diverse range of topics. We noticed that different names sometimes call the same person throughout the speech. This occurs when the person has a compound name, or the family name is not considered. Jair Messias Bolsonaro (Brazilian president at the time of the PCI) is a good example as he is mentioned throughout the process as *Jair Bolsonaro*, *Jair Messias Bolsonaro*, or just *Bolsonaro*. Although we consider *Jair Bolsonaro* and *Jair Messias Bolsonaro* as the same person when we only have "Bolsonaro", it can also be referring to one of their sons. This makes it almost impossible to guarantee that we always correctly detect all persons' names.

In future work, we aim to incorporate modern models such as Large Language Models and explore sentence representations like Sentence-BERT (Reimers & Gurevych, 2019) to preserve semantic relationships and better capture deep connections within the discourses. Furthermore, to validate GoViz, we aim to conduct user testing to collect feedback and provide design improvements. Other improvements include a new version of GoViz that works entirely online and supports other languages, such as Spanish and French. Finally, we aim to include arc diagrams to improve visualizations and show the correlation among people's dialogues.

6. Conclusion

In this work, we introduce GoViz, a visualization tool that automatically extracts and summarizes speech information. We propose a pipeline that extracts part-of-speech, named-entities, among other information, to provide visualizations that show who the main speakers are, how they connect, and the subject of the speeches. The user can improve GoViz output by adding specific information to the tool, such as person names that belong to two different groups. In this case, GoViz generates visualizations that compare the two groups according to the most spoken terms and connections between them. We evaluate GoViz in both Portuguese and English using open data from the Brazilian government and the United Kingdom. As a result, we show that the generated visualizations can provide insights about the main topics in discussion, as well as the main actors. This is an advance compared to existing tools, which require user input and previous knowledge to work properly.

Acknowledgement

Manssour would like to thank the financial support of the CNPq (N°303208/2023-6) and Griebler thanks the financial support of FAPERGS 09/2023 PqG (N° 24/2551-0001400-4) and CNPq Research Program (N°306511/2021-5)

References

Bernardes, C. B., & Bandeira, C. L. (2016). Information vs Engagement in parliamentary websites – a case study of Brazil and the UK. *Revista de Sociologia e Política*, *24*(59), 91–107. DOI: https://doi.org/10.1590/1678-987316245905.

Bönisch, K., Abrami, G., Wehnert, S., & Mehler, A. (2023). Bundestag-mine: Natural language processing for extracting key information from government documents. *Frontiers in Artificial Intelligence and Applications*, *379*, 391–394. DOI: https://doi.org/10.3233/FAIA230996.

Cantador, I., Viejo-Tardío, J., Cortés-Cediel, M. E., & Rodríguez Bolívar, M. P. (2021). A chatbot for searching and exploring open data: Implementation and evaluation in e-government. *DG.O2021: The 22nd Annual International Conference on Digital Government Research*, 168–179. DOI: https://doi.org/10.1145/3463677.3463681.

Diaz, G. A., Chesñevar, C. I., Estevez, E., & Maguitman, A. (2022). Stance trees: A novel approach for assessing politically polarized issues in twitter. *Proceedings of the 15th International Conference on Theory and Practice of Electronic Governance*, 19–24. DOI: https://doi.org/10.1145/3560107.3560296.

Harrison, T. M., Guerrero, S., Burke, G. B., Cook, M., Cresswell, A., Helbig, N., Hrdinová, J., & Pardo, T. (2011). Open government and e-government: Democratic challenges from a public value perspective. *Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times*, 245–253. DOI: https://doi.org/10.1145/2037556.2037597.

Heer, J., Bostock, M., & Ogievetsky, V. (2010). A tour through the visualization zoo: A survey of powerful visualization techniques, from the obvious to the obscure. *Queue*, *8*(5), 20–30. DOI: https://doi.org/10.1145/1794514.1805128.

Hinton, G. E., & Roweis, S. (2002). Stochastic neighbor embedding. *Advances in neural information processing systems*, *15*, 857–864.

Inter-Parliamentary Union. (2022). *Global Parliamentary Report 2022 - Public engagement in the work of parliament* (2022nd ed.) [publisher: Inter-Parliamentary Union].

Juvino Santos, L. R., Balby Marinho, L., & Calazans Campelo, C. E. (2022). Uniting politics and pandemic: A social network analysis on the covid parliamentary commission of inquiry in brazil. *Proceedings of the Brazilian Symposium on Multimedia and the Web*, 99–107. DOI: https://doi.org/10.1145/3539637.3556992.

Keim, D. A., & Oelke, D. (2007). Literature fingerprinting: A new method for visual literary analysis. *2007 IEEE Symposium on Visual Analytics Science and Technology*, 115–122. DOI: https://doi.org/10.1109/VAST.2007.4389004.

Kessler, J. (2017). Scattertext: A browser-based tool for visualizing how corpora differ. *Proceedings of ACL 2017, System Demonstrations*, 85–90.

Khartabil, D., Collins, C., Wells, S., Bach, B., & Kennedy, J. (2021). Design and evaluation of visualization techniques to facilitate argument exploration. *Computer Graphics Forum*, *40*(6), 447–465. DOI: https://doi.org/https://doi.org/10.1111/cgf.14389.

Montani, I., Honnibal, M., Honnibal, M., Landeghem, S. V., Boyd, A., Peters, H., McCann, P. O., Samsonov, M., Geovedi, J., O'Regan, J., Altinok, D., Orosz, G., Kristiansen, S. L., de Kok, D., Miranda, L., Roman, Bot, E., Fiedler, L., Howard, G., … Böing, B. (2020, June). spaCy: Industrial-strength Natural Language Processing in Python. DOI: https://doi.org/10.5281/zenodo.6621076.

Palma, I., Ladeira, M., & Reis, A. C. B. (2021). Machine learning predictive model for the passive transparency at the brazilian ministry of mines and energy. *DG.O2021: The 22nd Annual International Conference on Digital Government Research*, 76–81. DOI: https://doi.org/10.1145/3463677.3463715.

Quintero-Angulo, R. A. D., Sánchez-Torres, J. M., & Cardona-Román, D. M. (2020). Problem areas in e-participation: A systematic review. *Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance*, 544–550. DOI: https://doi.org/10.1145/3428502.3428584.

Rajaraman, A., & Ullman, J. D. (2011). Data mining. In *Mining of massive datasets* (pp. 1–17). Cambridge University Press. DOI: https://doi.org/10.1017/CBO9781139058452.002.

Rauh, C., & Schwalbach, J. (2020). The ParlSpeech V2 data set: Full-text corpora of 6.3 million parliamentary speeches in the key legislative chambers of nine representative democracies. DOI: https://doi.org/10.7910/DVN/L4OAKN.

Rehurek, R., & Sojka, P. (2011). Gensim–python framework for vector space modelling. *NLP Centre, Faculty of Informatics, Masaryk University, Brno, Czech Republic*, *3*(2), 45–50.

Reimers, N., & Gurevych, I. (2019). Sentence-BERT: Sentence Embeddings using Siamese BERT-Networks. *Proceedings of the Conference on Empirical Methods in Natural Language Processing*, 3980–3990. https://arxiv.org/abs/1908.10084

Steinbauer, M., Hiesmair, M., & Anderst-Kotsis, G. (2016). Making computers understand coalition and opposition in parliamentary democracy. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *9820 LNCS*, 265–276. DOI: https://doi.org/10.1007/978-3-319-44421-5_21.

Van der Maaten, L., & Hinton, G. (2008). Visualizing data using t-sne. *Journal of machine learning research*, *9*(11), 2579–2605.

Volkovskii, D., & Filatova, O. (2022). Agreement and disagreement in american social media discussions (evidence from facebook discussions on the second impeachment of d. trump). *Proceedings of the 15th International Conference on Theory and Practice of Electronic Governance*, 221–228. DOI: https://doi.org/10.1145/3560107.3560144.

Ward, M., Grinstein, G., & Keim, D. (2015). *Interactive data visualization: Foundations, techniques, and applications, second edition*. CRC Press.

Wattenberg, M., & Viégas, F. B. (2008). The word tree, an interactive visual concordance. *IEEE Transactions on Visualization and Computer Graphics*, *14*(6), 1221–1228. DOI: https://doi.org/10.1109/TVCG.2008.172.

Not only *what*, but also *when*: Understanding Brazilian political comments on legislative bills over time through Stance Detection and Topic Modeling

Matheus Cerqueira[a], *Nádia F. F. da* Silva[a,b], *Ellen* Souza[a,c], *Hidelberg O.* Albuquerque[c], *Márcio de S.* Dias[d], *André C. P. L. F. de* Carvalho[a]

[a]University of São Paulo, São Paulo, Brazil.
*matheuscerqueira@usp.br, andre@icmc.usp.br

[b]Federal University of Goiás, Goiás, Brazil.
nadia.felix@ufg.br

[c]Federal Rural University of Pernambuco, Pernambuco, Brazil.
{ellen.ramos,hidelberg.albuquerque}@ufrpe.br

[d]Federal University of Catalão, Goiás, Brazil.
marciodias@ufcat.edu.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Legislative public spaces are important structures for participatory democracy, allowing citizens' voices to get engaged with politic decisions. As a consequence of the popularization of information and communication technologies, internet based tools have played an important role to improve public participation in political decisions, known as e-Democracy. These tools are usually composed of a set of functionalities or small services, named microservices. The better the microservices, the higher the citizen participation. This work investigates how to extract useful knowledge from citizen participation in the microservices of the public portal of the Brazilian Chamber of Deputies. For such, it analyzes public comments incorporating Natural Language Processing and Artificial Intelligence techniques in a platform named Ulysses. The tasks developed on this paper focus on a temporal analysis of comments on bills in the portal through Stance Detection and dynamic Topic Modeling tasks. For the first task, OxêSD, a BERTimbau-based model, was trained on two different corpora, one of them translated into Portuguese, and its predictive performance was evaluated using the F1 and ROC-AUC metrics, achieving 73% for both on our proposed Political-BRSD a mixed dataset containing both translated content from a bigger multilingual dataset (adapted from x-Stance) and bill-specific content (adapted from Ulysses-SD); for the second, BERTopic, a Topic Modeling framework, was used. Visualization tools to analyze how the proposed approach addressed the task were also used to explore the knowledge extracted. They allow the user to understand over time how the comments relate to each other and how the comments relate to a given legislative bill.

Keywords. Natural Language Processing, Legal Text Analysis, Stance Detection, Topic Modeling.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.955

1. Introduction

Public portals, defined as inclusive and deliberative instances not monopolized by any entity, play a crucial role in democracies (Addor, 2018). As societies strengthen their relationships with the state, citizens evolve from passive to active participants, engaging in public discourse and decision-making processes. This evolution prompts a continuous redefinition of public spaces and democracy itself (Cardoso, 2007). Participatory

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

democracy, often viewed as a combination of direct and indirect democracy, has undergone a contemporary reevaluation. It now encompasses universal participation, leveraging various tools to expand public spaces in political and public decision making (Macedo, 2008). However, universal participation raises concerns about potentially suppressing the voices of minorities, necessitating careful attention to the expression of diverse social groups (Lessa, 2010).

The advent of the internet and digital technologies has transformed interactions among citizens, politicians, and governmental institutions. This transformation has given rise to the concept of e-Democracy, wherein Information and Communications Technologies (ICTs) support democratic decision-making, enhancing both institutions and processes (Pereira et al., 2022). Early studies emphasized the need to analyze the quality of information and interactions on the internet, focusing on their relevance, scope, and consequences (Rothberg, 2008). This paper focus on e-Democracy, exploring how ICTs can improve democratic processes. E-democracy operates on three dimensions: establishing essential conditions for the use of information and communication technology (ICT) in government, emphasizing citizen participation (e-participation) in decision-making, and concentrating on the effective delivery of government services online (e-Government) (Kneuer, 2016; Ronchi, 2019).

Natural Language Processing (NLP), a subfield of Artificial Intelligence, has evolved in recent years. Fueled by increased computing power, abundant data, and advances in Machine Learning, NLP encompasses various tasks, including Word Processing, Information Retrieval, and Sentiment Analysis (Chowdhary, 2020; Hirschberg & Manning, 2015). Stance Detection, a subtask of sentiment analysis, involves categorizing the expressed position of a given text regarding a particular target. This classification task finds applications in diverse areas such as rumor stance classification and fake news detection (Kuçuk & Can, 2020). Another important NLP task is Topic Modeling, an unsupervised technique for extracting latent topics from textual data. It plays a significant role in uncovering the underlying themes within complex and large corpora across various domains (George & Birla, 2018; Yamunathangam et al., 2021). Therefore, considering the temporal dynamics of language use, Temporal Text Analysis allows understanding how discourses change over time. In the context of media storms, where a specific subject experiences a surge in news coverage within a short time on social media, temporal text analysis becomes relevant (Lukito et al., 2019).

Legal AI and Legal NLP have emerged as areas focused on augmenting, assisting, or potentially replacing legal actors in various tasks. These tasks include the analysis of legal documents, like laws, bills, legislation texts, case laws, and more, often scattered across different databases and formats (Avgerinos Loutsaris et al., 2021; Katz et al., 2023). In this context, the Brazilian Chamber of Deputies uses multiple NLP and AI tools in a platform named Ulysses Câmara dos Deputados, 2018, which processes legislative texts from its portal named *E-democracia*[1]. The goal of this research is to apply NLP methods in the temporal domain to analyze comments on bills written on the E-Democracia portal through the Ulysses platform in order to understand how public opinion towards a given subject evolves through the time. In this work, we (1) provide a deep and thorough review of textual analysis within the legal domain over time, emphasizing Stance Detection and Topic Modeling tasks; (2) present significant advances in the PT-BR Stance Detection task within the legal domain by introducing a new large corpus (Political-BRSD[2]) and a novel Stance Detection model (OxêSD[3]); and (3) through Stance Detection and Topic Modeling over time, develop tools that enable an understanding of how texts engage with a specific bill and with each other over time.

2. Related Work

In this section, we introduce related works in NLP, specifically in Stance Detection and Topic Modeling, considering Legal Domain and Temporal applications.

2.1. Legal Domain Applications

Avgerinos Loutsaris et al., 2021 address the challenge posed by the enormous volume of legal information in each European Union country due to the integration of Digital Governance across all levels of society. They

[1] Available in https://www.camara.leg.br/participe
[2] Available in https://huggingface.co/datasets/cerqueiramatheus/Political-BRSD
[3] Available in https://huggingface.co/cerqueiramatheus/OxeSD

have developed an open and automated legal system that handles various tasks, including information extraction (such as law title, number, number of pages, and creation date), Named Entity Recognition (NER), law decomposition, and opinion extraction. On a different note, Ikram and Chakir, 2019 highlight the difficulty of archiving legal documents and accessing relevant information in Morocco. To assist legal professionals, they propose text classification methods employing multiple Machine Learning (ML) induced models. In the context of the Portuguese language, there are also several studies that deal with different legal text analysis problems. Carvalho and Barbosa, 2018 implement a legal visualization based software using tokenization, tagging, and lemmatization to enhance the understanding and analysis of documents such as the Portuguese Constitution. The Lima et al., 2021 study focuses on comparing different feature extraction models in Brazilian Portuguese texts from the Tribunal de Justiça do Rio Grande do Norte (TJRN), a clustering technique that can be useful for lawyers and even to finding controversial issues in legal texts. Also in Brazilian Portuguese, Medina et al., 2022 propose a model with different tasks, such as summarization, feature extraction, and classification, focused on legal proceedings texts.

Nababan et al., 2022 study is focused on understanding public positions and sentiments about the Job Creation Bill in Indonesia, through a Twitter data analysis; they collected and annotated several tweets to create a new corpus and also conducted experiments with different ML algorithms, such as Naïve Bayes, Support Vector Machine, and Logistic Regression. These algorithms were chosen because of their different inductive biases. Bergam et al., 2022 work delves into the analysis of US Supreme Court documents through Stance Detection, introducing and comparing new metrics that allowed them to correlate the responsiveness to public opinion to ideology expression. They also proposed *SC-stance*, a new dataset focused on legal Stance Detection, matching written opinions to legal questions. Usually, studies adopt a multilingual approach. Lai, Cignarella, et al., 2020 work select topics about politics in multiple languages, investigate the portability of tools, and then evaluate MultiTACOS algorithm performance. Egli et al., 2023 proposal is centered on the analysis of official voter information booklets; their experiments achieved best results using a fine-tuned multilingual BERT model Devlin et al., 2019. Finally, within the Brazilian Chamber of Deputies context, Maia et al., 2022 use digital media comments on political bills to understand the stances of the citizens and group the polarity of public opinions about new discussion topics. To achieve this, they developed a new dataset, *Ulysses-SD* and implemented a mBERT model. It is the nearest application in domain and approach compared to our goal; however, none of them leverages the temporal information.

Sarne et al., 2019 work is focused in large-scale corpora of privacy policies using unsupervised learning techniques. They developed a framework for privacy policy Topic Modeling and applied it over a corpus of privacy policies of mobile applications crawled from the Google Play Store. To build their framework, they used GraphLab, a machine learning platform that supports Latent Dirichlet allocation (LDA) Blei et al., 2003 Topic Modeling. Similarly, LawNet-Viz is a web-based system developed by La Cava et al., 2022 for modeling, analyzing and visualizing law reference networks extracted from law corpus. Their work was demonstrated using the Italian Civil Code and implemented the LDA topic model Blei et al., 2003 available on the Gensim Python library for the language modeling process. LawNet-Viz can benefit since lawyers and jurists to citizens. Joshi and Saha, 2020 developed a framework to automatically extract knowledge from Code of Federal Regulations from the United States government, such as key terms, rules, relationships and topic summaries. They used the Gensim library and the LDA Blei et al., 2003 topic model for the extraction of topic from summarized subsections task. Their work automated the analysis from CFR regulations. For the Brazilian Portuguese context, Silva et al., 2021 designed a specific sentence embedding technique to build topic models and achieved good results compared to other multilingual sentence embedding techniques. Their approach applied BERTopic Grootendorst, 2022 to extract topics from political comments on Brazilian bills and produced three different datasets. Again, on the same domain, the temporal information was not explored, one of our main goals in this work.

2.2. Temporal Applications

Usually, the temporal applications are focused in time information extraction. Viani et al., 2020 developed a system to identify relevant electronic health records and extract time expressions from them; this system was applied to two electronic health records datasets and resulted in the creation of a new corpus annotated with normalized values for time expressions. However, within the context of this work, our main task is to understand how texts can be grouped over time, that is, the analysis of documents in document networks Zhang and Lauw, 2022, specifically with Stance Detection and Topic Modeling. Although there are multiple

applications using temporal information, our work differs by combining two tasks, Stance Detection and Topic Modeling, for understanding texts in the legal domain.

Alturayeif et al., 2023 review highlighted that, despite that opinions change through time and the importance to record and evaluate temporal data, diachronic evolution is not a common explored topic within Stance Detection field; it also presented three different studies. The first, from Lai et al., 2019, introduces how political debate can be understood in a diachronic perspective, focusing on the aggregation of empirical data in a given granularity (days, weeks, months). Their main goal was the analysis of the Twitter debate about the 2016 referendum of Italian Constitution; they developed a new corpus leveraging the diachronic perspective to understand the citizens' opinion evolution through time. The second, proposed by Lai, Patti, et al., 2020, introduces a novel approach and annotation schema for Stance Detection to investigate the impact of social network community features and the evolution of stance over time within the Brexit referendum context. Their analysis highlighted the importance of temporal features. Finally, Alkhalifa et al., 2021 work produced two large-scale stance datasets using temporal information to mitigate the performance deterioration of classifiers over time, that is, to reduce impacts of the temporal gap between training and test data. Their approach adapted word embeddings used in training of the stance classifier.

One of the earliest approaches to dealing with the Topic Modeling task over time was proposed by Blei and Lafferty, 2006. Their work developed the Dynamic Topic Models, that employed probabilistic time series models has been developed to analyze the temporal evolution of topics within extensive document collections. Since then, several different proposals have been developed. He et al., 2014 emphasize the increasing interest in this area and mention, beyond the Dynamic Topic Models, its newer variations, like continuous-time and online multi-scale proposals. Their work also proposes a new method joining sentiment and topic model over time. Sharma et al., 2022 applied dynamic Topic Modeling on vaccine-related discussions on Twitter from 2020 to 2021, aiming to track public perception of vaccines over time and identify the factors influencing these evolving opinions. Ghosh et al., 2017 study explores the use of supervised temporal topic models to analyze large corpora of news articles and identify trends; they evaluated their method through multiple infectious disease outbreaks data from the United States of America, China and India. Finally, Grootendorst, 2022 study proposes BERTopic, a Topic Modeling framework that implements dynamic Topic Modeling.

3. Method

In this section, we describe our method, focusing on the steps, input and output of our task, the models used, and the evaluation metrics. Briefly, our approach follows the presented on Figure 1.

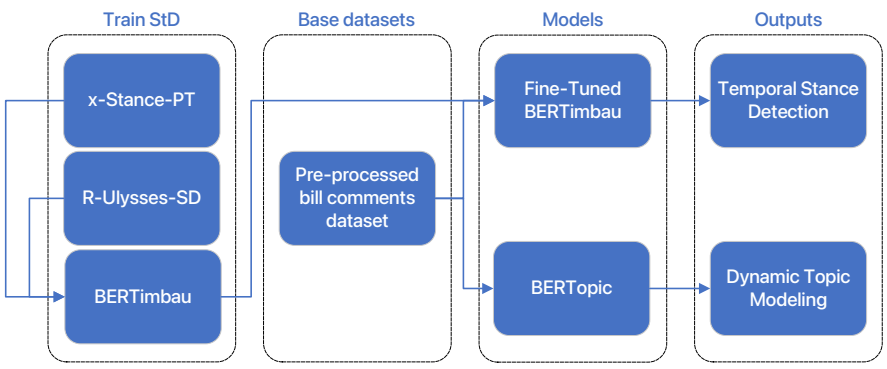


Fig. 1 – Methodological approach

3.1. Comment Analysis

Our main task is focused on the temporal analysis of Brazilian political comments through Stance Detection and Topic Modeling. First, we fine-tuned a model for the Stance Detection task using two different datasets

(train datasets). For the main task, our input is composed by comments written about a given bill on the E-Democracia portal (base datasets). We employ a pre-processing step for the base datasets. Then, we execute models for Stance Detection and Topic Modeling given the comments, what will be discussed in the next section. Finally, we provide graphs containing the output of each task (polarities over time and topics) for the given comments set.

3.2. Models

First, for the Stance Detection task, we fine-tuned a pre-trained BERT model, specifically BERTimbau. BERT models employ a bidirectional context approach, creating representations of words considering their contexts within a given sentence. BERTimbau, specialized for Brazilian Portuguese, outperforms generic BERT on Portuguese tasks. For the temporal Topic Modeling task, we utilized BERTopic (Grootendorst, 2022), a model leveraging class-based TF-IDF with pre-trained S-BERT models (Reimers & Gurevych, 2019) containing multiple Topic Modeling approaches, including Dynamic Topic Modeling.

3.3. Evaluation Metrics

To assess the performance of our models, we used the Hugging Face Evaluate library (HuggingFace, 2023), leveraging both the weighted F1 Score and Receiver Operating Characteristic Area Under the Curve (ROC AUC) metrics. The weighted F1 score is the harmonic mean of precision and recall, computed for each class independently and then averaged, with the contribution of each class weighted by its prevalence in the dataset. Simultaneously, the ROC AUC metric was employed to evaluate the model ability to discriminate between positive and negative instances, offering insights into their overall predictive power.

4. Experimental Setup

In this section, we describe our base dataset used as input of the tasks, the datasets used to training the Stance Detection Model, its setup and implementation.

4.1. Base Datasets

To generate the outputs for the Stance Detection and Topic Modeling tasks, we extract comments associated with specific bills from the E-democracia portal, each producing a unique dataset. Similarly to the works of (Maia et al., 2022; Silva et al., 2021), our extracted datasets are composed by comments written in Brazilian Portuguese from CSV files, containing columns such as comment ID, author, timestamp, number of likes, and manual labels. Finally, we preprocess the comments, filtering for a minimum length (default set at 15 characters) in order to keep only real comments and produce better results.

4.2. Train Datasets

Given the lack of large datasets for Brazilian Portuguese Stance Detection, we adopted a combination of the x-Stance dataset (Vamvas & Sennrich, 2020) and the Ulysses-SD dataset (Maia et al., 2022). To address language disparities, we translated the x-Stance dataset to Portuguese using the Google Translator class from the Deep Translator package (Baccouri, 2023), resulting in the x-Stance-PT dataset[4]. We also reduced the Ulysses-SD to two classes (`FAVOR` and `AGAINST`) in R-Ulysses-SD[5]. The Political-BRSD dataset, a combination of x-Stance-PT and R-Ulysses-SD, was created to join information from both datasets, as illustrated in Table 1. Each of them followed a 70/15/15 division for train, test and validation.

4.3. Setup and Implementation

Our Stance Detection experiments consisted in four approaches trained on a NVIDIA Tesla P100 GPU with 16GB memory, employing the same hyperparameters (`learning_rate` = 2^{-5} and `epochs` = 4). The approaches

[4]Available in https://huggingface.co/datasets/cerqueiramatheus/x-Stance-PT
[5]Available in https://huggingface.co/datasets/cerqueiramatheus/reduced-Ulysses-SD

Tab. 1 – **Number of comments for the train datasets** – Number of comments in each label for the R-Ulysses-SD, x-Stance-PT and Political-BRSD datasets.

Dataset	Favor	Against	Total
R-Ulysses-SD	524	685	1209
x-Stance-PT	34001	33270	67271
Political-BRSD	34525	33955	68480

included models fine-tuned only on Ulysses-SD, only on x-Stance-PT, sequentially on x-Stance-PT and Ulysses-SD, and finally on the merged Political-BRSD dataset. Each model received as input a combination of topic information, the comment itself from each dataset and a given label (`FAVOR` or `AGAINST`). For temporal Topic Modeling, we used Dynamic Topic Modeling within the existing BERTopic implementation on Ulysses services, which automatically selects 10 topics, automatically named.

5. Results

To exemplify our results, we selected two different bills from the E-democracy portal to show the outputs of each task. We selected the following bills because they have a high number of comments and are recent, both created in 2020: 1) Public Administration – **PL 2630/2020** (Câmara dos Deputados, 2020) (to combat fake news); and Health – **PL 2564/2020** (Câmara dos Deputados, 2021) (to establish salary floor for nursing professionals).

5.1. Stance Detection Model Training

Tab. 2 – **F1 and AUC measures** – F1 and AUC measure results for the proposed models 1, 2, 3 and 4 on x-Stance-PT, R-Ulysses-SD and Political-BRSD datasets.

Dataset	Model							
	1		2		3		4 (best)	
	F1	AUC	F1	AUC	F1	AUC	F1	AUC
x-Stance-PT	0.40	0.51	0.71	0.71	0.58	0.61	**0.73**	**0.72**
R-Ulysses-SD	0.86	0.85	0.54	0.56	**0.87**	**0.86**	0.85	0.84
Political-BRSD	0.58	0.61	0.71	0.71	0.59	0.62	**0.73**	**0.73**

We follow the model names from the previous section: 1) BERTimbau trained on R-Ulysses-SD; 2) BERTimbau trained on x-Stance-PT; 3) BERTimbau trained on R-Ulysses-SD and then on x-Stance-PT; and 4) BERTimbau trained on Political-BRSD. As Table 2 shows, 1 and 2, as expected, produced the worst outputs; they specialized only on the context of the dataset that they were trained. Model 3 appears to be forgetting its first training on x-Stance-PT, but this is a known issue since the recommended number of epochs for this task, at maximum, 4 (Devlin et al., 2019) and we performed two training steps of 4 epochs each. Finally, model 4 produces the best results, leveraging both datasets.

Our best model, BERTimbau trained on Political-BRSD, outperforms results from the original x-Stance work (F1=0.69). To the best of our knowledge, our produced results are the best for cross-topic Stance Detection in the PT-BR political domain. Then, we evaluated its confusion matrix produced for the test datasets. For R-Ulysses-SD, its performance is better at class `AGAINST`, with the same number of false negatives and false positives. However, for x-Stance-PT and Political-BRSD, the model produces better results for the `FAVOR` class; the number of false positives and false negatives is still similar. This indicates that our model learned to better classify the `FAVOR` stances, even with the use of well-balanced data sets, as previously shown.

5.2. Tasks Outputs

Usually, the number of comments on the bills is not constant, and there are months with much more interaction and this is due to external factors, like news or social networks; some bills are also more controversial than others. However, these factors are not explored in this work, as we propose a first step to this analysis, focused on identifying the reactions and interactions within the comments of a given bill.

5.2.1. Stance Detection

As shown in Figure 2, there is a prevalence of the `FAVOR` class for the PL 2630/2020, increasing from December 2021 to January 2022, what indicates that the bill is probably less controversial; its purpose (salary floor for nursing professional) can be a reason to it. However, PL 2564/2020 (Figure 3) seems to be more controversial, with small peaks before 2023 and two huge peaks between April 2023 to June 2023. Despite its majority class is `AGAINST`, there is a significant number of `FAVOR` comments.

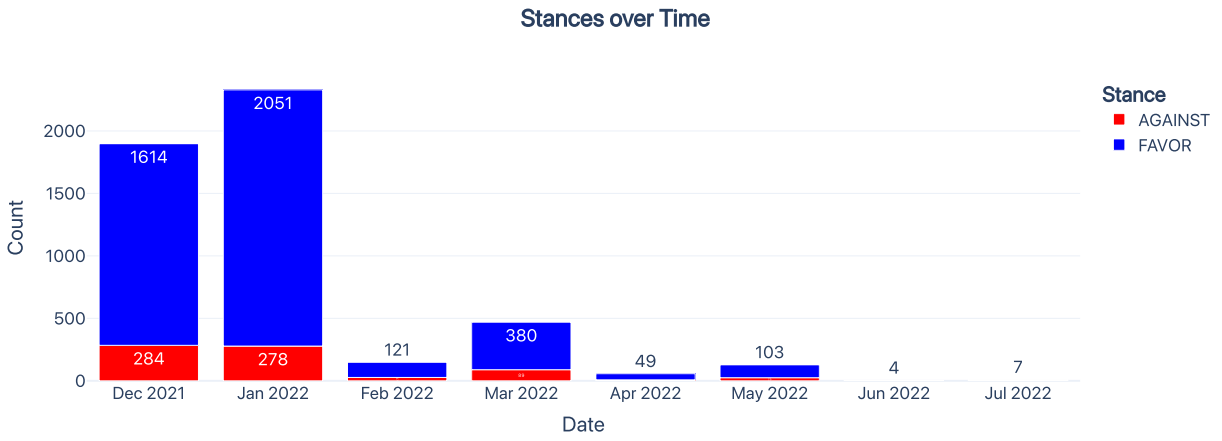


Fig. 2 – Stance Detection output for PL 2630/2020

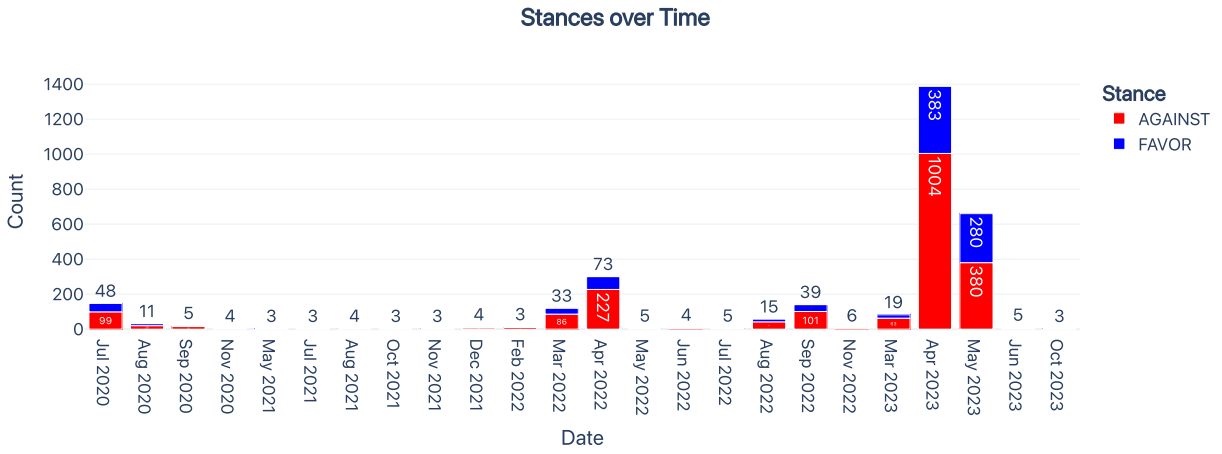


Fig. 3 – Stance Detection output for PL 2564/2020

In our experiments with multiple bills, there was a prevalence of comments distribution over time on bills with this same behavior, that is, concentrated in two or three months, with isolated peaks over time.

5.2.2. Topic Modeling

Figure 4 shows the comment groups for PL 2630/2020, matching the frequency peaks from the Stance Detection task. Topic 0 (PT-BR: `paciente_respeito_aprovar_trabalho`, EN-US: `patient_respect_approve_work`) groups most of the comments. For PL 2564/2020, as PL 2564/2020, there is again a concentration in a single topic, with other minor topics. Topic 0 (PT-BR: `rede_informação_fake_internet`, EN-US: `network_information_fake_internet`), as shown in Figure 5, groups most of the comments over time.

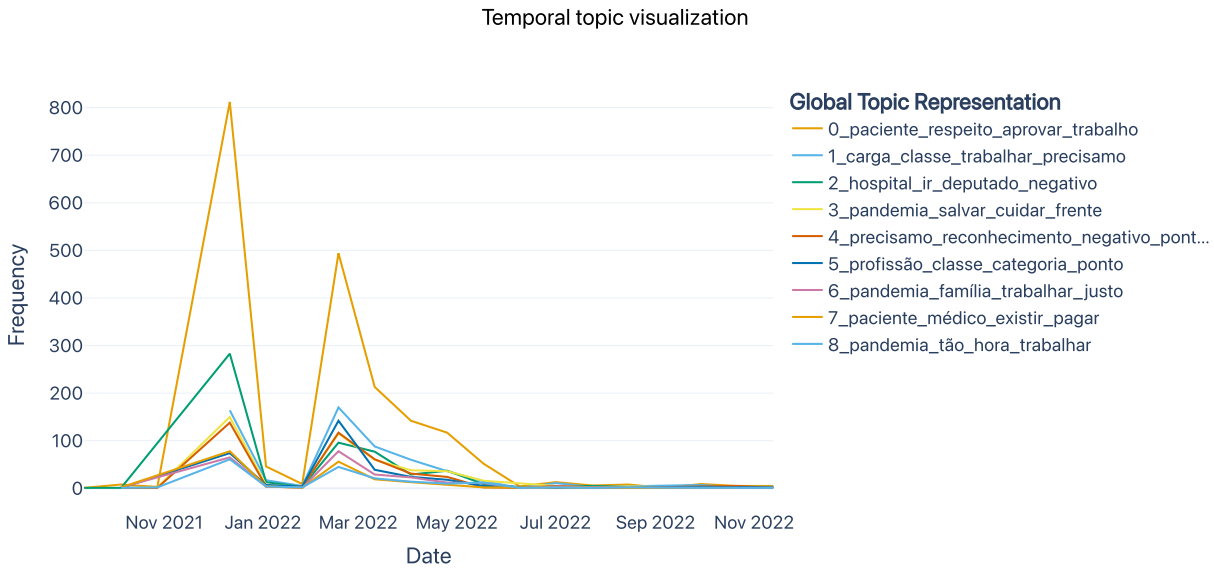


Fig. 4 – Topic Modeling output for PL 2630/2020

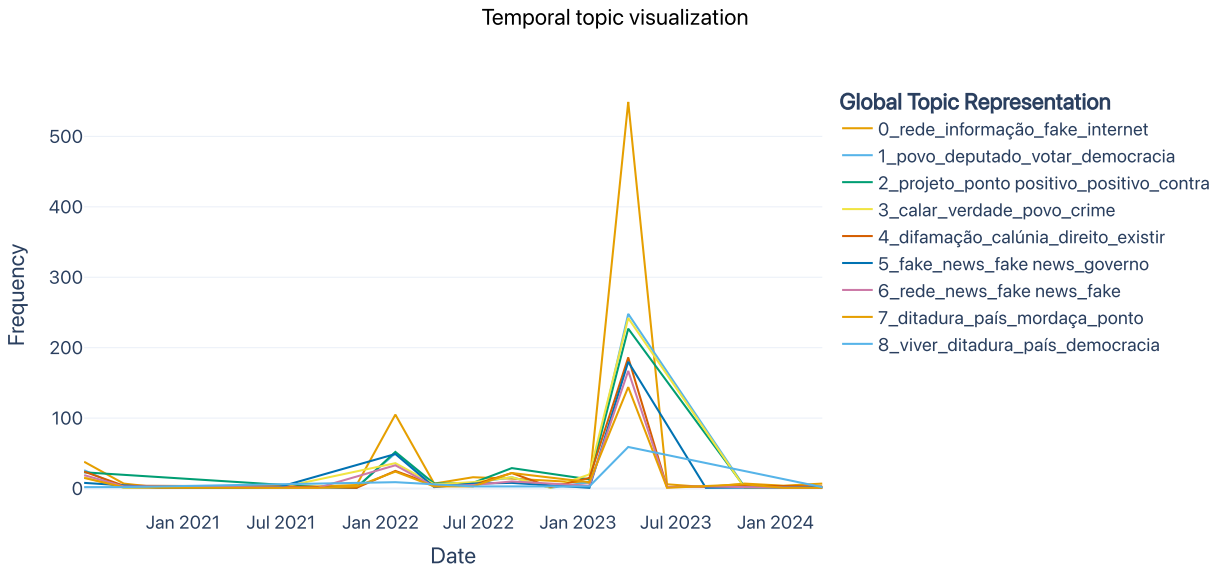


Fig. 5 – Topic Modeling output for PL 2564/2020

With multiple bills, there was always a main topic, as in the previous examples. As all the comments are about the same bill, this is expected behavior. However, the other topics seem to be relevant and can reveal important insights.

5.3. Discussion

Even though the Stance Detection and Topic Modeling tasks have been designed to be globally available, that is, to work on all available bills, their performance depends on the comments distribution over time (as shown in the first example), the total amount of available comments (usually bills take months to have a few comments), external factors (as the influence of external discussion and the bill relevance). Our selected examples were manually picked, since the Brazilian Chamber of Deputies services do not provide filters to select the most commented bills in a complete period, only in the last six months. In the examples, the Stance Detection visualization provides good insights about citizens' responses to bills; although the Topic Modeling focuses

on one topic, it groups other relevant secondary topics, which can be better seen through dynamic filtering in the graphs, which are interactive.

5.4. Limitations

Due to the lack of well-established evaluation metrics for dynamic topic models, we were unable to quantitatively assess the performance of our proposed model. However, we acknowledge the recent work of (James et al., 2023), that proposed a novel evaluation measure for dynamic topic models that analyzes the changes in the quality of each topic over time; they propose Temporal Topic Coherence, Temporal Topic Smoothness, Temporal Topic Quality and Dynamic Topic Quality. It is important to note that the non-temporal evaluation, that is, the traditional Topic Modeling evaluation, is already developed by other projects within Ulysses services, which is beyond the scope of this work.

Although significant progress has been made in developing cross-topic Stance Detection models, the evaluation of their performance remains a challenge. As highlighted in (Reuver et al., 2021), the generalizability of cross-topic Stance Detection models across diverse topics and socio-cultural contexts is a critical aspect that requires further investigation and demonstrates that topic, class, and their interaction can significantly impact model performance. This underscores the need for continuous evaluation of cross-topic Stance Detection models across a wide range of contexts and topics over different datasets to ensure their robustness and generalizability. Our research was limited to the context of Political-BRSD.

6. Conclusions

Our best-performing Stance Detection model (OxêSD, a BERTimbau-based model fine-tuned on Political-BRSD) surpassed results from existing works, demonstrating the effectiveness of our approach in cross-topic scenarios. The dynamic Topic Modeling framework provided a detailed temporal analysis, contributing to a deeper understanding of the evolving discourse around legislative proposals. Despite promising results, our research has limitations. The lack of well-established evaluation metrics for dynamic topic models poses challenges in quantitatively assessing their performance. Future work could focus on refining evaluation measures for temporal analysis tasks. Furthermore, expanding the scope to include more diverse topics and datasets would enhance the generalizability of our models. In this work, we addressed the challenges of cross-topic Stance Detection and dynamic Topic Modeling in the context of Brazilian political discussions. Our experiments with Stance Detection models revealed that training on a combination of datasets (Political-BRSD) significantly improves performance compared to models trained on individual datasets (x-Stance-PT and R-Ulysses-SD). The best performing model (trained on Political-BRSD) achieved superior F1 and ROC AUC scores, showcasing its effectiveness in capturing cross-topic stances in the PT-BR political domain.

The temporal analysis of stance over time provided valuable insights into citizens' responses to specific bills. By visualizing stances and topics, we observed patterns of interaction and identified potentially controversial bills. Our dynamic Topic Modeling framework successfully captured the evolution of topics over time, offering a nuanced understanding of the discussions surrounding legislative proposals. In conclusion, our research contributes to advancing the field of cross-topic Stance Detection and temporal analysis in the context of political discussions. The combination of effective models, dynamic visualizations, and an interactive demo platform positions our work as a valuable resource for researchers, policymakers, and the public interested in understanding and analyzing political discourse.

7. Acknowledgements

We sincerely appreciate the support provided by the research funding agencies CAPES, FAPESP, and CNPq, whose contributions have been essential to the development of this work. Furthermore, we extend our gratitude to the Brazilian Chamber of Deputies, the Center for Applied Research in Artificial Intelligence Recreating Environments (CPA IARA), and the Brazilian National Institute of Artificial Intelligence (IAIA) for their significant support in advancing this research.

References

Addor, F. (2018). Reflections on local participatory democracy in latin america. *Revista de Administração Pública*, *52*(6), 1108–1124. DOI: https://doi.org/10.1590/0034-761220170131.

Alkhalifa, R., Kochkina, E., & Zubiaga, A. (2021). Opinions are made to be changed: Temporally adaptive stance classification. *Proceedings of the 2021 Workshop on Open Challenges in Online Social Networks*, 27–32. DOI: https://doi.org/10.1145/3472720.3483620.

Alturayeif, N., Luqman, H., & Ahmed, M. (2023). A systematic review of machine learning techniques for stance detection and its applications. *Neural Computing and Applications*, *35*(7), 5113–5144. DOI: https://doi.org/10.1007/s00521-023-08285-7.

Avgerinos Loutsaris, M., Lachana, Z., Alexopoulos, C., & Charalabidis, Y. (2021). Legal text processing: Combing two legal ontological approaches through text mining. *DG.O2021: The 22nd Annual International Conference on Digital Government Research*, 522–532. DOI: https://doi.org/10.1145/3463677.3463730.

Baccouri, N. (2023). Deep translator.

Bergam, N., Allaway, E., & Mckeown, K. (2022). Legal and political stance detection of SCOTUS language. *Proceedings of the Natural Legal Language Processing Workshop 2022*, 265–275. DOI: https://doi.org/10.18653/v1/2022.nllp-1.25.

Blei, D. M., & Lafferty, J. D. (2006). Dynamic topic models. *Proceedings of the 23rd International Conference on Machine Learning*, 113–120. DOI: https://doi.org/10.1145/1143844.1143859.

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent dirichlet allocation. *Journal of machine Learning research*, *3*(Jan), 993–1022.

Câmara dos Deputados. (2018, November). Câmara lança ulysses, robô digital que articula dados legislativos. *Portal da Câmara dos Deputados*. Retrieved November 27, 2023, from https://www.camara.leg.br/noticias/548730-camara-lanca-ulysses-robo-digital-que-articula-dados-legislativos/o

Câmara dos Deputados. (2020, July). Enquete do PL 2630/2020. *Portal da Câmara dos Deputados*. Retrieved November 27, 2023, from https://www.camara.leg.br/enquetes/2256735/resultados

Câmara dos Deputados. (2021, December). Enquete do PL 2564/2020. *Portal da Câmara dos Deputados*. Retrieved November 27, 2023, from https://www.camara.leg.br/enquetes/2309349/resultados

Cardoso, F. H. (2007). A democracia no centro da agenda. In B. Sorj & M. D. d. Oliveira (Eds.), *Sociedade civil e democracia na américa latina: Crise e reinvenção da política* (pp. 7–10). SciELO Books - Centro Edelstein.

Carvalho, N. R., & Barbosa, L. S. (2018). Transforming legal documents for visualization and analysis. *Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance*, 23–26. DOI: https://doi.org/10.1145/3209415.3209424.

Chowdhary, K. R. (2020). Natural language processing. In *Fundamentals of artificial intelligence* (pp. 603–649). Springer India. DOI: https://doi.org/10.1007/978-81-322-3972-7_19.

Devlin, J., Chang, M.-W., Lee, K., & Toutanova, K. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, 4171–4186. DOI: https://doi.org/10.18653/v1/N19-1423.

Egli, E., Mamie, N., Dolev, E. L., & Muller, M. (2023). Voting booklet bias: Stance detection in swiss federal communication. *arXiv preprint arXiv:2306.08999*. https://arxiv.org/abs/2306.08999

George, L. E., & Birla, L. (2018). A study of topic modeling methods. *2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS)*, 109–113. DOI: https://doi.org/10.1109/ICCONS.2018.8663152.

Ghosh, S., Chakraborty, P., Nsoesie, E. O., Cohn, E., Mekaru, S. R., Brownstein, J. S., & Ramakrishnan, N. (2017). Temporal topic modeling to assess associations between news trends and infectious disease outbreaks. *Scientific Reports*, *7*(1), 40841. DOI: https://doi.org/10.1038/srep40841.

Grootendorst, M. (2022). Bertopic: Neural topic modeling with a class-based tf-idf procedure. *arXiv preprint arXiv:2203.05794*. https://arxiv.org/abs/2203.05794

He, Y., Lin, C., Gao, W., & Wong, K.-F. (2014). Dynamic joint sentiment-topic model. *ACM Trans. Intell. Syst. Technol.*, *5*(1). DOI: https://doi.org/10.1145/2542182.2542188.

Hirschberg, J., & Manning, C. D. (2015). Advances in natural language processing. *Science*, *349*(6245), 261–266. DOI: https://doi.org/10.1126/science.aaa8685.

HuggingFace. (2023). Evaluate. https://github.com/huggingface/evaluate

Ikram, A. Y., & Chakir, L. (2019). Arabic text classification in the legal domain. *2019 Third International Conference on Intelligent Computing in Data Sciences (ICDS)*, 1–6. DOI: https://doi.org/10.1109/ICDS47004.2019.8942343.

James, C., Nagda, M., Haji Ghassemi, N., Kloft, M., & Fellenz, S. (2023, September). *Evaluating dynamic topic models*. DOI: https://doi.org/10.48550/arXiv.2309.08627.

Joshi, K. P., & Saha, S. (2020). A semantically rich framework for knowledge representation of code of federal regulations. *Digit. Gov.: Res. Pract.*, *1*(3). DOI: https://doi.org/10.1145/3425192.

Katz, D. M., Hartung, D., Gerlach, L., Jana, A., & Bommarito, I., Michael J. (2023, February). *Natural language processing in the legal domain* [Provided by the SAO/NASA Astrophysics Data System]. DOI: https://doi.org/10.48550/arXiv.2302.12039.

Kneuer, M. (2016). E-democracy: A new challenge for measuring democracy. *International Political Science Review / Revue internationale de science politique*, *37*(5), 666–678. Retrieved September 18, 2023, from https://www.jstor.org/stable/26556880

Kuçuk, D., & Can, F. (2020). Stance detection: A survey. *ACM Comput. Surv.*, *53*(1). DOI: https://doi.org/10.1145/3369026.

La Cava, L., Simeri, A., & Tagarelli, A. (2022). Lawnet-viz: A web-based system to visually explore networks of law article references. *Proceedings of the 45th International ACM SIGIR Conference on Research and Development in Information Retrieval*, 3300–3305. DOI: https://doi.org/10.1145/3477495.3531668.

Lai, M., Cignarella, A. T., Hernández Farías, D. I., Bosco, C., Patti, V., & Rosso, P. (2020). Multilingual stance detection in social media political debates. *Computer Speech & Language*, *63*, 101075. DOI: https://doi.org/https://doi.org/10.1016/j.csl.2020.101075.

Lai, M., Patti, V., Ruffo, G., & Rosso, P. (2020). #brexit: Leave or remain? the role of user's community and diachronic evolution on stance detection (D. Pinto, V. Singh, & F. Perez, Eds.). *Journal of Intelligent &amp Fuzzy Systems*, *39*(2), 2341–2352. DOI: https://doi.org/10.3233/jifs-179895.

Lai, M., Tambuscio, M., Patti, V., Ruffo, G., & Rosso, P. (2019). Stance polarity in political debates: A diachronic perspective of network homophily and conversations on twitter. *Data & Knowledge Engineering*, *124*, 101738. DOI: https://doi.org/https://doi.org/10.1016/j.datak.2019.101738.

Lessa, R. (2010). Democracia, representação e desenvolvimento. In F. d. S. Silva, F. G. Lopez, R. R. C. Pires, et al. (Eds.), *Estado, instituições e democracia: Democracia* (pp. 47–89, Vol. 2). Instituto de Pesquisa Econômica Aplicada (Ipea).

Lima, J. P., Alfredo Costa, J., & Araujo, D. C. (2021). Comparison of feature extraction methods for brazilian legal documents clustering. *2021 IEEE Latin American Conference on Computational Intelligence (LA-CCI)*, 1–5. DOI: https://doi.org/10.1109/LA-CCI48322.2021.9769839.

Lukito, J., K Sarma, P., Foley, J., & Abhishek, A. (2019). Using time series and natural language processing to identify viral moments in the 2016 U.S. presidential debate. *Proceedings of the Third Workshop on Natural Language Processing and Computational Social Science*, 54–64. DOI: https://doi.org/10.18653/v1/W19-2107.

Macedo, P. S. N. d. (2008). Democracia participativa na constituição brasileira. *Revista de informação legislativa*, *45*(178), 181–193. http://www2.senado.leg.br/bdsf/handle/id/176529

Maia, D. F., Silva, N. F. F., Souza, E. P. R., Nunes, A. S., Procópio, L. C., Sampaio, G. d. S., Dias, M. d. S., Alves, A. O., Maia, D. F., Ribeiro, I. A., Pereira, F. S. F., & de Carvalho, A. P. d. L. F. (2022). Ulyssessd-br: Stance detection in brazilian political polls. In G. Marreiros, B. Martins, A. Paiva, B. Ribeiro, & A. Sardinha (Eds.), *Progress in artificial intelligence* (pp. 85–95). Springer International Publishing.

Medina, M. C. C., Da Silva Oliveira, L. M., Ferreira, J. F. C., Silva, L. H. D. S., Rodrigues, C. M. O., De Oliveira, J. F. L., Sobral, P. C., Souza, B., Feitosa, D., & Fernandes, B. J. T. (2022). Classification of legal documents in portuguese language based on summarization. *2022 IEEE Latin American Conference on Computational Intelligence (LA-CCI)*, 1–6. DOI: https://doi.org/10.1109/LA-CCI54402.2022.9981852.

Nababan, A. H., Mahendra, R., & Budi, I. (2022). Twitter stance detection towards job creation bill [Sixth Information Systems International Conference (ISICO 2021)]. *Procedia Computer Science*, *197*, 76–81. DOI: https://doi.org/https://doi.org/10.1016/j.procs.2021.12.120.

Pereira, M. A., Bernardes, C. B., & Vale, M. L. (2022). O papel da moderação nas audiências públicas interativas do e-democracia: Entre a promoção do debate e o receio da censura. *Revista Brasileira de Ciência Política*, (37), e249679. DOI: https://doi.org/10.1590/0103-3352.2022.37.249679.

Reimers, N., & Gurevych, I. (2019, November). Sentence-BERT: Sentence embeddings using Siamese BERT-networks. In K. Inui, J. Jiang, V. Ng, & X. Wan (Eds.), *Proceedings of the 2019 conference on empirical methods in natural language processing and the 9th international joint conference on natural language processing (emnlp-ijcnlp)* (pp. 3982–3992). Association for Computational Linguistics. DOI: https://doi.org/10.18653/v1/D19-1410.

Reuver, M., Verberne, S., Morante, R., & Fokkens, A. (2021, November). Is stance detection topic-independent and cross-topic generalizable? - a reproduction study. In K. Al-Khatib, Y. Hou, & M. Stede (Eds.), *Pro-*

ceedings of the 8th workshop on argument mining (pp. 46–56). Association for Computational Linguistics. DOI: https://doi.org/10.18653/v1/2021.argmining-1.5.

Ronchi, A. M. (2019, February). *E-democracy* (1st ed.). Springer International Publishing.

Rothberg, D. (2008). Por uma agenda de pesquisa em democracia eletrônica. *Opinião Pública*, *14*(1), 149–172. DOI: https://doi.org/10.1590/S0104-62762008000100006.

Sarne, D., Schler, J., Singer, A., Sela, A., & Bar Siman Tov, I. (2019). Unsupervised topic extraction from privacy policies. *Companion Proceedings of The 2019 World Wide Web Conference*, 563–568. DOI: https://doi.org/10.1145/3308560.3317585.

Sharma, A., Susan, S., Bansal, A., & Choudhry, A. (2022). Dynamic topic modeling of covid-19 vaccine-related tweets. *2022 the 5th International Conference on Data Storage and Data Engineering*, 79–84. DOI: https://doi.org/10.1145/3528114.3528127.

Silva, N., Silva, M., Pereira, F., Tarrega, J., Beinotti, J., Fonseca, M., Andrade, F., & Carvalho, A. (2021). Evaluating topic models in portuguese political comments about bills from brazil's chamber of deputies. *Anais da X Brazilian Conference on Intelligent Systems*. https://sol.sbc.org.br/index.php/bracis/article/view/19061

Vamvas, J., & Sennrich, R. (2020). X-stance: A multilingual multi-target dataset for stance detection [5th SwissText & 16th KONVENS Joint Conference 2020, SwissText and KONVENS 2020 ; Conference date: 23-06-2020 Through 25-06-2020]. *Proceedings of the 5th Swiss Text Analytics Conference (SwissText) & 16th Conference on Natural Language Processing (KONVENS)*. https://swisstext-and-konvens-2020.org/

Viani, N., Kam, J., Yin, L., Bittar, A., Dutta, R., Patel, R., Stewart, R., & Velupillai, S. (2020). Temporal information extraction from mental health records to identify duration of untreated psychosis. *Journal of Biomedical Semantics*, *11*(1), 2. DOI: https://doi.org/10.1186/s13326-020-00220-2.

Yamunathangam, D., Priya, C., Shobana, G., & Latha, L. (2021). An overview of topic representation and topic modelling methods for short texts and long corpus. *2021 International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA)*, 1–6. DOI: https://doi.org/10.1109/ICAECA52838.2021.9675579.

Zhang, D. C., & Lauw, H. (2022, July). Dynamic topic models for temporal document networks. In K. Chaudhuri, S. Jegelka, L. Song, C. Szepesvari, G. Niu, & S. Sabato (Eds.), *Proceedings of the 39th international conference on machine learning* (pp. 26281–26292, Vol. 162). PMLR. https://proceedings.mlr.press/v162/zhang22n.html

Track 5: Digital Government and Sustainable Development Goals

Track Description

The United Nations' Sustainable Development Goals (SDG) are shaping the global agenda in multiple areas, including public opinion, policy, and research. The 17 SDGs, detailed in 169 targets, have an ambition of linking separate goals of sustainable development across different areas, into a unitary vision. The main consequence of this new vision has been to move the focus beyond the individual instances of e.g., environmental impacts of human activities, or economic inequalities, and to link them in a coherent system within the framework of the Agenda for the Sustainable Development 2030. Digital government can act as an enabler to sustainability, equity, and social inclusion and it represents a cross-cutting objective across several SDGs at both sectoral and horizontal level, with a crucial importance in particular for goal 16 which aims to Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels. This track aimed to gather contributions focusing on the potential benefits and challenges of digital government in supporting the achievement of SDGs and the role of digital technologies in sustaining policy developments at both horizontal and sectoral levels, including, in particular, the impact on democratic innovation and institutional reforms of governance systems.

Track Chairs

J. Ubacht, Delft University of Technology, The Netherlands
I. Susha, Utrecht University, The Netherlands
R. Medaglia, Copenhagen Business School, Denmark
M. M. Ribeiro, Regional Center for Studies on the Development of the Information Society, Brazil

Content

Geospatial artificial intelligence for automating forest land encroachment detection in India 356
S. N. Satheesh

Geospatial artificial intelligence for automating forest land encroachment detection in India

Soorya Narayan Satheesh

[a] IEEE Member, sooryanarayan.ifs@gmail.com, ORCID number -0000-0001-5939-1438.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract.=Forest lands in India are under severe pressure from illegal encroachment despite the enactment of the Indian Forest Act(IFA) 1927 and Forest (Conservation) Act (FCA) 1980. This situation effectively reduces the land available for afforestation, affecting India's global commitment to fighting climate change. Encroachment in remote locations goes undetected, preventing any measures for removal. The feasibility of applying Artificial intelligence(AI) methods on Very High Resolution(VHR) satellite imagery to automate the identification of encroachments was examined. The evaluation found that the current level of research makes it feasible. A novel method for detection and monitoring of eviction of encroachment on forestland was proposed to increase the land available for afforestation. This method can ensure more CO_2 sequestration to help India meet its commitments in fighting climate change.

Keywords.=Forest, Conservation, Artificial intelligence, Climate change, Encroachment
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1028

1. Introduction

How the current generation deals with climate change will impact all the generations to come. Thanks to the awareness raised in this regard in the last few decades, the severity of the consequences of climate change and the required mitigation efforts is well known. Yet, in 2021, the world faced the calamitous impacts of climate change ranging from the deaths of countless mussels on beaches of Vancouver (Roxanne Egan-Elliott, 2021) to the unprecedented destructive rainfall in China (Jeff Masters, 2021).

1.1. India's global commitment

India's Intended Nationally Determined Contribution (INDC) in response to COP decisions 1/CP.19 and 1/CP.20 for the period 2021 to 2030 consisted of eight decisions which included one related to afforestation (Government of India, 2022). Through afforestation, the creation of an additional carbon sink of 2.5-3 billion tonnes of CO_2 equivalent by 2030 is one of India's INDC (Government of India, 2022).

1.2. Concerns on impact of forest land encroachment in fighting climate change in 2016

Due to the increase in people's concern, questions are rising on the efficacy of the climate change mitigation measures, like afforestation on forest land. In the Lok Sabha of the Indian Parliament, such a question was raised in July 2016 by the Member of Parliament Neelam Sonker (Sonker, 2016). Amongst others, the most pertinent question was,

> Will the Minister of Environment, Forest and Climate Change be pleased to state :(a) whether it is a fact that rapid climate change has been taking place in the country due to encroachment on forestland;

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

(Sonker, 2016). However, the reply to this question stated that

> No study has so far come to the notice of the Ministry regarding rapid climate change in the country due to encroachment on forest land.

, the subsequent questions raised by Neelam Sonker and the answers received need to be analysed (Sonker, 2016).

The other questions raised by Neelam Sonker (Sonker, 2016) were on details of forest land encroachment in India, steps being taken by the Government to check forest encroachment and details of the incentives being given by the Government to increase the forest cover. The answer to the question regarding forest encroachment stated that 1.48 million hectares of forest land are under encroachment (Sonker, 2016). On the question of the government's financial incentives to increase the forest cover, the answer revealed that 3962.6 million Indian Rupees had been spent in 2014-15 & 2015-16 by the government (Sonker, 2016). This expenditure was on three afforestation schemes, namely the National Afforestation Program(NAP), Intensification of Forest Management Scheme(IFMS), and Green India Mission(GIM) (Sonker, 2016).

Now, one may wonder if the climate change mitigation efforts may have been more effective had afforestation been carried out on the 1.48 million hectares of forest land under encroachment.

1.3. India's forests and their carbon sequestration capacity

Forest land available for afforestation is limited. Forest in India is a tract of land legally proclaimed to be one under the Indian Forest Act, 1927 or Forest (Conservation) Act,1980 (Parliamentary Standing Committee, 2019). In India there are three types of legal forests under the Indian Forest Act,1927 (Government of India, 1927): Reserved forests (RF), Protected Forests (PF), and Unclassed Forests (UF)(Parliamentary Standing Committee, 2019). India has a notified forest area of 76.79 million hectares (m ha), comprising 43.47 m ha of Reserved, 21.94 m ha of Protected and 11.38 m ha of Unclassed (unclassified) Forests (Parliamentary Standing Committee, 2019).

Studies have found that planted forests/woodlots have the highest CO_2 removal rates, ranging from 4.5 to 40.7 t CO_2 ha^{-1} $year^{-1}$ during the first 20 years of growth(Bernal et al., 2018). Therefore, additionally, a minimum of 6.66 to a maximum of 60.236 million t CO_2 $year^{-1}$ could have been sequestered for the first 20 years of growth on the 1.48 million hectares of forest land under encroachment. There also exist other concerns on India's efforts to meet its forestry NDC goal of ensuring sequestration of 2.5-3 billion tonnes of CO_2 equivalent through additional afforestation by 2030 (Mathur et al., 2021).

1.4. Dearth of unequivocal answers on forest land encroachment

The concern with which the people of India view encroachment on forest land can be inferred from the frequent questions asked by the people's representatives in the Indian Parliament to the Government of India. Apart from the question on encroachment on forest land raised in the 16^{th} Lok Sabha, questions on the same have been raised by other parliamentarians in the 17^{th} Lok Sabha also, in 2020 (Kaushik and Saikia, 2020), and 2021 (Chand, 2021).

The information on forest land under encroachment provided through the reply to Lok Sabha questions in 2016 (Sonker, 2016), and in 2021 (Chand, 2021) reveals that 13 states/union territories (n=13/31) reported an increase, 15 (n=15/31) reported a decrease, and 8 (n=8/31) reported no change. However, these reports (Sonker, 2016,Chand, 2021) lack detailed information on new encroachments detected in the year and encroachment evicted in the year, due to which a year-on-year dynamic view of combating encroachment cannot be ascertained. These reports (Sonker, 2016,Chand, 2021) are also not providing information on the duration, type of encroachments as well as their numbers, for example, Roads(since 2018)-0.05 million km or Buildings(since 2000) -0.5 million or Buildings(since 1990)-0.8 million or Agricultural fields(since 2003)-0.3 million or Rubber Plantation(since 1998)-0.1 million hectares.

1.5. Challenges

The shortage of staff to monitor all the remote forest areas (Times of India, 2019,Times of India, 2021) makes the classification of encroachment based on types like buildings, roads, fields, and others challenging. There is

also an absence of an openly available GIS map of forest encroachments in India, which could have been helpful for different anti-encroachment activities. Reducing human involvement in quantifying forest land encroachment may be a solution to get accurate figures. These issues may hamper timely eviction of encroachment to carry out afforestation in such reclaimed areas. The planting of species with fast growth and high CO_2 sequestrating ability in the location could have otherwise aided India's efforts to meet its forestry INDC goal of ensuring sequestration of 2.5-3 billion tonnes of CO_2 equivalent through additional afforestation by 2030.

1.6. Contours of a solution

Therefore, in reference to the paragraphs above, there is a need to quantify, classify, and geo-reference encroachment on forest land through automation. To achieve the above, remote sensing in the form of Very High Resolution(VHR) satellite imagery or drone imagery may be required. In India already satellite imagery has been used to assess the forest land area under encroachment in the north eastern state of Manipur (Sastry et al., 2007). However, this study (Sastry et al., 2007), cannot classify the encroachments in the form of the number of buildings or roads. It has given only the area under different types of encroachment. This issue is crucial because all the buildings, roads, agricultural fields within forest land may not be illegal. The suspected buildings, roads and others may be legally built or legalised through the diversion of forest land for non-forestry purposes (Government of India, 1980) or under the Forest Rights Act (Government of India, 2006) or regularised before the enactment of Forest Conservation Act 1980 (Government of India, 1980) or constructed by the State Forest Departments(SFDs) themselves. Therefore, only an assessment of built-up area or agricultural fields area (Sastry et al., 2007) may not be sufficient to distinguish the illegal from the legal.

A system that can rapidly identify any new encroachment on forest land is required to nip at the bud any such efforts. This system could be on the lines of Forest Survey of India's Fire Alert System (FAST) Version 3.0 ("FSI Fire Alert System (FAST) Version 3.0 ", 2019). Artificial intelligence methods in general and Computer vision in particular like image classification, image/semantic segmentation, and instance recognition may be necessary in this situation (Szegedy et al., 2016;Szeliski, 2011;Girshick et al., 2014;Haralick and Shapiro, 1985;L.-C. Chen et al., 2017).

This paper attempts to ascertain if the different types of forest encroachments happening in India can be automatically identified using existing artificial intelligence methods from VHR remote sensing imagery and distinguish the legal from the illegal.

Also, a method is proposed to develop a web GIS portal for viewing locations of encroachments and monitoring their eviction followed by afforestation.

2. Literature Review: AI Methods for Forest Encroachment Detection

2.1. AI for Building Detection in Remote Forest Areas

There are several means to extract buildings from satellite imagery using artificial intelligence techniques like image classification, semantic segmentation and instance segmentation (L.-C. Chen et al., 2017;Haralick and Shapiro, 1985). From only three-channel RGB satellite imagery, using a modified DeeplabV3+ module with a Dilated ResNet backbone, building footprints masks were generated with the incorporation of F-Beta objective by Jiwani et al in 2021 (Jiwani et al., 2021;Baheti et al., 2020). In 2021 Arndt et al identified that deep neural networks perform better in classifying urban buildings over different cities using diverse satellite imagery collections (Arndt and Lunga, 2021). QGIS an open-source RS/GIS software also has plugins for the identification of buildings and construction sites (GeoAlert, 2022). Using such tools initially may be useful since different state forest departments, and national agencies use ArcGIS/QGIS software.

2.2. AI for Road Network Identification on Forest Land

Road extraction from satellite imagery is necessary to identify illegally constructed roads in forest land. Such roads may be used by encroachers, timber smugglers, and wildlife poachers to expand their illegal activities. Artificial intelligence techniques are being used successfully by different researchers for road extraction.

Abdollahi et al found in 2020 that VNet+CEDL deep learning model was able to preserve boundary information and obtain high-resolution road segmentation maps from satellite imagery (Abdollahi et al., 2020). Rural roads detection from satellite imagery has been improved by an ensemble Wasserstein Generative Adversarial Network with Gradient Penalty (WGAN-GP) method called E-WGAN-GP by Yang et al in 2020 (Chuang Yang and Z. Wang, 2020), crucial for use in forest areas. Plugins capable of detection of roads are available with QGIS (GeoAlert, 2022).

2.3. AI for Agricultural Field Detection

Various researchers have applied different artificial intelligence techniques for the extraction of agricultural fields and identification of crops, a few are mentioned here.

Even with cloud cover, using deep learning, crop mapping was carried out from one shot hyperspectral satellite imagery by Meng et al in 2021 (Meng et al., 2021). Agricultural field boundaries in northern Germany were extracted by Wagner et al in 2020 from sensor independent RGB imagery using a combination of deep learning models and graph-based growing contours (GGC) method (Wagner and Oppelt, 2020). Crop type detection was carried out on RGB imagery from UAVs using Deep learning and transfer learning by Chew et al in 2020 in Rwanda (Chew et al., 2020). Paddy fields, which may constitute a large part of forest encroachments, were classified using deep learning from Dual Polarized Synthetic Aperture Radar (SAR) imagery by Chatterjee et al in 2020 (Chatterjee et al., 2021).

2.4. AI for Mine Detection

Illegal mining and tailings dams were detected in Brazil using deep neural networks and Sentinel-2 imagery processed in Google Earth Engine by Blaniuk et al (Balaniuk et al., 2020). They have brought to light 263 illegal mines using freely available low-cost data science tools (Balaniuk et al., 2020), which can be replicated in India also.

2.5. AI for Illegal Plantation and Tree Species Detection

There are several methods for tree species identification and tree crown detection, which may be used to identify illegal plantations in forest land. In 2020 Miyoshi et al were able to identify individual tree species in a dense forest area of semi-deciduous forest of the Brazilian Atlantic biome, from hyperspectral imagery using deep learning (Miyoshi et al., 2020). Individual Tree-Crown Detection and Species Classification were achieved by Pleşoianu et al using a Deep Learning Ensemble Model in 2020 (Pleşoianu et al., 2020).

2.6. AI for Deforestation Detection

Deforestation is a tell-tale sign of forest encroachment, and researchers worldwide are now using artificial intelligence for detecting and predicting it.Adarme et al in 2020 evaluated the effectiveness of four different deep learning models for automatic deforestation detection in Brazilian forests, finding Early Fusion (EF) and Siamese Network (SN) to be the most effective (Ortega Adarme et al., 2020). Deforestation probability assessment was carried out in Eastern India by Saha et al using multi-layer perceptron neural nets with hybrid ensemble classifiers in 2021 (Saha et al., 2021). In 2020 Irvin et al have classified the primary drivers of deforestation using a deep learning model called ForestNet in Indonesia, this may be of relevance for India also (Irvin et al., 2020).

3. India Case Study: Application Context and Challenges

3.1. Types of encroachments on forest land in India

The encroachment of forest land in India include construction of buildings, mining, agriculture, roads, illegal plantations, and all other land-related non-forestry activities within legal forest boundaries in contravention of different laws in India(Government of India, 1927, 1980, 2006; Kh et al., 2013). Illegal buildings in forest land have been reported from different states of India (Kerala High Court, 2021; National Green Tribunal, 2019).

The forests of the mineral-rich states of India have been affected by illegal mining (Kanchi Kohli, 2014; Ministry of Environment,Forests,Climate Change, 2021; Supreme Court of India, 2005). Encroachments are also in the form of illegal rubber plantations, cannabis and others (Ankur Paliwal, 2018; Times of India, 2020). Large scale deforestation is often a prelude to encroachment in Forests, therefore they also need to be monitored.

3.2. Current State of Forest Land Data in India

3.2.1. Availability of Geo-referenced Forest Land Data

In connection with the Lafarge Umiam Mining Pvt. Ltd. vs Govt of India W.P.(C) No.-000202-000202 / 1995, the Hon'ble Supreme Court of India issued guidelines for dealing with such future cases on 6th July 2011 (Kapadia, 2011). The guideline number (vii) at page 107 (Kapadia, 2011, p. 107) reads as follows -

> (vii) Creation and regular updating of a GIS based decision support database, tentatively containing inter-alia the district-wise details of the location and boundary of (i) each plot of land that may be defined as forest for the purpose of the Forest (Conservation) Act, 1980; (ii) the core, buffer and eco-sensitive zone of the protected areas constituted as per the provisions of the Wildlife (Protection) Act, 1972; (iii) the important migratory corridors for wildlife; and (iv) the forest land diverted for non-forest purpose in the past in the district. The Survey of India toposheets in digital format, the forest cover maps prepared by the Forest Survey of India in preparation of the successive State of Forest Reports and the conditions stipulated in the approvals accorded under the Forest (Conservation) Act, 1980 for each case of diversion of forest land in the district will also be part of the proposed decision support database.

As per this guideline of the Hon'ble Supreme Court of India, almost all states have completed or are in the process of completion of geo-referencing of forest land in their respective states. States like Odisha have even developed an Android mobile application called "KYFL @ ODISHA (Know Your Forest Location in Odisha)" (ORSAC, 2022a).

The guideline number (xii) (Kapadia, 2011, p. 110) also speaks of preparation of Geo-referenced district forest maps,as seen below-

> (xii) Completion of the exercise undertaken by each State/UT Govt. in compliance of this Court's order dated 12.12.1996 wherein inter-alia each State/UT Government was directed to constitute an Expert Committee to identify the areas which are "forests" irrespective of whether they are so notified, recognized or classified under any law, and irrespective of the land of such "forest" and the areas which were earlier "forests" but stand degraded, denuded and cleared, culminating in preparation of *Geo-referenced district forest-maps* containing the details of the location and boundary of each plot of land that may be defined as "forest" for the purpose of the Forest (Conservation) Act, 1980.

3.2.2. Geo-referenced Dataset of Legal Activities on Forest Land

Areas with buildings, roads, fields, rubber plantations and others within forest land that are legal and need to be excluded from encroachment identification exercise are-

1. Areas diverted for non-forestry purposes under the Forest (Conservation) Act 1980 Government of India, 1980. Till now 3,28,979 hectares of forest land have been diverted (Forest Survey of India, 2022b).
2. Buildings/roads/Forest Nurseries other structures built by the State Forest Department
3. Areas distributed under The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 (Government of India, 2006). As of 30.11.2019 12.96 million acres or 5.24 million hectares of forest land has been distributed under this Act (Ministry of Tribal Affairs, 2020).
4. Areas given on lease for various purposes by the State Governments before the enactment of Forest (Conservation) Act 1980 (Government of India, 1980)

GIS polygons of diverted land (DL) as mentioned in sl no. 1 above, are available in the E-Green Watch portal of Forest Survey of India (Forest Survey of India, 2022a, 2022b). These may be merged to form a layer of diverted land for the entire country. This may also help ensure that construction/other activities are not taking place outside the approved area. Different State Forest Departments are having survey and GIS analysis units, which may be having the required spatial information as mentioned in sl no. 2 above. If not available, such spatial information can be easily prepared. Concerning areas as mentioned in sl no.3 above, states like Odisha and Tripura are carrying out GIS mapping using Android mobile apps (ORSAC, 2022b, 2022c).

Regarding land given under lease before the enactment of the Forest (Conservation) Act 1980 (Government of India, 1980), the leases if expired will have to be renewed as per the provisions of Forest (Conservation) Act 1980 (Government of India, 1980) which will provide GIS polygon data of such land in E-Green Watch portal (Forest Survey of India, 2022a, 2022b).

3.3. Implementation Challenges

3.3.1. Data Availability and Quality Challenges

Implementation of AI-based forest encroachment detection in India faces significant data availability and quality challenges that must be addressed for successful deployment. The absence of India-specific training datasets for various encroachment types represents a major obstacle, as most existing AI models are trained on Western architectural styles and landscapes that differ substantially from Indian contexts. Additionally, the high temporal variability of Indian landscapes due to pronounced seasonal changes (monsoon versus dry season) necessitates multi-seasonal imagery to avoid false positives. Cloud cover presents another persistent challenge, particularly in the northeastern states and Western Ghats where cloud-free days are limited, potentially creating significant gaps in monitoring continuity. Furthermore, the highly fragmented nature of both legal and illegal activities in Indian forests, with small-scale encroachments often measuring less than 0.1 hectares, demands very high resolution imagery that may be costly or difficult to acquire at national scales.

3.3.2. Technical Challenges

The technical implementation of an AI-based encroachment detection system encounters several formidable challenges related to both computational requirements and algorithmic limitations. The sheer scale of India's forest cover (approximately 77 million hectares) necessitates substantial computational infrastructure for processing high-resolution imagery at a national level, particularly when temporal analysis is required to detect new encroachments. Algorithm performance varies significantly across India's diverse biogeographic zones, with models trained in the relatively open deciduous forests of central India often performing poorly in the dense evergreen canopies of the Western Ghats or the complex mountainous terrain of the Himalayas. Technical expertise represents another limitation, as many state forest departments lack specialized personnel trained in advanced geospatial AI techniques, creating a knowledge gap between research capability and operational implementation. Furthermore, distinguishing between legal and illegal activities through automated means requires complex rule sets that can incorporate numerous exceptions and special cases that vary by region and legal framework, adding significant complexity to model development and validation protocols.

3.3.3. Administrative and Political Barriers

The implementation of an automated forest encroachment detection system in India confronts multifaceted administrative and political barriers that extend beyond technical considerations. Forest management in India operates under a complex jurisdictional framework where responsibilities are distributed across central, state, and local authorities, creating coordination challenges for implementing a unified monitoring system. Politically sensitive issues surrounding forest rights, particularly those related to indigenous communities under the Forest Rights Act of 2006, require careful handling to avoid potential conflicts when automated systems flag activities that may be legally contested or in regulatory gray areas. Additionally, cross-departmental coordination between Forest, Revenue, and Tribal Affairs departments—each maintaining separate and some-

times contradictory land records—presents significant administrative hurdles for creating a consistent reference layer of legal activities. The system's implementation may also face resistance from vested interests benefiting from the current opacity in encroachment reporting, as increased transparency could threaten established patronage networks or expose previous administrative failures in preventing forest loss.

3.3.4. Resource and Cost Constraints

The development and implementation of a comprehensive AI-based forest encroachment detection system faces significant resource and cost constraints that must be realistically addressed for sustainable operation. Acquisition of very high resolution (VHR) satellite imagery presents a substantial recurring expense, with commercial providers charging approximately $10-25 per square kilometer, potentially amounting to millions of dollars annually for comprehensive national coverage of priority forest areas. Hardware infrastructure requirements for processing and storing massive imagery datasets represent another major cost center, necessitating either substantial capital investment in computing infrastructure or ongoing cloud computing expenses. Human resource costs for system development, operation, and field verification teams constitute a significant operational expense, requiring specialized personnel who command higher salaries than typical forestry staff. Additionally, the development of India-specific training datasets through professional annotation services represents a substantial initial investment, potentially costing $150,000-300,000 for comprehensive coverage of all encroachment types across India's diverse biogeographic zones, though this represents a one-time expense that could be partially offset through academic partnerships and crowdsourcing initiatives.

3.3.5. Need for Regular Updates and Maintenance

A forest encroachment detection system requires systematic regular updates and maintenance to remain effective, creating operational challenges beyond initial implementation. AI models require periodic retraining to address concept drift as encroachment patterns evolve over time, with encroachers potentially adapting their methods to avoid detection once they become aware of monitoring systems. The underlying base maps of forest boundaries and legal activities require constant updating as new land is legally diverted for non-forestry purposes, rights are granted under the Forest Rights Act, or forest boundaries are modified through legal processes. Technical infrastructure demands regular software updates, security patches, and hardware upgrades to maintain system performance and protect sensitive data from emerging cybersecurity threats. Additionally, the verification feedback loop must be continuously maintained through field staff training and engagement to ensure ground-truthing data continues flowing back into the system, preventing degradation of model accuracy over time. This continuous improvement cycle requires institutional commitment to long-term funding and staffing that transcends typical government project cycles, necessitating dedicated budget lines and performance metrics tied to system maintenance rather than just initial deployment.

4. Methodology: Framework for AI-based Encroachment Detection

4.1. Preparation of AOI for analysis

The area of interest(AOI) of remote sensing imagery where the encroachment identification processes (explained in 2.1) will be applied, has to be first determined.

$$AOI = L_{ForestLand} - L_{Legalactivities} \tag{1}$$

where:

AOI= Area of Interest to check for encroachment using artificial intelligence
$L_{\textbf{Forest Land}}$**=** GIS layer of forest land
$L_{\textbf{Legal activities}}$**=** GIS layer of the area to be excluded from checking for any encroachment identification exercise

The Forest Land layer comprises legally designated forests under the Indian Forest Act, 1927, including Reserved Forests, Protected Forests, and Unclassed Forests. Following the Supreme Court of India guidelines

in the Lafarge Umiam Mining case (2011), most states have completed or are finalizing geo-referencing of their forest boundaries, with some states like Odisha developing mobile applications for public access to this information.

The Legal Activities layer must include four categories of authorized non-forest use: (1) areas diverted for non-forestry purposes under the Forest Conservation Act 1980 (approximately 328,979 hectares); (2) infrastructure built by State Forest Departments; (3) lands distributed under the Forest Rights Act 2006 (approximately 5.24 million hectares); and (4) pre-1980 leases granted by state governments. GIS data for these exemptions is available through the E-Green Watch portal, state Forest Department GIS units, and state-level FRA implementation tracking systems.

4.2. Data Requirements and Dataset Development

4.2.1. Preparation of India specific datasets and training of models

The success of any artificial intelligence project depends on the quality of datasets used for training the machine/deep learning model (H. Chen et al., 2020; Ding and Li, 2018). Therefore, to get accurate results we need to have India specific datasets for each encroachment type like buildings, road networks, agricultural fields, mines and plantations.

Currently, no comprehensive India-specific remote sensing datasets exist for these encroachment types. Existing repositories like Kaggle offer datasets for Western contexts (e.g., Massachusetts Roads and Buildings Datasets (Mnih, 2013)) but lack representation of Indian landscapes and settlement patterns. The development of India-specific datasets would provide significant benefits beyond encroachment detection, supporting broader geospatial AI applications throughout the country.

4.2.2. Data Collection Protocols and Standards

To ensure dataset quality and consistency, standardized protocols must be established regarding Imagery specifications, Annotation standards, Quality control process and Data augmentation. Data collection efforts should prioritize biogeographic representativeness, ensuring samples from all forest types in India (tropical, subtropical, montane, etc.) and capturing seasonal variations that significantly affect feature visibility and appearance.

4.3. Model Selection and Training Process

4.3.1. Criteria for Model Selection Based on Indian Conditions

Model selection must consider India's unique geographical and technical context like Performance across diverse landscapes, Resilience to seasonal variations, Computational efficiency and Adaptation to data limitations. Based on literature review, recommended model architectures include DeepLabV3+ with DenseNet backbone for building detection, MFPN (Multiple Feature Pyramid Network) for road detection, ResuNet-a for agricultural field boundaries, and enhanced Mask R-CNN for mining operations.

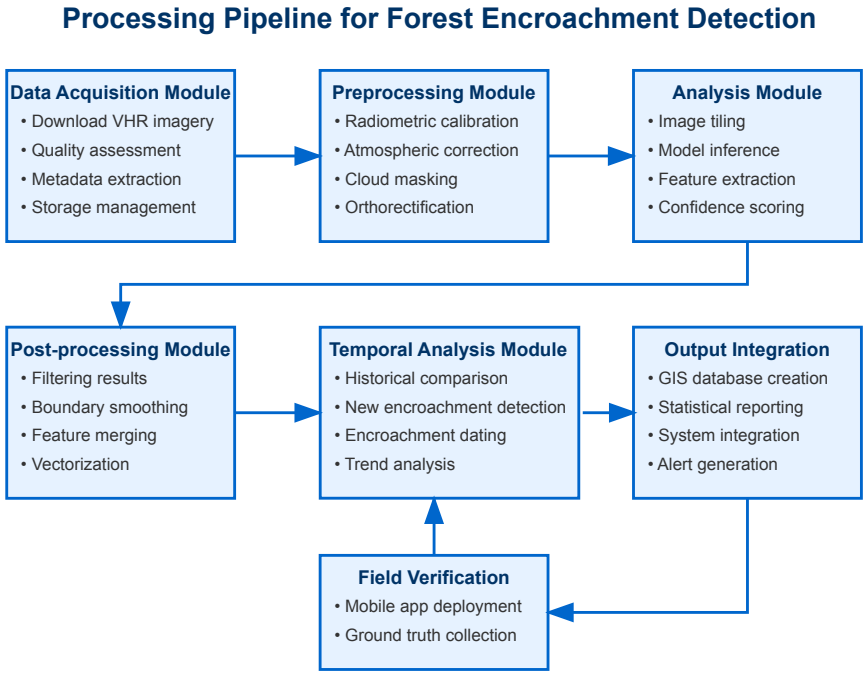
4.3.2. Training and Validation Protocols

A rigorous training and validation framework is essential for reliable model performance through Dataset partitioning, Hyperparameter optimization, Cross-validation strategy and Evaluation metrics. The testing and validation pipeline should explicitly include challenging scenarios (monsoon-affected imagery, partially obscured features, terrain shadows) to ensure robust real-world performance beyond ideal conditions.

4.4. Implementation Architecture

4.4.1. Processing Pipeline for VHR Satellite Imagery

Fig. 1 – Processing Pipeline



The operational implementation requires a structured processing pipeline(Fig. 1). The processing results will create geo-referenced databases of semantically segmented encroachment features that can be integrated with administrative boundaries to generate state-wise and district-wise statistics. This historical perspective is particularly valuable for legal proceedings and policy development, providing a chronological record of encroachment patterns.

4.4.2. Integration with Existing GIS Systems

The encroachment detection system must integrate seamlessly with existing government platforms like Forest Survey of India systems, State Forest Department GIS and National geospatial infrastructure. The integration architecture should employ standard OGC-compliant web services (WMS, WFS) for data sharing, with appropriate access controls to manage sensitive information while promoting transparency.

4.5. Validation and Verification Framework

4.5.1. Web GIS Platform Design

An interactive Web GIS platform (Fig(s). 2,4) will provide visualization and management capabilities. The platform design should follow the successful model of FSI's Forest Fire Portal, which has demonstrated effective integration of remote sensing alerts with field verification workflows at the national scale.

4.5.2. Ground Verification Protocol

Suspected encroachments identified by the AI system require field verification using mobile application and verification workflow. Once verification is complete, the web platform will enable tracking of both verification progress and subsequent enforcement actions, providing transparency for all stakeholders including policy-makers, judiciary, and citizens.

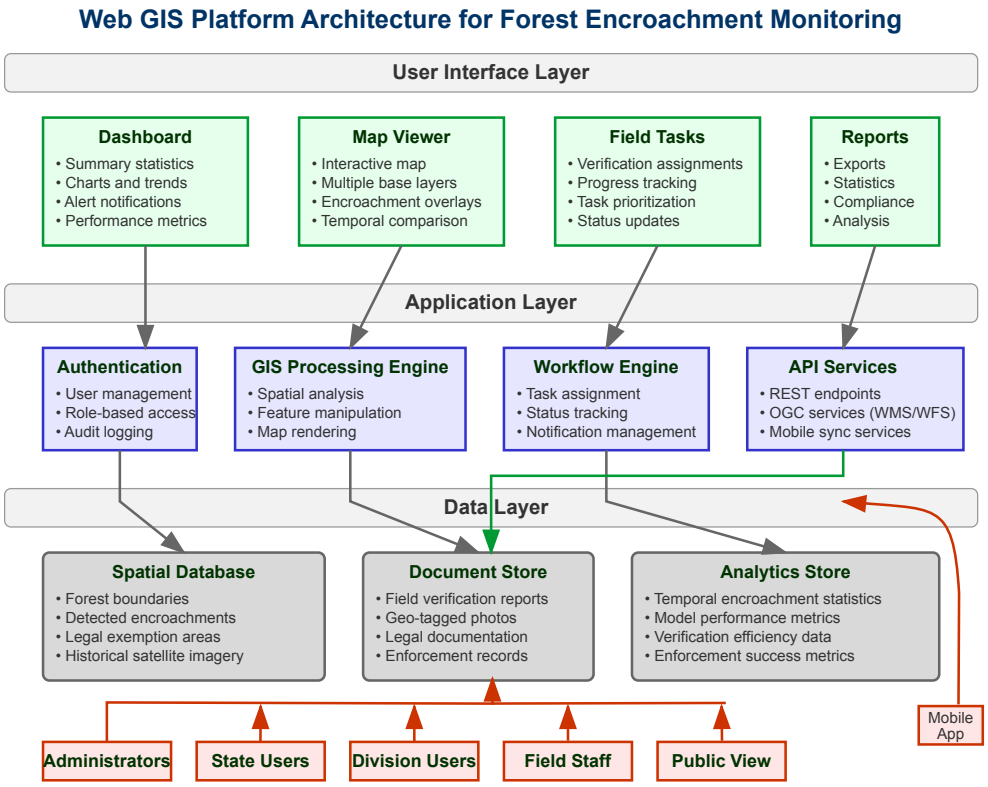


Fig. 2 – WebGIS Platform Architecture

4.5.3. Continuous Improvement through Feedback

The system design must incorporate feedback loop mechanisms for ongoing enhancement. This continuous improvement framework ensures the system evolves to address emerging encroachment patterns and adapts to regional variations in effectiveness, ultimately creating a learning system rather than a static monitoring tool.

5. Results and Discussion: Global Applications and Policy Implications

5.1. Lessons from India Applicable to Other Countries

The study of forest encroachment in Jiribam Sub-Division of Manipur (Kh et al., 2013) offers valuable insights applicable to similar challenges globally. As demonstrated in the Jiribam study, the application of remote sensing and GIS technologies allowed researchers to identify that 21.22% of the total area was under encroachment, primarily due to shifting cultivation practices (Kh et al., 2013).

In the Brazilian Amazon, where deforestation for agriculture is a significant concern, the Indian approach of combining high-resolution satellite imagery with ground verification could enhance existing monitoring systems by detecting smaller encroachments before they expand. Brazil's existing DETER system (Doblas et al., 2022) could be supplemented with AI-based detection to improve early intervention capabilities in remote areas.

5.2. Policy Implications for Forest Conservation

The findings from India's encroachment detection work suggest several important policy implications for forest conservation globally.

Integrated Jurisdictional Approaches: Forest monitoring technologies must be embedded within comprehensive jurisdictional frameworks that connect detection with enforcement and restoration. The Jiribam study

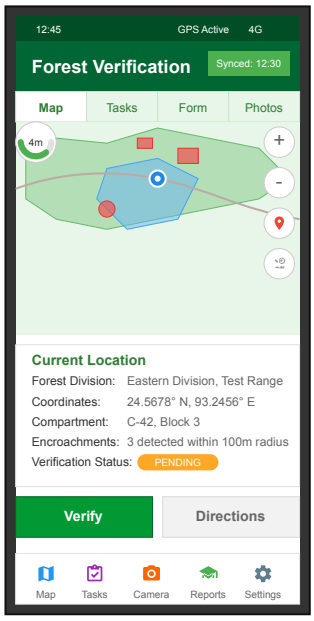


Fig. 3 – Field Verification Mobile Application Mock Up

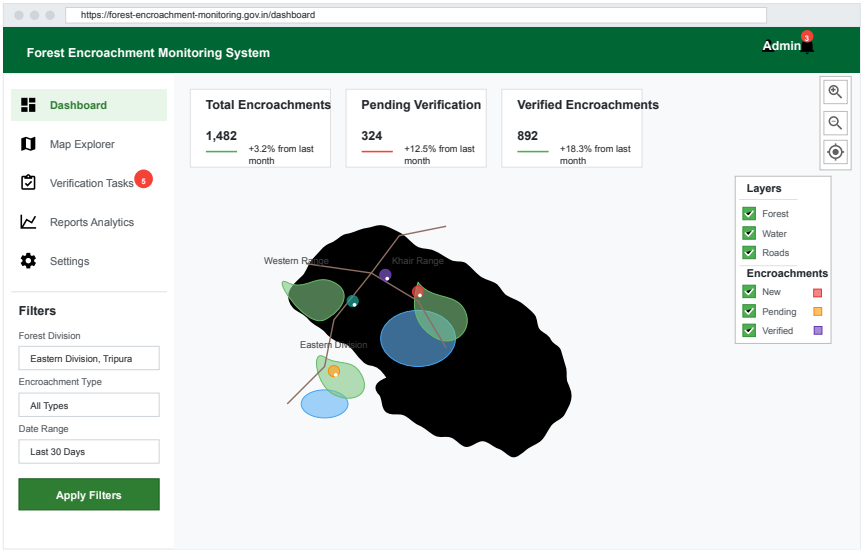


Fig. 4 – Desktop Web Application Mock Up

showed that merely identifying encroachment is insufficient; responding to it requires coordinated action across departments (Kh et al., 2013). Policy frameworks should establish clear protocols for inter-agency coordination when encroachment is detected.

Addressing Root Causes: The Jiribam study identified shifting cultivation as the primary driver of encroachment, with socio-economic factors like "food habits and misconceived food security feelings" contributing to continued forest clearance (Kh et al., 2013). Effective policies must address these root causes through alternative livelihood development and sustainable agriculture initiatives rather than focusing solely on enforcement.

Community Engagement: The recommendation from the Jiribam study to "manage jhum affected areas...without neglecting the demands and needs of the farmers" (Kh et al., 2013) emphasizes the importance of community-based conservation approaches. Policies should recognize indigenous and traditional forest rights while providing pathways to more sustainable practices through collaborative management. Technology Access and Standardization: For monitoring systems to be effective globally, policies need to support technology transfer, capacity building, and data standardization. The methodologies used in India can be adapted to different contexts, but require policy frameworks that enable access to satellite imagery, analysis software, and training for local forestry officials.

5.3. Integration with Climate Change Mitigation Efforts

AI-based encroachment detection systems directly support global climate change mitigation efforts, particularly within frameworks like REDD+ (Reducing Emissions from Deforestation and Forest Degradation) (Duchelle et al., 2018). This can be achieved through Enhanced Carbon Accounting, Supporting Results-Based Payments, Addressing Forest Degradation and Protecting Ecosystem Services.

5.4. Recommendations for Implementation in Various Contexts

Based on the Indian experience and the Jiribam study in particular, implementation recommendations can be tailored to different contexts:

For National Governments:

1. Establish comprehensive legal frameworks that clearly define forest boundaries
2. Develop institutional coordination mechanisms between rstakeholders
3. Invest in capacity building for technical staff at multiple levels of government
4. Create transparent monitoring dashboards that promote accountability and public engagement

For Conservation Organizations:

1. Support development of regionally-specific training datasets for AI algorithms
2. Facilitate technology transfer and capacity building between countries facing similar challenges
3. Develop community-based monitoring protocols that complement satellite detection
4. Advocate for funding mechanisms that support sustained monitoring rather than short-term projects

For Development Partners:

1. Fund pilot implementations that demonstrate effectiveness in different contexts
2. Support creation of regional centers of excellence for technology adaptation
3. Integrate encroachment monitoring with broader sustainable development initiatives
4. Invest in alternative livelihoods for forest-dependent communities

6. Conclusion

This paper demonstrates that current artificial intelligence techniques provide a viable foundation for automating forest encroachment detection in India. The comprehensive framework proposed here—integrating deep learning models with GIS systems, field verification protocols, and administrative workflows—addresses a critical need in forest conservation governance. By enabling systematic monitoring of encroachments through building detection, road network identification, and land use classification, this approach could substantially increase available land for afforestation efforts. The implementation challenges identified—including data availability, computational requirements, and administrative coordination—while significant, can be addressed through phased deployment, starting with high-priority forest regions.

Beyond theoretical potential, next steps should include pilot implementations across diverse biogeographic zones, development of India-specific training datasets, and quantitative evaluation of model performance under varying seasonal conditions. The long-term success of such a system depends not merely on technical implementation, but on integration with existing governance structures and community engagement initiatives. If successfully deployed, this approach could serve as a model for other forest-rich nations facing similar challenges, ultimately contributing to global climate change mitigation efforts by protecting the carbon sequestration potential of forest ecosystems. The return on investment—both environmental and economic—justifies the resources required for implementation, particularly as India strives to meet its commitment of creating an additional carbon sink of 2.5-3 billion tonnes of CO_2 equivalent by 2030.

Acknowledgement

I acknowledge the support I received from the editorial board and reviewers of the Dg.o2025 conference for their valuable feedback and guidance that significantly enhanced the quality of this paper. Their constructive comments helped refine the methodology and strengthen the analytical framework. I also extend my gratitude to my family and friends for their continued encouragement throughout the research and writing process.

Funding or Grant

No external funding was required for this paper.

Data/Software Access Statement

Not applicable.

Contributor Statement

Soorya Narayan Satheesh: Conceptualization, Methodology, Data Curation, Formal Analysis, Investigation, Software, Visualization, Writing - Original Draft, Writing - Review & Editing, Project Administration, Validation.

Use of AI

During the preparation of this work, the author(s) used Claude 3.7 Sonnet in order to check grammar, and correct LaTeX code formatting. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Abdollahi, A., Pradhan, B., & Alamri, A. M. (2020). VNet: An End-to-End Fully Convolutional Neural Network for Road Extraction From High-Resolution Remote Sensing Data. *IEEE Access*, *8*, 179424–179436. DOI: https://doi.org/10.1109/ACCESS.2020.3026658.

Ankur Paliwal. (2018). Threat to the environment? Rubber plantations in Northeast eat into forests. https://www.business-standard.com/article/economy-policy/threat-to-the-environment-rubber-plantations-in-northeast-eat-into-forests-118031900035_1.html

Arndt, J., & Lunga, D. (2021). Large-scale classification of urban structural units from remote sensing imagery. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *14*, 2634–2648. DOI: https://doi.org/10.1109/JSTARS.2021.3052961.

Baheti, B., Innani, S., Gajre, S., & Talbar, S. (2020). Semantic scene segmentation in unstructured environment with modified DeepLabV3+. *Pattern Recognition Letters*, *138*, 223–229. DOI: https://doi.org/https://doi.org/10.1016/j.patrec.2020.07.029.

Balaniuk, R., Isupova, O., & Reece, S. (2020). Mining and Tailings Dam Detection in Satellite Imagery Using Deep Learning. *Sensors*, *20*(23). DOI: https://doi.org/10.3390/s20236936.

Bernal, B., Murray, L. T., & Pearson, T. R. H. (2018, November). Global carbon dioxide removal rates from forest landscape restoration activities. DOI: https://doi.org/10.1186/s13021-018-0110-8.

Chand, N. (2021, July). Encroachment on forest land- lok sabha unstarred question no. 1851 to be answered on 30th july 2021 [Member of Indian Parliament, 16th Lok Sabha. Available at: http://164.100.24.220/loksabhaquestions/annex/176/AU1851.pdf].

Chatterjee, A., Mukherjee, J., Aikat, S., & Misra, A. (2021). Semi-supervised classification of paddy fields from dual polarized synthetic aperture radar (sar) images using deep learning. *International Journal of Remote Sensing*, *42*(5), 1867–1892. DOI: https://doi.org/10.1080/01431161.2020.1846223.

Chen, H., Chen, J., & Ding, J. (2020). Data evaluation and enhancement for quality improvement of machine learning. *2020 IEEE 20th International Conference on Software Quality, Reliability and Security (QRS)*, 13–13. DOI: https://doi.org/10.1109/QRS51102.2020.00014.

Chen, L.-C., Papandreou, G., Schroff, F., & Adam, H. (2017). Rethinking atrous convolution for semantic image segmentation. https://arxiv.org/pdf/1706.05587.pdf

Chew, R. F., Rineer, J., Beach, R., O'Neil, M., Ujeneza, N., Lapidus, D., Miano, T., Hegarty-Craver, M., Polly, J., & Temple, D. (2020). Deep Neural Networks and Transfer Learning for Food Crop Identification in UAV Images. *Drones*, *4*(1). DOI: https://doi.org/10.3390/drones4010007.

Chuang Yang and Z. Wang. (2020). An Ensemble Wasserstein Generative Adversarial Network Method for Road Extraction From High Resolution Remote Sensing Images in Rural Areas. *IEEE Access*, *8*, 174317–174324. DOI: https://doi.org/10.1109/ACCESS.2020.3026084.

Ding, J., & Li, X. (2018). An approach for validating quality of datasets for machine learning. *2018 IEEE International Conference on Big Data (Big Data)*, 2795–2803. DOI: https://doi.org/10.1109/BigData.2018.8622640.

Doblas, J., Reis, M. S., Belluzzo, A. P., Quadros, C. B., Moraes, D. R. V., Almeida, C. A., Maurano, L. E. P., Carvalho, A. F. A., Sant'Anna, S. J. S., & Shimabukuro, Y. E. (2022). Deter-r: An operational near-real time tropical forest disturbance warning system based on sentinel-1 time series analysis. *Remote Sensing*, *14*(15), 3658. DOI: https://doi.org/10.3390/rs14153658.

Duchelle, A. E., Simonet, G., Sunderlin, W. D., & Wunder, S. (2018). What is redd+ achieving on the ground? [Environmental change issues 2018]. *Current Opinion in Environmental Sustainability*, *32*, 134–140. DOI: https://doi.org/https://doi.org/10.1016/j.cosust.2018.07.001.

Forest Survey of India. (2022a). Booklet on e-Green Watch web portal. https://odishaforest.in/media/filer_public/ed/2a/ed2ada66-1d87-496b-bb5d-6c67754d6d4c/e-greenwatch3010116.pdf

Forest Survey of India. (2022b). e-Green Watch web portal -Integrated e-Governance Portal for automation, streamlining & effective management of processes related to plantation & other forestry works under all schemes. http://164.100.195.16/

FSI Fire Alert System (FAST) Version 3.0. (2019). Available at: http://117.239.115.41/smsalerts/index.php.

GeoAlert. (2022). Run AI-Mapping in QGIS over high-resolution satellite imagery. https://www.gislounge.com/run-ai-mapping-in-qgis-over-high-resolution-satellite-imagery/

Girshick, R. B., Donahue, J., Darrell, T., & Malik, J. (2014). Rich feature hierarchies for accurate object detection and semantic segmentation. *2014 IEEE Conference on Computer Vision and Pattern Recognition*, 580–587. DOI: https://doi.org/10.1109/CVPR.2014.81.

Government of India. (1927). Indian Forest Act ,1927.

Government of India. (1980). Forest Conservation Act ,1980.

Government of India. (2006). The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.

Government of India. (2022, August). India's intended nationally determined contribution: Working towards climate justice. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/India%20First/INDIA%20INDC%20TO%20UNFCCC.pdf

Haralick, R. M., & Shapiro, L. G. (1985). Image Segmentation Techniques (J. F. Gilmore, Ed.). *International Society for OpticsPhotonics*.

Irvin, J. A., Sheng, H., N., R., Johnson-Yu, S., Zhou, S., Story, K. T., Rustowicz, R., Elsworth, C., Austin, K., & Ng, A. (2020). ForestNet: Classifying Drivers of Deforestation in Indonesia using Deep Learning on Satellite Imagery. *ArXiv*, *abs/2011.05479*. https://arxiv.org/pdf/2011.05479.pdf

Jeff Masters. (2021, July). Extreme rainfall in China: over 25 inches falls in 24 hours, leaving 33 dead.

Jiwani, A., Ganguly, S., Ding, C., Zhou, N., & Chan, D. (2021). A Semantic Segmentation Network for Urban-Scale Building Footprint Extraction Using RGB Satellite Imagery. *ArXiv*, *abs/2104.01263*. https://arxiv.org/pdf/2104.01263.pdf

Kanchi Kohli. (2014, November). Targeting Illegal Mining in India's Forests. https://namati.org/news-stories/targeting-illegal-mining-in-indias-forests/

Kapadia, S. H. (2011). Guidelines issued by Hon'ble Supreme Court of India in Lafarge Umiam Mining Pvt. Ltd. vs Govt of India W.P.(C) No.-000202-000202 / 1995 dated 6th July 2011.

Kaushik, R. C., & Saikia, D. (2020, March). Encroachment in forest areas- lok sabha unstarred question no. 3303 to be answered on 13th march 2020 [Member of Indian Parliament, 16th Lok Sabha. Available at: http://164.100.24.220/loksabhaquestions/annex/173/AU3303.pdf].

Kerala High Court. (2021, April). Sukumaran Kani V/s Govt of Kerala and others,Kerala High Court,WP(C) No.29279/2017 and 9997/2018. https://www.casemine.com/judgement/in/60af53114653d00e3c27c56d

Kh, R., Singh, Singh, K., De, A., & Chintala, S. R. (2013). Forest encroachment mapping in jiribam sub-division of imphal east district, manipur, north east india using rs and gis techniques. https://www.researchgate.net/publication/384285890_Forest_encroachment_mapping_in_Jiribam_Sub-Division_of_Imphal_East_District_Manipur_North_East_India_using_RS_and_GIS_techniques

Mathur, A., Sharma, J., Ashutosh, S., & Priyanka. (2021, January). TERI - Will India attain its Forestry NDC target of achieving 2.5-3 billion tonnes of CO_2 equivalent through additional Forest and tree cover by 2030? [Available at: https://www.teriin.org/sites/default/files/2021-02/will-india-attain-forestry.pdf].

Meng, S., Wang, X., Hu, X., Luo, C., & Zhong, Y. (2021). Deep learning-based crop mapping in the cloudy season using one-shot hyperspectral satellite imagery. *Comput. Electron. Agric.*, *186*, 106188. DOI: https://doi.org/10.1016/j.compag.2021.106188.

Ministry of Environment,Forests,Climate Change. (2021, August). Lok Sabha Question/Answer- Illegal Mining in Forest Areas. http://164.100.24.220/loksabhaquestions/annex/176/AU2993.pdf

Ministry of Tribal Affairs. (2020, March). Lok Sabha Question/Answer- Forest land allotted to Tribals. http://164.100.24.220/loksabhaquestions/annex/173/AU4752.pdf

Miyoshi, G. T., Arruda, M. d. S., Osco, L. P., Marcato Junior, J., Gonçalves, D. N., Imai, N. N., Tommaselli, A. M. G., Honkavaara, E., & Gonçalves, W. N. (2020). A Novel Deep Learning Method to Identify Single Tree Species in UAV-Based Hyperspectral Images. *Remote Sensing*, *12*(8). DOI: https://doi.org/10.3390/rs12081294.

Mnih, V. (2013). *Machine learning for aerial image labeling* [Doctoral dissertation, University of Toronto]. https://www.cs.toronto.edu/~vmnih/data/

National Green Tribunal. (2019, March). Ram Avatar Yadav V/s Govt of India ,National Green Tribunal OA No.334/2019. https://www.casemine.com/judgement/in/600066af9fca1917ab0f5e03

ORSAC. (2022a). KYFL @ Odisha (Know Your Forest Location in Odisha). https://play.google.com/store/apps/details?id=web.gov.orsac.odishaknowyourlocation

ORSAC. (2022b). Odisha Forest Rights: Mobile GPS Survey App. https://play.google.com/store/apps/details?id=ofms.odishafra.com

ORSAC. (2022c). Tripura Forest Rights: Mobile GPS Survey App. https://play.google.com/store/apps/details?id=gov.tripura.rofrsurvey

Ortega Adarme, M., Queiroz Feitosa, R., Nigri Happ, P., Aparecido De Almeida, C., & Rodrigues Gomes, A. (2020). Evaluation of Deep Learning Techniques for Deforestation Detection in the Brazilian Amazon and Cerrado Biomes From Remote Sensing Imagery. *Remote Sensing*, *12*(6). DOI: https://doi.org/10.3390/rs12060910.

Parliamentary Standing Committee. (2019, February). Status of Forests in India, Report No.324,Rajya Sabha,Parliament of India [Department related Parliamentary Standing Committee on Science & Technology,Environment and Forests].

Pleşoianu, A.-I., Stupariu, M.-S., Şandric, I., Pătru-Stupariu, I., & Drăguţ, L. (2020). Individual Tree-Crown Detection and Species Classification in Very High-Resolution Remote Sensing Imagery Using a Deep Learning Ensemble Model. *Remote Sensing*, *12*(15). DOI: https://doi.org/10.3390/rs12152426.

Roxanne Egan-Elliott. (2021, July). A billion seashore animals may have died during B.C. heat wave, says UBC marine biologist.

Saha, S., Paul, G. C., Pradhan, B., Maulud, K. N. A., & Alamri, A. M. (2021). Integrating multilayer perceptron neural nets with hybrid ensemble classifiers for deforestation probability assessment in Eastern India. *Geomatics, Natural Hazards and Risk*, *12*(1), 29–62. DOI: https://doi.org/10.1080/19475705.2020.1860139.

Sastry, K. L. N., Kandya, A. K., Thakker, P. S., Ajai, Shangkooptong, L. B., Devi, R. S., Singh, N. S., Singh, K. J., Khaizalian, Singh, K. T., & Singsit, S. (2007, December). Final technical report-nationwide forest encroachment mapping using remote sensing and gis manipur state by manipur forest department (mfd), manipur state remote sensing applications centre (marsac), space applications centre (sac - isro) [Available at: http://moef.gov.in/wp-content/uploads/2017/08/ftr-gis-manipur.pdf].

Sonker, N. (2016, July). Encroachment on forest land- lok sabha unstarred question no. 1565 to be answered on 26th july 2016 [Member of Indian Parliament, 16th Lok Sabha. Available at: http://164.100.24.220/loksabhaquestions/annex/9/AU1565.pdf].

Supreme Court of India. (2005). Case judgement on mining in forest areas of Chattisgarh. http://www.indiaenvironmentportal.org.in/files/file/Iron_Ore_Mining_Chhattisgarh_SC_Order.pdf

Szegedy, C., Vanhoucke, V., Ioffe, S., Shlens, J., & Wojna, Z. (2016). Rethinking the inception architecture for computer vision. *2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 2818–2826. https://arxiv.org/pdf/1512.00567.pdf

Szeliski, R. (2011). Computer vision - algorithms and applications.

Times of India. (2019, September). 56 per cent staff shortage in Andhra Pradesh Forest Department.

Times of India. (2020). Chamarajanagar police crack whip on cannabis growers. https://timesofindia.indiatimes.com/city/mysuru/cnagar-police-crack-whip-on-cannabis-growers/articleshow/78175999.cms

Times of India. (2021, May). Severe staff shortage hits tiger monitoring in Ranthambore.

Wagner, M. P., & Oppelt, N. (2020). Deep Learning and Adaptive Graph-Based Growing Contours for Agricultural Field Extraction. *Remote. Sens.*, *12*, 1990. DOI: https://doi.org/10.3390/rs12121990.

Track 6: Digital Government Cybersecurity Management: Paradoxical Tensions and Responsible Innovation

Track Description

There are paradoxical tensions in public-sector cybersecurity management, alongside approaches to responsible innovation for an equitable digital government ecosystem. Innovation is oriented toward fast-paced technological adoption that may be high-risk; cybersecurity measures moderate the pace while aiming to lower organizational risk. This paradoxical tension between innovation and security can exacerbate digital government inequities. Resource-constrained public organizations may lead to low-level tech adoption and inadequate security measures. Marginalized communities could be left behind in the digital ecosystem, making them more susceptible to exploitation. Public sector management needs to adopt technological innovation holistically, in a responsible way, while considering organizational cybersecurity risks. Towards this end, this track aimed to examine the intersecting dimensions of organizational cybersecurity risks and responsible innovation in the public sector to build a more inclusive, equitable digital government ecosystem.

Track Chairs

S. Ganapati, Florida International University, United States of America
K. C. Desouza, Queensland University of Technology, Australia
D. A. Johnson, Florida International University, United States of America

Contents

Enhancing Government Efficiency Through Cybersecurity Hardening 372
S. Kumar, A. Garg, and M. Niranjan

Managing AI risks in the Public Sector: A Distributed Digital Leadership Approach 387
B. U. Adie, E. Valentine, M. Tate, and W. Cho

Enhancing Government Efficiency Through Cybersecurity Hardening

Shreyas Kumar[a], Anika Garg[b], Maitreya Niranjan[c]

[a]Texas A&M University, College Station, TX, USA, shreyas.kumar@tamu.edu, https://orcid.org/0009-0009-7035-9768
[b]Texas A&M University, College Station, TX, USA, https://orcid.org/0009-0000-6704-1761
[c]Texas A&M University, College Station, TX, USA, https://orcid.org/0009-0002-6282-3670

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 13 June 2025

Abstract. The rapid digitization of public sector services has fundamentally reshaped how governments operate, manage resources, and interact with citizens. From digital identity platforms to AI-enabled service portals, technology enables faster decision-making, seamless operations, and more responsive governance. Yet, this digital transformation introduces growing cyber risks, including ransomware, insider threats, and nation-state attacks. These risks not only threaten data privacy and national security but also undermine service reliability and institutional trust. To mitigate such threats and sustain innovation, cybersecurity hardening has emerged as a critical enabler of government efficiency. It includes proactive strategies such as continuous threat monitoring, network segmentation, encryption, and Zero Trust frameworks that reinforce operational continuity. While existing literature often frames cybersecurity as a compliance necessity, our research recasts it as a core strategic asset for enhancing public service performance. Specifically, we examine how cybersecurity contributes to resilience, reduces service disruptions, and improves resource allocation—three pillars of efficient governance. This approach aligns with emerging policy shifts, notably the formation of the U.S. Department of Government Efficiency (DOGE) in January 2025, which identifies cybersecurity as central to improving operational outcomes. Supported by similar initiatives in Texas, Kansas, and Louisiana, this paper situates cyber defense as a linchpin of modern administrative reform. By exploring real-world breach case studies and integrating economic modeling with cybersecurity strategy, we demonstrate how protecting systems is not just a cost-saving imperative but a means to power smarter, faster, and safer governance.

Keywords. Cybersecurity Hardening, Government Efficiency, Risk Management, Automation, Cost-Benefit Analysis.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1047

1. Introduction

The digitization of government services has transformed public administration, enabling efficient resource management, streamlined operations, and enhanced citizen engagement. From online tax filings to e-governance platforms, technology has become integral to the functioning of modern governments. However, this increasing reliance on digital infrastructure has also made governments vulnerable to an array of cybersecurity threats, including ransomware, data breaches, and state-sponsored cyberattacks. The consequences of these threats are far-reaching, impacting not only operational continuity but also national security, public trust, and the overall efficiency of government systems. Cybersecurity hardening has emerged as a critical strategy to mitigate these risks. This involves implementing advanced measures such as encryption, network segmentation, and continuous threat monitoring to safeguard sensitive data and ensure uninterrupted service delivery. While the technical aspects of cybersecurity hardening are well-documented, its broader implications for government efficiency remain underexplored. This paper examines how enhancing cybersecurity measures can improve the operational efficiency of government agencies, reduce costs associated with cyber incidents, and build resilience in the face of evolving threats. Government efficiency refers to the ability of public agencies to deliver services, manage resources, and execute operations in a timely, cost-effective,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and streamlined manner that maximizes public value and minimizes waste or redundancy.

The intersection of cybersecurity and government efficiency highlights the critical role of robust digital transformation in modern governance, where technology streamlines operations, enhances service delivery, and fosters effective decision-making. Centralized data systems enable faster retrieval and updates, improving productivity and collaboration across departments while minimizing errors and redundancies. Real-time access to information equips decision-makers with actionable insights, transforming static data into dynamic tools for effective resource allocation. Digital transformation also fosters responsive public services, enabling governments to adapt to evolving priorities and citizen needs with agility. However, the rapid digitization of government operations exposes vulnerabilities to cyber threats such as data breaches and ransomware, which can disrupt services, compromise sensitive data, and erode public trust. Strong cybersecurity measures are essential to secure these digital systems, ensuring continuity of operations and reinforcing public confidence. By aligning cybersecurity with digital transformation efforts, governments can achieve operational resilience, sustain innovation, and deliver efficient, citizen-centric services in an increasingly complex digital landscape.

Drawing on computer science to analyze technical security measures, public administration to assess operational impacts, and economics to evaluate cost-benefit considerations, this study provides a holistic analysis of the intersection between cybersecurity and government efficiency. It includes case studies of significant government-related cyber incidents, shedding light on the financial, operational, and societal impacts of cyberattacks. By focusing on actionable strategies and policy recommendations, the study aims to inform decision-makers on how cybersecurity hardening can improve the operational efficiency of government agencies, mitigate the financial and operational impacts of cyber incidents, and build resilience against evolving cyber threats.

The U.S. Department of Government Efficiency (DOGE) has identified cybersecurity hardening as a cornerstone of its mission to optimize public service delivery and enhance the resilience of critical infrastructure (Gianfortune, 2025). As federal, state, and local governments accelerate their digital transformation efforts, the risk of cyberattacks has grown exponentially. High-profile incidents, such as the SolarWinds breach and the ransomware attack on the city of Atlanta, highlight the urgent need for robust cybersecurity measures to protect sensitive data and ensure the continuity of essential services.

The U.S. government has prioritized cybersecurity as a key component of its strategic goals, reflected in initiatives such as the Cybersecurity and Infrastructure Security Agency's (CISA) Continuous Diagnostics and Mitigation (CDM) program. These efforts aim to strengthen the security posture of federal agencies by providing real-time threat monitoring, vulnerability management, and automated incident response capabilities. Moreover, the Biden Administration's 2023 National Cybersecurity Strategy emphasizes public-private collaboration, supply chain security, and workforce development to address the growing complexity of cyber threats. (Jaikaran, 2023) Small- and medium-sized government entities face unique challenges, often lacking the resources and expertise needed to implement advanced cybersecurity measures. This paper underscores the importance of equipping such agencies with cost-effective tools and strategies to enhance their cyber resilience. By addressing these gaps, governments can minimize service disruptions, reduce remediation costs, and foster public trust in digital systems.

At its core, this research is motivated by the dual need to protect national assets and improve the efficiency of government operations. The focus on cybersecurity hardening not only aligns with DOGE's mission but also contributes to broader national priorities, including economic stability, public safety, and democratic integrity. By highlighting the intersection of cybersecurity and government efficiency, this paper seeks to provide actionable insights that support the development of resilient, cost-effective, and citizen-centric governance models.

2. Background

2.1. The rising cost of governance due to data breaches

As digitization accelerates, the frequency and sophistication of cyber threats continue to grow exponentially. The global cost of cybercrime is projected to surge from $9.22 trillion in 2024 to $13.82 trillion by 2028, as

shown in 1. This alarming trajectory emphasizes the critical need for robust cybersecurity measures. Additionally, IBM's 2024 report on data breach costs highlights the increasing prevalence of cybersecurity incidents, with the global average cost of a data breach reaching $4.88 million in 2024—a 15% increase since 2020.

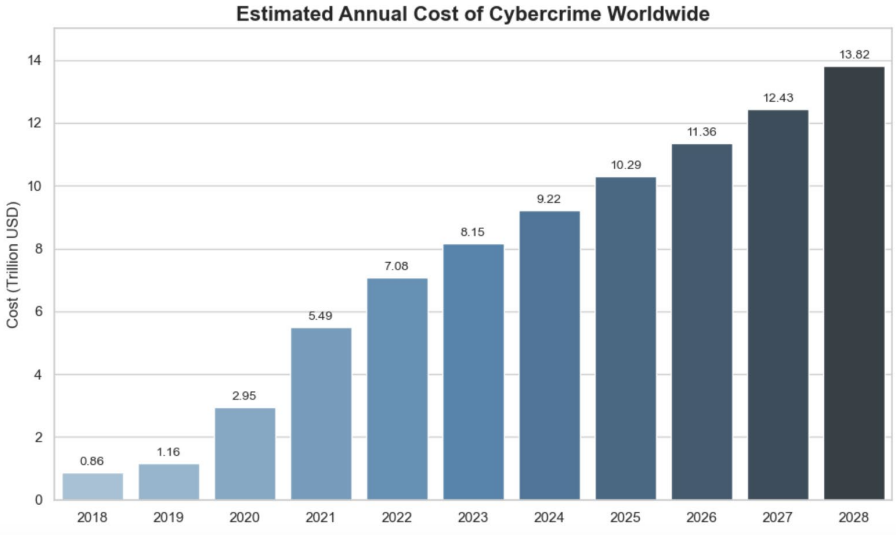


Fig. 1 – Estimated global cost of cybercrime and the rising cost of data breaches. Data sourced from Statista.

Governments and organizations face a diverse range of cyber threats, each with significant potential to disrupt operations and compromise sensitive information. Ransomware attacks, where malicious actors encrypt critical data and demand ransom payments for its release, pose a serious risk. For instance, the Costa Rica ransomware attack in 2022 paralyzed essential public services, causing widespread economic and operational damage (Nato, 2022). Phishing and social engineering tactics exploit human vulnerabilities through deceptive emails and messages to gain unauthorized access to systems (Kumar et al., 2024). Such attacks can lead to data breaches, as evidenced by the 2015 Office of Personnel Management (OPM) hack, where stolen credentials compromised millions of sensitive records (Gootman, 2016). State-sponsored cyber espionage, often in the form of advanced persistent threats (APTs) backed by nation-states, targets critical infrastructure and sensitive government data. The SolarWinds hack of 2020 exposed vulnerabilities in numerous U.S. federal agencies, raising national security concerns (Alkhadra et al., 2021). Furthermore, Distributed Denial of Service (DDoS) attacks represent another significant threat. These attacks overwhelm systems with excessive traffic, disrupting essential services. Governments and public institutions often become targets, impeding their ability to serve citizens. The diverse nature of these cyber threats demonstrates the need for comprehensive cybersecurity strategies and robust defense mechanisms to protect critical infrastructure and sensitive information.
The impacts of these cyber threats extend beyond financial losses. They compromise public trust, disrupt essential services, and expose sensitive data, which can have long-term implications for national security and societal stability. Recognizing the direct correlation between the rate of digitization and the scale of cybersecurity risks, governments must prioritize cybersecurity hardening to mitigate these threats effectively and ensure the continuity of public services.

In December 2015, a significant data breach exposed personal information of around 191 million U.S. voters due to a misconfigured database that was publicly accessible without security measures. This breach revealed sensitive data, including names, addresses, and party affiliations. The lack of basic security protocols and poor database configuration underscored the need for stringent data security measures and clear data ownership. The breach delayed remediation and highlighted the importance of proper configuration management and ownership accountability (Finkle, 2015).

Similarly, in 2022, Costa Rica faced a series of devastating ransomware attacks that targeted 27 public institutions, including the Ministry of Finance and the Costa Rican Social Security Fund. The attackers demanded millions in ransom, leading to severe operational disruptions. The government's refusal to pay the ransom resulted in an estimated economic loss of $125 million within the first 48 hours. The attack paralyzed essential services, including tax systems and healthcare records, demonstrating the far-reaching consequences of

ransomware on public institutions and the economy. The national emergency declaration underscored the importance of robust cybersecurity defenses and incident response plans. (Nato, 2022)

While many governments have faced cyberattacks, some have proactively strengthened their security frameworks, preventing major incidents and ensuring the continued resilience of their digital infrastructures. Estonia, often hailed as a global leader in e-governance and cybersecurity, stands out with its robust infrastructure, including its Data Embassy and blockchain-secured systems (Bitton, 2022). These measures, combined with a focus on citizen education and strong public-private collaboration, have significantly reduced cyber incidents, bolstering the nation's digital governance. Estonia's proactive measures have established it as a leader in cybersecurity, setting an example for other nations. Similarly, Singapore, with its Smart Nation initiative, integrates both technological innovation and cybersecurity at its core. The country's Cybersecurity Act and the work of the Cybersecurity Agency of Singapore (CSA) have made cybersecurity a key element of the nation's digital transformation (Cyber Security Agency of Singapore, 2025). By embedding security measures within its evolving digital infrastructure, Singapore has ensured the secure and efficient delivery of public services, becoming a model for how digital security and innovation can work hand-in-hand. These case studies illustrate the financial and operational impacts that data breaches can have on both public institutions and private organizations. From the misconfigured U.S. voter database to the crippling ransomware attacks in Costa Rica, each incident highlights the urgent need for robust cybersecurity frameworks, proactive risk management, and swift incident response. In contrast, countries like Estonia and Singapore demonstrate the effectiveness of strategic investments in cybersecurity. With well-established national cybersecurity agencies, public-private collaborations, and innovative security technologies, these nations have created more resilient digital infrastructures. They've built strong foundations that have not only mitigated cyber risks but have also enhanced their ability to innovate securely in the digital age. While the United States has taken significant steps to bolster its cybersecurity, particularly through initiatives like the Cybersecurity and Infrastructure Security Agency (CISA) and the Continuous Diagnostics and Mitigation (CDM) program, these efforts, though valuable, are not enough. The U.S. has made progress in strengthening federal systems and reducing downtime, but as recent breaches have shown, there is still much work to be done to protect critical infrastructure. The country's current cybersecurity framework needs to evolve more rapidly to keep pace with the growing sophistication of cyber threats.

These successful models, however, provide valuable insights for nations and organizations seeking to safeguard their digital infrastructures. They show that the cost of data breaches goes far beyond financial losses—impacting public trust, operational continuity, and even national security. To mitigate these risks, governments and organizations must prioritize cybersecurity, continually adapt to emerging threats, and make significant investments in both technology and human resources. Only through these sustained, concerted efforts can we hope to build resilient digital governance frameworks capable of standing up to the challenges of an increasingly interconnected and cyber-vulnerable world.

2.2. Government Efficiency initiatives in the United States

The establishment of the US Department of Government Efficiency (DOGE) in January 2025 highlights the commitment of the federal government to improving operational efficiency through strategic technological and organizational measures. The formal purpose of DOGE, as stated in the executive order that established it, is to "modernize federal technology and software to maximize government efficiency and productivity" (The White House, 2025). Several U.S. states, including Texas, Kansas, and Louisiana, have recently undertaken similar initiatives to enhance government efficiency. In Texas, the Committee on Delivery of Government Efficiency has been formed to reduce inefficiencies, increase transparency, and promote the use of science and technology. (Texas House of Representatives, 2024). As digitization reshapes public administration, these organizations play a pivotal role in driving initiatives that ensure seamless service delivery while addressing systemic vulnerabilities. These initiatives focus on preventing service disruptions, safeguarding critical public services such as healthcare and emergency response, and optimizing resource allocation by reducing financial and reputational losses linked to cyber incidents. A key way to achieve this is through cybersecurity hardening - proactive securing systems to enhance resilience, reduce downtime, and ensure seamless operations. Strong cybersecurity prevents costly breaches, minimizes reactive spending, and compliance burdens while supporting DOGE's mission to cut inefficiencies. Hardened systems also foster trust in digital services, ensuring secure and frictionless operations. Without a strong security foundation, modernization efforts risk being undermined by cyber threats. Our approach helps to achieve the broader objectives of government efficiency while suggesting the addition of cybersecurity jobs and the reinvestment, leading to not only efficiency

of government operations, but also potentially avoiding multi-million dollar costs of data breaches. Our research demonstrates that cybersecurity improvements are integral to government efficiency by improving operational resilience, reducing the likelihood and impact of service disruptions, enabling smarter resource allocation, and strengthening public trust in digital infrastructure.

Sl	State	Committee Name	Cybersecurity Agenda
1	Kansas	Senate Committee on Govt Efficiency	Not specified
2	Louisiana	Fiscal Responsibility Program	Not specified
3	Texas	Committee on Delivery of Govt Efficiency	Cybersecurity, privacy, and identity theft

Tab. 1 – Government Efficiency Committees Launched in the USA (Oct 2024–Feb 2025)

2.3. The Role of Cybersecurity Hardening

The National Institute of Standards and Technology (NIST) defines hardening as the process of reducing attack opportunities by addressing vulnerabilities and disabling unnecessary services. Cybersecurity hardening is a holistic strategy designed to protect organizations from cyber threats and reduce risks. By limiting the attack surface, organizations can lower their susceptibility to breaches and bolster their overall security framework. Organizations can enhance cybersecurity hardening by addressing key vulnerabilities through measures like strengthening password security, replacing default passwords with strong, unique ones to prevent breaches, and providing regular employee and client training on emerging threats and best practices. Automated updates and patching are crucial for efficiently managing zero-day vulnerabilities across complex IT environments. Encrypting network traffic ensures sensitive data is protected during transmission, while regular audits help identify and resolve misconfigurations in servers, routers, firewalls, and other systems. These steps collectively reduce risks, safeguard data, and strengthen overall network security. To achieve a robust cybersecurity framework, organizations should regularly assess their data storage and sharing processes. This includes reviewing the security of collaboration tools and addressing any gaps in system configuration to mitigate risks effectively.

3. Related Work

3.1. Regulatory Frameworks and Governance

The regulatory landscape of cybersecurity has evolved significantly, with governments and organizations developing comprehensive frameworks to address emerging threats. This evolution is driven by the increasing frequency and sophistication of cyber attacks, as well as the growing importance of data protection and privacy. Karabacak et al., 2016 demonstrated how nations can develop and implement regulatory frameworks for critical infrastructure protection. This approach is mirrored in other countries, such as the United States, where sector-specific regulations like HIPAA for healthcare and FISMA for government agencies have been implemented (Federal Information Security Management Act of 2002, 2002; Health Insurance Portability and Accountability Act of 1996, 1996). The European Union has taken a more comprehensive approach with the General Data Protection Regulation (GDPR) and the Network and Information Systems (NIS) Directive, setting global benchmarks for data protection and network security.

Furthermore, Bechara and Schuch, 2021 examined the challenges of creating unified global regulatory standards, particularly highlighting the complexities of cross-border cooperation. This is evident in the difficulties faced by businesses operating internationally, who must comply with multiple, sometimes conflicting, regulations. Albalas et al., 2022 provided a foundational understanding of cybersecurity governance structures and their implementation across different sectors. This understanding is crucial as the regulatory landscape continues to evolve, with new cybersecurity rules being enacted in major economies worldwide in 2024. These new laws aim to provide enhanced cybersecurity guardrails to effectively counter evolving cyber threats, including those leveraging advanced technologies like artificial intelligence.

Adding to this body of work, Hiller et al., 2024 proposed an innovative approach that breaks away from traditional regulatory frameworks by introducing a ”carrots and sticks” tax strategy to incentivize stronger cybersecurity postures. Their framework for a Federal Cybersecurity Investment Tax Credit, combined with a cyber insecurity tax, offers a more flexible and adaptive approach to cybersecurity governance that goes beyond conventional compliance-based requirements.

3.2. Economic and Resource Allocation

The economic aspects of cybersecurity hardening remain a critical concern for organizations in 2025, as they navigate uncertain economic times (Kissoon, 2020). Despite the growing need for robust cybersecurity measures, businesses are scrutinizing their budgets closely. Recent studies indicate that cybersecurity budgets have seen slower growth, with average increases dropping from 17% to 6% year-over-year (Krishna & Sebastian, 2021). However, cybersecurity spending remains relatively resilient, accounting for an increasing proportion of total IT costs, rising from 8.6% in 2020 to 11.6% in 2023 (IANS Research & Artico Search, 2023). This trend reflects the strategic importance of cybersecurity in organizational growth and continuity plans. CISOs are facing pressure to justify their budgets, leading to a focus on cost-effective solutions such as automation and security tool consolidation. Organizations are prioritizing basic cyber hygiene practices over investing in new technologies, emphasizing the need to maximize the outcome of every dollar spent on cybersecurity (Argyridou et al., 2023). As the global cybersecurity spend approaches $100 billion annually, with potential losses nearing $1 trillion, the economic imperative for effective resource allocation in cybersecurity hardening has never been more apparent. (Falco et al., 2019)

3.3. E-Government Implementation

The incorporation of cybersecurity into e-government initiatives is crucial for ensuring their success and resilience. Alrubaiq and Alharbi, 2021 identify key cybersecurity threats in e-government implementations, including data breaches, denial-of-service attacks, and insider threats. Their study highlights the need for a comprehensive cybersecurity framework that addresses both technical vulnerabilities and human factors in e-government projects. Recent advancements in e-government implementation include the development of more sophisticated risk assessment models. Ganin et al., 2020propose a novel cybersecurity risk assessment framework specifically tailored for e-government applications, incorporating dynamic threat landscapes and interdependencies between different government systems. This approach allows for more accurate prediction and prioritization of potential vulnerabilities in government networks. The National Institute of Standards and Technology (NIST) has developed Cybersecurity Framework 2.0, which provides a comprehensive approach to managing cybersecurity risks in critical infrastructure, including e-government systems. This updated framework now emphasizes six core functions: Govern, Identify, Protect, Detect, Respond, and Recover, offering a structured approach to cybersecurity implementation in e-governance initiatives.(National Institute of Standards and Technology, 2024)

The concept of ”security by design” has gained significant traction in e-government implementations. Alreemy et al., 2016 propose a framework for integrating security considerations throughout the entire lifecycle of e-government projects, ensuring that cybersecurity measures are not an afterthought but are embedded in the design and development phases. This approach aligns with a demonstration by Conklin and White, 2006 of the practical value of cybersecurity exercises in strengthening government organizations' security posture and incident response capabilities. As e-government systems become more sophisticated and widespread, the need for robust, adaptive, and comprehensive cybersecurity strategies becomes increasingly important, necessitating ongoing research and development in this critical area.

4. Methodology

This study integrates qualitative and quantitative analyses to assess how cybersecurity hardening enhances government efficiency and resilience. The methodology consists of three key components: a comprehensive literature review, an in-depth case study analysis, and economic modeling to evaluate the financial impact of cybersecurity investments. The literature review involves a systematic analysis of academic research, government reports, and industry publications to establish a foundational understanding of cybersecurity hardening strategies, digital transformation, and their effects on government operations. This review focuses on identifying key challenges in cybersecurity, evaluating best practices, and exploring how robust security frameworks improve public sector efficiency. It provides a theoretical basis for assessing the economic and operational benefits of proactive cybersecurity measures, guiding the case study selection and subsequent financial analysis. The case study analysis examines five major government-related cyber breaches to illustrate the financial and operational consequences of cyberattacks. The selected cases include the SolarWinds Attack (2020), which exposed vulnerabilities in supply chain security across U.S. federal agencies; the OPM Breach (2015), which compromised 22.1 million security clearance records; a U.S. Voter Data Breach, highlighting risks to

election integrity; and the Costa Rica Government Ransomware Attack (2022), which paralyzed public services and caused significant economic losses. These cases were chosen based on their scale, relevance to government operations, and the financial and reputational damages incurred. The analysis identifies common vulnerabilities, assesses incident response effectiveness, and extracts key lessons to inform best practices for cybersecurity hardening. The economic modeling component synthesizes findings from the literature review and case studies to evaluate the financial impact of cybersecurity investments. It identifies cost patterns across breaches, estimates potential losses that could have been mitigated through proactive security measures, and highlights best practices for maximizing return on investment (ROI). The study leverages risk reduction frameworks and historical breach cost data to assess how cybersecurity spending can lead to long-term cost savings and improved operational stability in government agencies. This study acknowledges certain limitations, including reliance on publicly available data, which may not fully capture remediation costs, classified response strategies, or long-term policy changes following breaches. Additionally, quantifying indirect costs such as reputational harm, erosion of public trust, and political fallout remains complex. However, by triangulating insights from multiple sources, this study provides a comprehensive assessment of cybersecurity's role in strengthening government efficiency and resilience while offering actionable recommendations for policymakers and security professionals.

5. Case Studies and Analysis

5.1. SolarWinds Incident

The SolarWinds hack was a supply chain attack where malicious actors breached the SolarWinds Orion software system (Alkhadra et al., 2021). A supply chain attack exploits weaker points in an organization's network, often through third-party vendors, to gain unauthorized access to systems and data. In this case, over 18,000 SolarWinds customers installed software updates containing malicious code, unknowingly enabling attackers to infiltrate their networks. The attack had a far-reaching impact on government and private organizations alike. According to the White House, nine federal agencies—including the Departments of Homeland Security, State, Treasury, Justice, Energy, and Defense—along with over 100 technology companies, were compromised (Cybersecurity and Infrastructure Security Agency & Federal Bureau of Investigation, 2021). A report by Roll Call estimated that American businesses and government agencies could spend upwards of $100 billion over months to contain and mitigate the damage (Pexton, 2021). The indirect costs compounded the financial toll, with companies losing an average of 11% of their annual revenue. The United States faced the highest financial impact, where companies suffered losses averaging 14% of their annual revenue, compared to 8.6% in the United Kingdom and 9.1% in Singapore (Fortinet, 2021). Beyond monetary losses, the attack tarnished the reputations of affected organizations, increased their operational costs, triggered legal actions and customer refunds, and compromised sensitive data. Moreover, a ProPublica investigation revealed that the U.S. government had spent $2.2 million on a cybersecurity system that, if implemented, might have prevented the SolarWinds attack.(ProPublica, 2021)

5.2. US Office of Personnel Management Incident

The 2015 Office of Personnel Management (OPM) data breach targeted sensitive information contained in Standard Form 86 (SF-86) records, which are used for U.S. government security clearances. This breach exposed critical data retained by OPM, affecting 22.1 million individuals, including federal employees, contractors, and their associates.(Gootman, 2016) OPM reported two separate but related cybersecurity incidents stemming from malicious activity on its network. The breach was traced back to a compromised contractor credential, as revealed by a collaborative investigation by the FBI and the Department of Homeland Security. By 2017, the breach had cost the U.S. government over $1 billion, primarily to provide identity theft protection for affected individuals. Two contracts were signed with ID Experts to address these concerns: the first for $340 million in credit monitoring and identity theft protection services, and the second for up to $416 million in extended services. In 2022, an additional $63 million settlement was reached for individuals who could demonstrate financial hardship caused by the breach (Giaritelli, 2022). This incident highlighted vulnerabilities in the bureaucratic system, which some argue contributed to inadequate protection of proprietary information. Others place the blame on senior leadership for failing to implement necessary security protocols to protect sensitive data. Warnings of such a breach were not unforeseen. According to Boyd, 2015, government auditors had warned the Office of Personnel Management (OPM) and other federal agencies about vulnerabilities in their systems. Security experts had recommended enhancing defenses through encryption and deploying software tools to mitigate risks. Unfortunately, these warnings went unheeded.(Brown, 2019)

5.3. Economic Modeling and Analysis

A comprehensive review of existing literature underscores the critical need for economic frameworks that balance cybersecurity investments with organizational risks and outcomes. The Gordon-Loeb Model has long served as a cornerstone in cybersecurity economics, offering a structured approach to determining optimal spending on security measures (Gordon & Loeb, 2002). However, as technology advances and cyber risks evolve, it is imperative to adapt this model to reflect contemporary challenges. This section explores the Gordon-Loeb Model's insights, integrates findings from IBM's 2024 report on breach costs, and incorporates emerging considerations from research on cyber risk quantification, including the work of Böhme et al., 2018.(Ponemon Institute, 2023)

5.4. The Gordon-Loeb Model: Foundational Insights

The Gordon-Loeb Model provides a mathematical framework to help organizations determine the optimal level of investment in protecting their information assets. It offers several key insights into cybersecurity investment strategies. First, the model highlights the principle of diminishing returns on investment. It suggests that the optimal level of security investment should not exceed 37% of the expected loss from a potential security breach. Investing beyond this threshold often results in diminishing returns, making additional expenditures less effective in mitigating risks. Second, the model emphasizes the importance of focusing on mid-vulnerability information. Protecting high-vulnerability information can demand significant resources, which may not always justify the costs. Similarly, securing low-vulnerability data often provides limited returns on investment. Therefore, the model advises prioritizing information assets with medium vulnerability, where security investments are likely to be most cost-effective. Lastly, the model underscores the need for strategic resource allocation. Organizations are encouraged to categorize their information assets based on their value and susceptibility to breaches, enabling a more rational and efficient distribution of security resources. This framework provides a valuable guide for balancing investment and risk in cybersecurity.

5.5. Adapting the Gordon-Loeb Model to Current Challenges

While the Gordon-Loeb Model provides a solid theoretical foundation, adapting its principles to today's dynamic cyber threat landscape involves addressing key developments. Insights from IBM's 2024 report highlight several pressing issues. The global average cost of a data breach has surged to $4.88 million, marking a 10% increase over the previous year and emphasizing the financial stakes of inadequate cybersecurity measures. Additionally, organizations that leverage security AI and automation can save an average of $2.22 million per breach, demonstrating the return on investment in technologies like AI-driven threat detection, encryption, and endpoint protection. Another growing concern is the proliferation of shadow data, which now plays a role in one-third of breaches. This trend complicates the task of tracking and securing sensitive information, necessitating the implementation of advanced data governance frameworks and visibility tools (IBM, 2024).

Furthermore, public sector entities face distinct cybersecurity challenges due to their responsibility for protecting critical infrastructure and citizen data. High-profile breaches, such as the Office of Personnel Management (OPM) hack, have resulted in substantial direct and indirect costs, highlighting the need for optimal budget allocation (Brown, 2019). Unlike private organizations, governments must also address externalities, including public trust, national security, and economic stability. Meanwhile, cyber risk insurance remains an underutilized tool for managing financial exposure to breaches. Böhme et al., 2018 argue that its adoption is hindered by the lack of actuarial data and the unpredictable nature of emerging threats. They advocate for data-sharing frameworks to improve risk quantification, which would help insurers price policies more effectively and incentivize better security practices. As cyber threats evolve, insurers may also need to collaborate with software vendors to mitigate vulnerabilities proactively, creating a feedback loop that benefits both parties.

Emerging technological paradigms further complicate cyber risk modeling. The rise of distributed ledger technologies, such as blockchain, introduces new risks that require novel analytical approaches. These systems rely on cryptographically enforced rules and autonomous algorithms, posing unique challenges for cybersecurity. Moreover, broader trends like the Internet of Things (IoT) and the Fourth Industrial Revolution underscore the necessity for dynamic, predictive models capable of addressing interconnected risks. Adapting

the Gordon-Loeb Model to these realities will require a more nuanced approach that integrates evolving technological, economic, and policy considerations. Leveraging Gordon-Loeb's research, we have modeled the optimal cybersecurity investment based on the average annual cost of a data breach in 2. This investment is projected to reduce the risk of a data breach by 26%, potentially saving organizations millions of dollars per incident (Accenture, 2023).

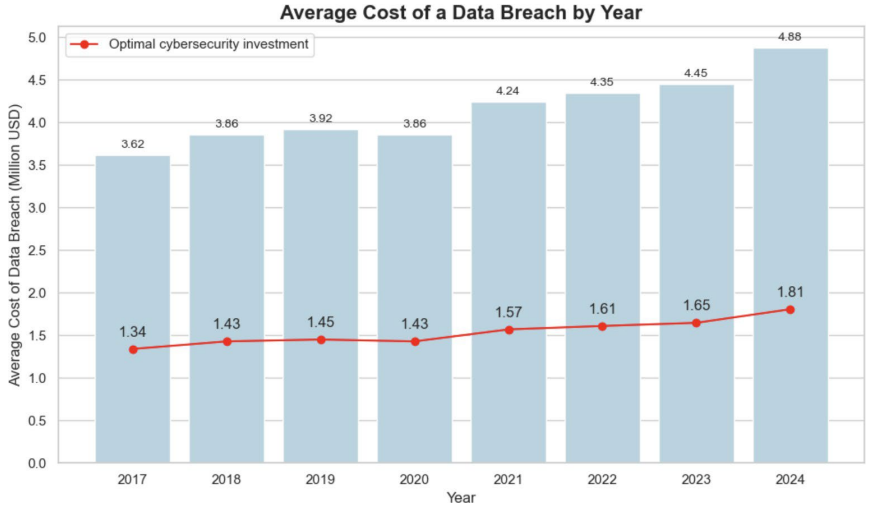


Fig. 2 – Yearly average data breach cost and recommended cybersecurity spending. Data sourced from IBM.

Analyzing the SolarWinds and OPM data breaches through the Gordon-Loeb model demonstrates the importance of optimizing security investments to address vulnerabilities effectively. In both cases, proactive spending on cybersecurity measures—such as robust identity verification systems, privileged access management (PAM) solutions, and AI-driven threat detection—could have mitigated vulnerabilities and reduced overall costs. The model's principle that security investments should be proportional to potential losses and risk levels underscores the need for strategic allocation of resources to areas with the highest impact. An equally critical component of risk mitigation is investing in human capital. Both the SolarWinds and OPM breaches highlight the importance of recruiting skilled security engineers and providing employee training to recognize and respond to potential threats. For example, the average salary of a DevOps Security Engineer in 2025 is approximately $140,000 annually—a cost that pales in comparison to the billions of dollars in direct and indirect costs resulting from these breaches. Organizations should aim to have at least one dedicated security engineer per development team, with larger enterprises requiring a centralized, specialized security team to oversee and manage the overall security posture. Finally, adopting advanced security technologies, such as endpoint protection, encryption, and AI-enabled threat detection systems, combined with a disciplined approach to patch management, is essential to reducing vulnerabilities. Although these measures involve significant upfront costs, they provide a high return on investment by reducing risk exposure and strengthening organizational resilience. By leveraging economic models like Gordon-Loeb and implementing smarter spending strategies, organizations can mitigate the likelihood and impact of future breaches, turning cybersecurity investments into a long-term safeguard for operational and financial stability.

5.6. Application to Government Efficiency

By integrating insights from the Gordon-Loeb Model and Böhme et al.'s research, governments can enhance cybersecurity investments in ways that align with their broader goals of efficiency and resilience. Strategic investments in AI, automation, and encryption can significantly reduce breach costs. Proactive measures to manage shadow data can mitigate risks stemming from poor data governance. According to Gordon and Loeb, the optimal level of security investment (S) should not exceed 37% of the expected loss (L) from a breach, expressed mathematically as $S \leq 0.37 \times L$, which helps avoid over-investment while addressing critical vulnerabilities (Gordon & Loeb, 2002). Governments can use data-sharing frameworks to assess risk at both individual and systemic levels, improving decision-making. The shortage of skilled cybersecurity professionals presents a significant challenge to maintaining secure systems, so investing in training programs for existing employees and recruiting specialized security engineers can dramatically improve an organization's ability to detect and mitigate threats. By employing Security Operations (SecOps) teams equipped with advanced tools

and knowledge, governments can enhance real-time threat monitoring and incident response capabilities. Training initiatives can also extend to non-technical personnel, fostering a culture of cybersecurity awareness and reducing human errors, often a major source of breaches. Cyber insurance can play a pivotal role in promoting security best practices, with premium differentiation, as proposed by Böhme et al., 2018, encouraging organizations to adopt secure-by-design approaches and prioritize risk mitigation throughout the supply chain. Finally, a robust cybersecurity posture fosters trust in digital public services, which is critical for successful digital transformation initiatives The Gordon-Loeb Model offers a robust framework for optimizing cybersecurity investments, and its relevance has become increasingly critical in the context of rising breach costs, and the rapid evolution of technological landscapes. As demonstrated in the research, organizations and governments can adopt a more comprehensive approach to managing cyber risks by balancing investments with expected losses, embracing cutting-edge technologies such as AI, automation, and Privileged Access Management (PAM) solutions, investing in human capital through the recruitment of skilled security professionals and employee training programs, and leveraging cyber insurance to incentivize better practices and mitigate risk exposure. By integrating economic models such as the Gordon-Loeb framework with predictive analytics, dynamic risk assessments, and a forward-thinking approach to emerging threats, organizations can enhance their resilience, ensuring their ability to navigate the complexities of a rapidly advancing digital landscape.

6. Strategies for Cybersecurity Hardening

Governments must adopt a multi-pronged approach to harden cybersecurity systems, especially as threats grow in sophistication and impact. Strategic investments, technical controls, workforce development, and public-private partnerships all play critical roles in strengthening national cybersecurity postures. Strategic investments in cybersecurity are often shaped by economic constraints, policy priorities, and perceived risks. Governments tend to increase funding when the cost of inaction—such as fallout from major cyberattacks—surpasses the cost of implementation. High-impact events like ransomware incidents or geopolitical tensions prompt accelerated adoption of Zero Trust Architectures (ZTA), Endpoint Detection and Response (EDR), and AI-powered threat intelligence platforms. Frameworks like NIST CSF, FedRAMP, and ISO 27001 promote investment by enforcing compliance, while partnerships with the private sector offer access to funding and technical expertise (Cybersecurity and Infrastructure Security Agency, 2023; National Institute of Standards and Technology, 2022).

On the technical front, scalable defenses are necessary to safeguard sensitive government systems against nation-state actors and cybercriminals. Following the SolarWinds attack, U.S. agencies prioritized ZTA, which enforces continuous verification through identity and access management (IAM), micro-segmentation, multi-factor authentication (MFA), and conditional access policies (Alkhadra et al., 2021; Cybersecurity and Infrastructure Security Agency, 2023). Broader deployment of EDR, mobile device management (MDM), and automated threat intelligence tools enhances detection while balancing operational efficiency (National Institute of Standards and Technology, 2022).

Given that human error remains a leading cause of breaches, workforce training and cyber hygiene are essential. However, enforcing best practices across large public institutions can be challenging. Integrating mandatory cybersecurity training, gamified learning, and phishing simulations boosts employee engagement and adoption (European Union Agency for Cybersecurity, 2023; Ogundare, 2024). Practices like strong password policies, MFA, secure access management, and automated patching reduce exploitable vulnerabilities (National Institute of Standards and Technology, 2022). Regular audits and assessments help evaluate the effectiveness of these initiatives and ensure compliance.

Finally, public-private partnerships are vital for accessing cutting-edge technologies and real-time threat intelligence. Collaborations with cybersecurity vendors, ISACs, and CISA's Joint Cyber Defense Collaborative (JCDC) support proactive threat mitigation and rapid incident response (Cybersecurity and Infrastructure Security Agency, 2023). Joint cyber exercises improve crisis coordination and expose vulnerabilities in existing systems. Academic partnerships also contribute to workforce development by advancing research and specialized training.

By integrating strategic investments, technical defenses, workforce preparedness, and cross-sector collaboration, governments can enhance resilience, minimize disruptions, and respond more effectively to the evolving cybersecurity threat landscape.

7. Discussion

7.1. Benefits of Cyber Security Hardening

Improved Service Reliability: Secure systems play a pivotal role in ensuring the uninterrupted availability of critical services, ranging from emergency response systems to welfare distribution networks. For instance, a study by Zhani et al., 2021 highlights that robust cybersecurity measures significantly reduce the downtime of essential services during cyberattacks, ensuring operational continuity even under duress. This reliability not only minimizes disruptions but also builds public confidence in digital governance frameworks. Furthermore, high service reliability mitigates the ripple effects of service outages, such as economic losses and reputational damage, thereby stabilizing broader societal systems reliant on these services.

Cost Savings: Preventing cyber incidents reduces the financial burden of remediation, legal liabilities, and lost productivity. Investments in cybersecurity yield substantial financial benefits by preempting the high costs associated with cyber incidents. According to Ponemon Institute's 2023 Cost of a Data Breach Report, organizations with advanced security frameworks reported an average cost reduction of 28% per breach compared to those with minimal defenses (Ponemon Institute, 2023). This cost efficiency is achieved through reduced expenditures on incident remediation, legal liabilities, regulatory fines, and the indirect costs of lost productivity. Moreover, proactive measures such as network segmentation and endpoint security can significantly decrease the financial impact of potential threats, transforming cybersecurity from a cost center to a strategic investment with measurable returns (Böhme & Schwartz, 2022).

Enhanced Public Trust: A strong cybersecurity posture not only protects sensitive information but also fosters public trust in digital systems. Citizens are more likely to engage with government-led technological initiatives, such as e-voting platforms or digital health records, when assured of their data's safety. Research by Smith and Duggan, 2020 reveals that public trust in digital services increases by 45% when organizations visibly demonstrate adherence to cybersecurity best practices. Additionally, transparent communication about security measures and regular audits can reinforce this trust, creating a virtuous cycle of increased adoption and innovation in public service delivery.

Strategic Advantage: Cybersecurity hardening equips organizations and governments with a proactive approach to risk management, enabling them to allocate resources toward innovation rather than crisis mitigation. As noted by Johnson et al., 2022, governments that prioritize cybersecurity are better positioned to leverage emerging technologies, such as artificial intelligence and blockchain, without the fear of compromising system integrity. This strategic advantage not only enhances operational efficiency but also bolsters national security by preempting cyber threats. Furthermore, strong cybersecurity frameworks provide a competitive edge in the global arena, as they attract international investments and partnerships by demonstrating robust risk management capabilities.

7.2. Challenges

Budget Constraints: Implementing comprehensive cybersecurity measures demands substantial financial resources, which can be a significant hurdle, particularly for developing nations. Many governments face competing priorities, such as healthcare, education, and infrastructure, making it difficult to allocate sufficient funds for cybersecurity. The high costs of acquiring advanced security technologies, maintaining robust infrastructure, and ensuring continuous monitoring and response capabilities further strain limited budgets. As a result, governments may resort to outdated security systems, increasing their vulnerability to cyber threats. Cost-effective solutions, such as leveraging open-source security tools and fostering public-private partnerships, can help mitigate these financial challenges.

Talent Shortages: The global shortage of skilled cybersecurity professionals remains a pressing issue, making it difficult for governments to build and maintain resilient security systems. A lack of trained personnel can lead to gaps in threat detection, incident response, and overall security posture. Many developing nations struggle with brain drain, where skilled professionals seek higher-paying opportunities in the private sector or abroad (Reuters, 2024). To address this, governments must invest in workforce development initiatives, such as specialized training programs, cybersecurity education in universities, and incentives to retain talent within the public sector. Additionally, collaboration with international organizations and private companies can help bridge the talent gap by providing training and expertise.

Evolving Threats: Cyber threats are constantly evolving, with attackers developing more sophisticated techniques to bypass security measures. Governments must stay ahead of emerging risks, including artificial intelligence-driven attacks, advanced persistent threats (APTs), and zero-day vulnerabilities. One of the most pressing future challenges is the potential impact of quantum computing, which could render current encryption standards obsolete. Proactive investment in quantum-resistant cryptographic solutions and adaptive cybersecurity frameworks will be essential to mitigate this risk. Continuous threat intelligence gathering, regular security audits, and agile policy adjustments are necessary to ensure that security measures remain effective against emerging cyber threats.

Bureaucratic Hurdles: The implementation of cybersecurity measures within government institutions often faces significant bureaucratic challenges. Lengthy procurement processes, rigid administrative structures, and inter-agency coordination difficulties can delay the adoption of critical security solutions (U.S. Government Accountability Office, 2024). Additionally, differing priorities among government departments can lead to fragmented security policies and inconsistent implementation. Overcoming these hurdles requires streamlined governance structures, clear cybersecurity mandates, and enhanced collaboration between agencies (Report of Commission on the National Defense Strategy, 2024). Establishing centralized cybersecurity authorities and implementing clear accountability frameworks can improve decision-making and accelerate the deployment of effective security measures.

7.3. Limitations

The foundation of our economic modeling relies heavily on accurate estimations of data breach costs, which are inherently difficult to measure and can vary significantly. While we have utilized industry-standard reports like IBM's Cost of a Data Breach study, these figures represent averages across diverse organizations and may not perfectly reflect the unique circumstances of government entities. The long-term and indirect costs of breaches, such as reputational damage or loss of public trust, are particularly challenging to quantify accurately.

Furthermore, we propose that investing in cybersecurity might lead to a substantial decrease in risk. Our proposal relies on generalized models, such as the Gordon-Loeb Model, which are built on theoretical assumptions like diminishing returns on security investments and a linear correlation between spending and risk reduction. These assumptions may oversimplify real-world complexities, such as interdependencies between different security measures and organizational processes. The effectiveness of security investments can vary greatly depending on factors such as the quality of implementation and operation, the maturity of existing security measures, and the specific threat landscape faced by an organization. As a result, the actual outcomes of security investments may deviate from our projections.

Overall, cybersecurity is a rapidly evolving field, with new threats, technologies, and defensive strategies emerging continuously. As a result, our research may become outdated over time as novel attack vectors and mitigation techniques reshape the security landscape. Excessive cybersecurity controls can hinder the efficiency and responsiveness of government operations, while too little leaves critical systems vulnerable to attack. Striking the right balance between security and functionality is essential to ensure both resilience and operational success.

Additionally, while we have relied on industry reports and established models, these sources may age quickly, potentially limiting their applicability to future cybersecurity challenges. Continuous updates and reassessments will be necessary to ensure the relevance and accuracy of our findings.

8. Future Directions

The future of cybersecurity will be shaped not just by cutting-edge technologies, but also by how well we collaborate globally and engage everyday people. Artificial intelligence (AI) is already transforming the field by helping detect threats faster, automate responses, and find system vulnerabilities before attackers do. These systems learn over time, getting better at spotting unusual behavior and taking action quickly, which helps security teams focus on big-picture strategy. But while AI makes defense smarter, quantum computing introduces new risks. Encryption methods we rely on today—like RSA and ECC—could be broken by quantum computers in the next couple of decades (Vermeer & Peet, 2020). That's why there's a growing push to

develop quantum-safe alternatives like lattice-based and hash-based algorithms. On the global stage, cyber threats don't stop at borders. International efforts—like the Budapest Convention, the Five Eyes alliance, and INTERPOL's cybercrime programs—are becoming essential for sharing threat intelligence and coordinating response efforts (Council of Europe, 2025; INTERPOL, 2025; Rix, 2023). And beyond governments and tech, people play a key role too. When citizens are educated about digital risks and know how to report suspicious activity, they become part of the solution. Strong cybersecurity in the future will depend not only on smart machines and strong laws but also on an informed and engaged public.

9. Conclusion

Cybersecurity hardening has evolved from a defensive measure to a strategic imperative for modern governance. As governments accelerate their digital transformation, safeguarding critical infrastructure and sensitive data against cyber threats must remain a top priority. Case studies of significant cyber incidents, such as the SolarWinds attack and the OPM breach, highlight the severe financial and operational consequences of insufficient security measures. Despite challenges like budget constraints, talent shortages, and the rapidly changing nature of cyber threats, a proactive, multilayered cybersecurity approach can greatly enhance government efficiency. This paper emphasizes that cybersecurity hardening is not merely a cost, but a vital enabler of innovation and operational effectiveness. Governments that prioritize cybersecurity will be better positioned to harness emerging technologies, optimize resource allocation, and uphold public trust. Looking ahead, international collaboration, workforce development, and investment in quantum-resistant cryptography will be essential to sustaining secure and effective digital governance in an increasingly complex threat landscape. By integrating cybersecurity into the core of governance strategies, nations can protect their digital futures while advancing efficient and secure public administration.

References

Accenture. (2023, June). Aligning cybersecurity to business objectives helps drive revenue growth and lower costs of breaches [Access]. https://newsroom.accenture.com/news/2023/aligning-cybersecurity-to-business-objectives-helps-drive-revenue-growth-and-lower-costs-of-breaches-accenture-report-finds

Albalas, T., Modjtahedi, A., & Abdi, R. (2022). Cybersecurity governance: A scoping review. *International Journal of Professional Business Review*, *7*(4), e0629. DOI: https://doi.org/10.26668/businessreview/2022.v7i4.629.

Alkhadra, R., Abuzaid, J., AlShammari, M., & Mohammad, N. (2021). Solar winds hack: In-depth analysis and countermeasures. *2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT)*, 1–7. DOI: https://doi.org/10.1109/ICCCNT51525.2021.9579611.

Alreemy, Z., Chang, V., Walters, R., & Wills, G. (2016). Critical success factors (csfs) for information technology governance (itg). *International Journal of Information Management*, *36*(6), 907–916. DOI: https://doi.org/10.1016/j.ijinfomgt.2016.05.015.

Alrubaiq, A., & Alharbi, T. (2021). Retracted: Developing a cybersecurity framework for e-government project in the kingdom of saudi arabia [Retracted: 10 October 2024]. *Journal of Cybersecurity and Privacy*, *1*(2), 302–318. DOI: https://doi.org/10.3390/jcp1020017.

Argyridou, E., Nifakos, S., Laoudias, C., Panda, S., Panaousis, E., Chandramouli, K., Navarro-Llobet, D., Mora Zamorano, J., Papachristou, P., & Bonacina, S. (2023). Cyber hygiene methodology for raising cybersecurity and data privacy awareness in health care organizations: Concept study. *Journal of Medical Internet Research*, *25*, e41294. DOI: https://doi.org/10.2196/41294.

Bechara, F. R., & Schuch, S. B. (2021). Cybersecurity and global regulatory challenges. *Journal of Financial Crime*, *28*(2), TBD. DOI: https://doi.org/10.1108/JFC-04-2020-0061.

Bitton, M. (2022). The estonian miracle: E-estonia and the future of digital infrastructure. *Metaverse Blog, NYU School of Professional Studies*. https://www.sps.nyu.edu/homepage/metaverse/metaverse-blog/the-estonian-miracle-e-estonia-and-the-future-of-digital-infrastructure.html

Böhme, R., & Schwartz, G. (2022). Economic incentives for cybersecurity investments. *Journal of Cybersecurity Economics*, *9*(2), 121–138.

Böhme, R., Laube, S., & Riek, M. (2018). A fundamental approach to cyber risk analysis. https : / / api . semanticscholar.org/CorpusID:49526942

Boyd, A. (2015). *Could opm have prevented the breach?* [Accessed: January 30, 2025]. https : / / www . federaltimes.com/smr/opm-data-breach/2015/06/18/could-opm-have-prevented-the-breach/

Brown, I. (2019). Cybers' cost: The potential price tag of a targeted trust attack [Accessed: 2025-01-29]. *MCU Journal*, *10*(1). https://doi.org/10.21140/mcuj.2019100105
Conklin, W. A., & White, G. B. (2006). E-government and cyber security: The role of cyber security exercises. *Proceedings of the 39th Annual Hawaii International Conference on System Sciences (HICSS'06)*, 79–79. DOI: https://doi.org/10.1109/HICSS.2006.133.
Council of Europe. (2025). The budapest convention [Accessed on January 30, 2025]. *Council of Europe*. https://www.coe.int/en/web/cybercrime/the-budapest-convention
Cyber Security Agency of Singapore. (2025, January). Cybersecurity act: Information on the cybersecurity act [Last updated 28 January 2025]. https://www.csa.gov.sg/legislation/cybersecurity-act
Cybersecurity and Infrastructure Security Agency. (2023). Cybersecurity best practices for government agencies.
Cybersecurity and Infrastructure Security Agency & Federal Bureau of Investigation. (2021). *Joint statement from the federal bureau of investigation (fbi) and the cybersecurity and infrastructure security agency (cisa)* [Accessed: January 30, 2025]. https://www.cisa.gov/news-events/news/joint-statement-federal-bureau-investigation-fbi-cybersecurity-and-infrastructure-security-agency-0
European Union Agency for Cybersecurity. (2023). Cybersecurity culture guidelines: Behavioral aspects of cybersecurity awareness.
Falco, G., Noriega, A., & Susskind, L. (2019). Cyber negotiation: A cyber risk management approach to defend urban critical infrastructure from cyberattacks. *Journal of Cyber Policy*, *4*(1), 90–116. DOI: https://doi.org/10.1080/23738871.2019.1586969.
Federal Information Security Management Act of 2002 (2002).
Finkle, J. (2015). Database of 191 million u.s. voters exposed on internet: Researcher. *Reuters*. https://www.reuters.com/article/world/us/database-of-191-million-us-voters-exposed-on-internet-researcher-idUSMTZSAPEBCT4IJVCW/
Fortinet. (2021). *Impact of the solarwinds cyber attack on organizations* [Accessed: January 30, 2025]. https://www.fortinet.com/resources/cyberglossary/solarwinds-cyber-attack#:~:text=Impact%20Of%20Attack%20On%20Organization's,additional%20information%20with%20government%20agencies
Ganin, A. A., Quach, P., Panwar, M., Collier, Z. A., Keisler, J. M., Marchese, D., & Linkov, I. (2020). Multicriteria decision framework for cybersecurity risk assessment and management. *Risk Analysis*, *40*(1), 183–199. DOI: https://doi.org/10.1111/risa.12891.
Gianfortune, R. (2025, January). *Proposed doge reforms target technology, efficiency* [Accessed: 2025-01-23]. https://govciomedia.com/proposed-doge-reforms-target-technology-efficiency/
Giaritelli, A. (2022). Judge finalizes $63m opm hack settlement for feds, two months of damages [Accessed: 2025-01-29]. *Government Executive*. https://www.govexec.com/pay-benefits/2022/10/judge-finalized-63m-opm-hack-settlement-feds-two-months-damages/378950/
Gootman, S. (2016). Opm hack: The most dangerous threat to the federal government today. *Journal of Applied Security Research*, *11*(4), 517–525. DOI: https://doi.org/10.1080/19361610.2016.1211876.
Gordon, L. A., & Loeb, M. P. (2002). The economics of information security investment. *5*(4). DOI: https://doi.org/10.1145/581271.581274.
Health Insurance Portability and Accountability Act of 1996 (1996).
Hiller, J. S., Kisska-Schulze, K., & Shackelford, S. (2024). Cybersecurity carrots and sticks. *American Business Law Journal*, *61*(1), 5–45. DOI: https://doi.org/10.1111/ablj.12238.
IANS Research & Artico Search. (2023). *2023 security budget benchmark summary report* (tech. rep.). IANS Research. https://cdn.iansresearch.com/Files/Marketing/2023SurveyContent/IANS+ArticoSearch-2023SecurityBudgetBenchmarkSummaryReport.pdf
IBM. (2024). Cost of a data breach report 2024 [Accessed: 2025-01-23]. https://www.ibm.com/reports/data-breach
INTERPOL. (2025). Interpol innovation centre [Accessed on January 30, 2025]. *International Criminal Police Organization*. https://www.interpol.int/en/How-we-work/Innovation/INTERPOL-Innovation-Centre
Jaikaran, C. (2023, July). The national cybersecurity strategy—going where no strategy has gone before [Accessed: 2025-01-23]. https://crsreports.congress.gov/product/pdf/IN/IN12123
Johnson, K., Li, X., & Patel, M. (2022). Leveraging cybersecurity for strategic governance. *International Journal of Digital Strategy*, *14*(3), 203–219.
Karabacak, B., Yildirim, S. O., & Baykal, N. (2016). Regulatory approaches for cyber security of critical infrastructures: The case of turkey. *Computer Law Security Review*, *32*(3), 526–539. DOI: https://doi.org/10.1016/j.clsr.2016.03.005.

Kissoon, T. (2020). Optimum spending on cybersecurity measures. *Transforming Government: People, Process and Policy*, *14*(3), 417–431. DOI: https://doi.org/10.1108/TG-11-2019-0112.
Krishna, B., & Sebastian, M. P. (2021). Examining the relationship between e-government development, nation's cyber-security commitment, business usage and economic prosperity: A cross-country analysis. *Information and Computer Security*, *29*(5), 737–760. DOI: https://doi.org/10.1108/ICS-12-2020-0205.
Kumar, S., Menezes, A., Giri, S., & Kotikela, S. (2024). What the phish! effects of ai on phishing attacks and defence [05–06 December]. *Proceedings of the 4th International Conference on AI Research (ICAIR)*.
National Institute of Standards and Technology. (2022). Framework for improving critical infrastructure cybersecurity.
National Institute of Standards and Technology. (2024, February). Nist releases version 2.0 of landmark cybersecurity framework. https://www.nist.gov/news-events/news/2024/02/nist-releases-version-20-landmark-cybersecurity-framework
Nato. (2022). Costa rica ransomware attack (2022) [Retrieved January 29, 2025]. https://cyberlaw.ccdcoe.org/wiki/Costa_Rica_ransomware_attack_(2022)
Ogundare, E. (2024). The human factor in cyber security.
Pexton, P. (2021, January). Cleaning up solarwinds hack may cost as much as $100 billion [Accessed: 2025-01-29]. https://www.rollcall.com/2021/01/11/cleaning-up-solarwinds-hack-may-cost-as-much-as-100-billion/
Ponemon Institute. (2023). Cost of a data breach report [Retrieved from Ponemon Institute website]. https://www.ponemon.org
ProPublica. (2021, December). How the solarwinds cybersecurity system was breached [Accessed: 2025-01-29]. https://www.propublica.org/article/solarwinds-cybersecurity-system
Report of Commission on the National Defense Strategy. (2024). *Report of commission on the national defense strategy*. Commission on the National Defense Strategy. https://www.armed-services.senate.gov/imo/media/doc/nds_commission_final_report.pdf
Reuters. (2024). Borderless europe fights brain drain as talent heads north [Accessed: 2025-01-29]. *Reuters*. https://www.reuters.com/world/europe/borderless-europe-fights-brain-drain-talent-heads-north-2024-11-14/?utm_source=chatgpt.com
Rix, M. (2023). Why the five eyes? power and identity in the formation of a multilateral intelligence grouping. *Journal of Cold War Studies*, *25*(1), 101–140. DOI: https://doi.org/10.1162/jcws_a_01109.
Smith, J., & Duggan, R. (2020). Public trust in digital governance: The role of cybersecurity. *Digital Society Quarterly*, *18*(1), 45–67.
Texas House of Representatives. (2024). Committee on delivery of government efficiency [Accessed: 2025-03-23]. https://house.texas.gov/committees/committee/233
The White House. (2025). Establishing and implementing the president's department of government efficiency [Accessed: 2025-03-23]. https: / / www. whitehouse. gov/ presidential- actions/ 2025/ 01/ establishing-and-implementing-the-presidents-department-of-government-efficiency/
U.S. Government Accountability Office. (2024, June). What are the biggest challenges to federal cybersecurity? (high risk update). https://www.gao.gov/blog/what-are-biggest-challenges-federal-cybersecurity-high-risk-update
Vermeer, M. J. D., & Peet, E. D. (2020). *Securing communications in the quantum computing age: Managing the risks to encryption* (tech. rep.). RAND Corporation. https://www.rand.org/pubs/research_reports/RR3102.html
Zhani, M., Karim, R., & Taylor, P. (2021). Cyber resilience in public infrastructure. *Journal of Information Security Studies*, *11*(4), 345–361.

Managing AI risks in the Public Sector: A Distributed Digital Leadership Approach.

Boniface Ushaka Adie [a*], *Elizabeth* Valentine [b], *Mary* Tate [c], *Wonhyuk* Cho [d].

[a] Wellington School of Business and Government, Victoria University of Wellington, New Zealand, boni.adie@vuw.ac.nz, ORCID number 0009-0009-9118-9358.

[b] Wellington School of Business and Government, Victoria University of Wellington, New Zealand, lizzie.l.valentine@vuw.ac.nz, ORCID number 0009-0001-4096-6251.

[c] Wellington School of Business and Government, Victoria University of Wellington, New Zealand, mary.tate@vuw.ac.nz, ORCID number 0000-0002-4284-7467.

[d] Wellington School of Business and Government, Victoria University of Wellington, New Zealand, wonhyuk.cho@vuw.ac.nz, ORCID number 0000-0001-7607-6480.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. Ensuring organisations are safe from cyber-attacks requires the contribution of every staff member and this also applies to AI risk mitigation. Organisations must assess and implement strategies that ensure AI risk mitigation is not just the responsibility of the cybersecurity team (who are always in short supply), but the entire organisation from the front-line staff who need to classify documents correctly, to the cybersecurity engineers who implement technology solutions to mitigate risks, and top management who drive and implement effective AI strategies, policies and investment prioritisation. In this study, we examine how the distributed digital leadership (DDL) framework can be used to enable agencies across government to mitigate AI risks in the public sector. We conducted semi-structured interviews with cybersecurity practitioners from public sector agencies and determined that AI risk mitigation is indeed everyone's responsibility – spanning people, process, technology and data controls. Using the distributed digital leadership (DDL) framework, we provide actionable suggestions on how collective, and collaborative risk mitigation strategies can be implemented across the public sector by making everyone competent in their respective job role responsibilities. We suggest that a well-aligned DDL can help cushion the skills shortage risks in cybersecurity and the overall management of AI risks in the public service.

Keywords. Cybersecurity, AI risks, Digital Leadership Competencies, Distributed Digital Leadership, All-of-Government.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.957

1. Introduction

The use of Artificial Intelligence (AI) in the public sector has gained momentum over the last couple of years as shown in two recent surveys conducted in the New Zealand public service around the use of AI (DIA, 2025b). The first survey conducted in 2023, was a cross-agency AI survey that focused on the views and uses of AI in the public service. Key takeaways from the survey showed that agencies are increasingly interested in the use of AI, they plan to grow their AI use, knowledge and skills, and they want the benefits that AI provides (efficiency, analysis and service delivery). But they are also concerned about the risks that AI poses including security, privacy and skills shortage (DIA, 2025b). The second survey conducted in 2024 provides an in-depth analysis of how AI is used in the New Zealand public service and the areas of risks that public servants are concerned about. Agencies reported seven areas of risk and barriers for the use of AI in the public service which include: a) skills, capabilities; b) policies, guidance; c) privacy; d) security; e) technical barriers; f) cost, funding; and, g) understanding and support (DIA, 2025b). Similar results were found in other jurisdictions like Canada, the United Kingdom and South Korea where studies of government guidelines for AI use in the public sector have been studied (Beltran et al., 2024). According to Wirtz et al. (2019), the exponential growth of AI has necessitated the need for specialist skills and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

competencies to support the implementation of AI in the public sector. Importantly, a common theme that runs through current studies is the lack of AI skills and competencies including in the cybersecurity domain. In addition, the benefits versus risks debate of AI use in the public sector provides paradoxical tensions that are exacerbated by the shortage of cybersecurity talent and competencies across the public sector (Bright et al., 2024; DIA, 2025b). These tensions need to be managed adequately by effective and collaborative AI risk mitigation strategies that will enable the safe use of AI in the public sector.

Managing the tensions requires a new approach that ensures risk mitigation capabilities are embedded in and are contributed from every job/role in the organisation (agency). That way everyone gets to contribute to AI risk mitigation as it is often said 'security is everyone's responsibility'. We argue that by focusing on an All-of-Government (AoG) risk mitigation capability (outcome to be achieved) of the role rather than the number of persons (or skills) that occupy cybersecurity roles, we can achieve better AI risk management outcomes. This means two things: 1) effective risk management as a measurable outcome that is everyone's responsibility, i.e., deliberately and intentionally taking the focus of security risk and mitigation beyond the cybersecurity team, and 2) we must focus on building the skills and competencies in other areas of the business (outside the core cybersecurity team) that contribute to effective AI risk management. For example, data and information management teams should be responsible for developing and enforcing data governance strategies that underpin the use of technology tools in data ecosystems. For example, where technical skills are in short supply, looking more widely across the wider public sector and drawing on the capabilities of different agencies to collectively manage risks that impact the public sector as a whole. Here, if an agency has cybersecurity competencies in AI and has figured out how to safely deploy off-the-shelf AI products, such knowledge can be shared across the sector to benefit agencies without such capabilities. Similarly, effective AI strategies and policies need not be written from scratch by every agency – especially for agencies lacking specialist strategy and policy capabilities. The same can be said of privacy impact assessments, risk assessments, data governance policies, et cetera. These capabilities and artefacts can be shared across the sector, allowing agencies to leverage them within their specific contexts. AI risk management can therefore benefit from an AoG approach underpinned by a distributed digital leadership (DDL) framework, which is the focus of this research. To undertake this, we ask the following research question:

RQ: How can government agencies better manage AI risks across the public sector?

To address this question, we interviewed cybersecurity practitioners in the public sector involved in the day-to-day management of cybersecurity risks in their respective agencies. The rest of this paper is structured as follows. In Section 2 we provide background research covering AI risks and mitigation strategies identified in literature specific to the public sector and in Section 3 we provide a summary of the research methodology. In Section 4 we provide an analysis of our research findings, explaining how DDL can be implemented in Section 5.

2. Background

2.1 AI risks and mitigation strategies in the public sector

Despite the many advantages of using AI, numerous risks abound that may negatively impact the adoption of AI (Beltran et al., 2024) or the realisation of its full potential in the public sector. Knutsen et al. (2024) suggested that implementing AI technologies that are effective and responsibly deployed is a complex undertaking that requires skills and competencies that are in short supply. They also suggested that the benefits and risks of AI are still emerging, making it difficult to manage adequately. Bright et al. (2024) identified some technology risks (e.g. hallucinations, challenges in explainability, and AI bias), economic risks (e.g. dependence on a few corporate organisations for GenAI tools) and the absence of structured skills development programs in AI which may lead to inequities in AI adoption and utilisation. Privacy risks and data leakage are also identified as the unauthorised exposure of personal information or an unintended exposure of sensitive information may negatively impact the adoption of AI tools (Beltran et al., 2024). There is also the issue of technical debt whereby structural redesign challenges and the limited understanding of AI's impact on organisational systems may introduce vulnerabilities or exacerbate existing risks within the technology ecosystem of the organisation (Mergel et al., 2024). Several authors suggest that one of the biggest areas of risk is the lack of skills and competencies in the adoption and management of AI tools in the organisation (Bright et al., 2024; Medaglia et al., 2023; Peretz-Andersson et al., 2021; Persson & Zhang, 2025). This may manifest in the lack of skills for strategizing, leading and governing all types of digital transformation (Valentine, 2016) implementing AI solutions (Mergel et al., 2024), guiding how to appropriately use GenAI tools (Bright et al., 2024), difficulty in integrating AI tools with legacy systems (Persson & Zhang, 2025), over-reliance on private sector expertise (Medaglia et al., 2023) and hesitancy in adopting AI tools (Mergel et al., 2024). The lack of skills and competencies in AI may result in governance, trust and accountability failures for AI systems (Straub et al., 2023) and the ability to adequately identify and mitigate AI risks (Beltran et al., 2024; Knutsen et al., 2024).

In Table 1, we provide a summary of some AI risk mitigation strategies (not an exhaustive list) which shows that skills and competencies in different job roles (not just in cybersecurity) are required to mitigate AI risks.

Tab. 1 – Summary of AI risk mitigations in literature.

Authors	AI risk mitigation strategies
Knutsen et al. (2024)	Enhance cybersecurity programs specific to AI and continuously align AI policy and strategy, learning, collaboration and information sharing.
Bright et al. (2024)	Provide National guidance, training and education, and organisational support, for the use of GenAI. Use open-source solutions like BLOOM to democratise access to GenAI and reduce dependency on large corporations.
Mergel et al. (2024)	Monitor AI privacy concerns, enhance user engagement, and develop an AI maturity framework. Promote peer learning and establish intergovernmental forums to share knowledge about AI implementation.
Beltran et al. (2024)	Ensure adherence to data protection mechanisms and compliance with privacy regulations for AI. Implement cybersecurity standards and risk assessments for AI. Develop explainable AI models and transparency initiatives. Undertake workforce training to develop AI literacy and encourage critical evaluation of AI-generated content.
Medaglia et al. (2023)	Codify ethical AI standards and regulations and monitor their enforcement, fostering data availability and accessibility through centralized data platforms.
Persson and Zhang (2025)	Modernise IT infrastructure to support AI technologies, establish data quality, model independence, adopt ethical frameworks to address societal impacts and prevent bias in AI systems.
Peretz-Andersson et al. (2021)	Foster interdisciplinary research to provide clear definitions and frameworks for AI transformation. Implement top-down and bottom-up strategies for AI transformation, and establish governance frameworks that address responsibility, ethics, and societal communication.

Consistent across these risk mitigation strategies (and as shown in the New Zealand survey), is the need for competencies in AI risk management and mitigation strategies which should include people, process, technology and data controls (Duong et al., 2024) that would enable the successful development and adoption of ethical AI in the public sector (Straub et al., 2023).

People-oriented controls are centred around end users (Duong et al., 2024) and the skills they need (Ferdynandus et al., 2024) to use AI tools effectively. This requires training and education for all management and staff in the organisation centred around security awareness, privacy awareness, AI strategy awareness, et cetera. Risk awareness and mitigation at this level enable the proper classification of data, setting document permissions, management of personal information, et cetera. Process controls ensure that proper business processes and procedures (Duong et al., 2024) have been put in place to mitigate risks and are enforced. For example, ensuring that privacy impact and data assessments are conducted at the start of an AI project implementation rather than at the end and that AI guardrails are identified and implemented from the start. Technology controls relate to the underlying AI technology infrastructure (Ferdynandus et al., 2024), ensuring that technical settings are configured correctly, security and privacy are present by design, AI integrations to legacy systems are managed properly and that security controls are monitored, enforced and operationally effective. Finally, data controls have to do with technical and non-technical controls that govern the use of organisational data. These controls could range from having a holistic data strategy, data governance, data quality enforcement, data loss prevention, data lifecycle management (Duong et al., 2024), et cetera. AI risk mitigation draws on the collective responsibilities and capabilities of data management, privacy, cybersecurity, technology and strategic job roles (Sattlegger & Bharosa, 2024) within the organisation and across the public sector (Knutsen et al., 2024) for effective risk management. In other words, an All-of-government (AoG) approach to AI risk management is required and introduced in the next section.

2.2 AoG approach to cybersecurity risk management

Mature e-government requires both vertical and horizontal integration of information systems across multiple government agencies and departments that provide similar aspects of a shared service to citizens (Layne & Lee, 2001). For example, there can be horizontal integration between government departments that provide social services to citizens which may entail the provision of financial assistance administered by the tax department. This joined-up (all-of-government, or whole-of-government) approach to digital services provides a one-stop-shop for citizens accessing government services through digital channels and enables improved efficiency, enhanced

service delivery (or new service delivery channels e.g., AI) and value creation for citizens. Thus, digital transformation at this stage begins to deliver digital government benefits (Lindgren & Van Veenstra, 2018) because public sector agencies are working together towards a shared goal (Janowski, 2015) – e.g. AI risk mitigation, efficiency gains and cost reduction.

To fully maximise the potential of new digital technologies, public sector agencies need to rethink their institutionalised assets, structures, leadership orientations (job roles accountabilities), skills and competencies because such transformations trigger significant changes that must be properly managed to achieve intended outcomes (Tangi et al., 2021). The alignment of job roles and accountabilities to competencies underpins the success of digital transformation and digital government in the public sector and provides the basis by which leadership competencies can be matched to strategy (Leblanc & Gillies, 2005). In New Zealand for example, the Strategy for a Digital Public Service (NZ SDPS) sets the strategic direction for the digital transformation of the public sector with digital leadership as a key aspect of the strategy. In the strategy, it is stated that digital leadership among other things aims to identify and grow talent at all levels that are diverse and multi-disciplinary, to deliver public sector-wide results – including ensuring cybersecurity resilience and support for government agencies (Adie et al., 2024b; DIA, 2020; Ushaka Adie et al.). Further to the NZ SDPS, is a service modernisation roadmap which is a 3-year programme of customer-focused digital initiatives from across the public sector requiring agencies to implement initiatives that will benefit the public sector as a whole (DIA, 2024b). Again, this reflects the need for more distributed digital leadership in the public sector (Adie et al., 2024a).

2.3 Distributed digital leadership for cybersecurity risk management

We define distributed digital leadership (DDL) as ***the intentional alignment of job-role accountability of digital leaders and the adoption of their shared capabilities for digital government outcomes***. We adopt this working definition as it best describes the DDL framework conceptualised by Adie et al. (2024a) and suggests that this framework can be adapted to support the AoG management of AI risks. This is especially important given the shortage of cybersecurity competencies (DIA, 2025b) in the public sector and the requirement for other job roles to contribute to AI risk mitigation strategies. According to Khisro (2025, p. 1859), "*…AI capability encompasses not only expertise but also various technical and non-technical components [competencies] that are necessary for effectively developing and utilising AI technologies*". The DDL framework demonstrates how both technical and non-technical roles must align (both within an agency and across the public sector) for the effective deployment and mitigation of AI risks in the public sector.

3. Research Methods

We adopted a qualitative research methodology to understand the views of cybersecurity practitioners on AI risks and mitigation strategies in the public sector as they are involved in the day-to-day management of cybersecurity risks (Myers, 1997).

2.1 Data collection

We conducted a semi-structured interview with 21 cybersecurity professionals across four different agencies including the lead agency for digital transformation in the New Zealand public sector. Semi-structured interviews are used when the study would benefit from an open framework and where they can provide more useful insights from a small sample size of interviewees (Pathak & Intratat, 2012). Using semi-structured interviews allowed us to talk about the main themes of AI risks and mitigation strategies, while also allowing the direction of the interview to be shaped by the participant's practical understanding of these (O'Keeffe et al., 2016). We used purposive sampling (Miles Matthew et al., 2020) to recruit our interview participants because we: a) wanted to talk to cybersecurity practitioners involved in the day-to-day management of AI risks in the public sector; and, b) wanted to talk to agencies who are engaging in DDL practice as suggested by Adie et al. (2024a). Those interviewed included three Chief Information Security Officers (CISO), five cybersecurity managers, and thirteen team members comprising cybersecurity architects, analysts and advisors across the four government agencies. We asked these cybersecurity practitioners about their views on the use of AI in government – focusing on AI risk mitigation strategies.

2.2 Data analysis

Interviews were recorded, transcribed and coded into themes using a thematic analysis approach (Braun & Clarke, 2012) similar to (Kumar et al., 2025) beginning with open codes, axial codes (themes) and selective codes (dimensions) relevant to AI risk mitigation strategies. We also provided suggestions on risk mitigation categorisation showing that mitigating strategies span people, process, technology and data controls (Duong et al., 2024). Although not included in our final codes, we highlighted in our discussion section, some of the areas of concern that cybersecurity practitioners have regarding the use of AI in government. Finally, using the DDL framework proposed by Adie et al. (2024a), we provide a practical analysis of how AI risk mitigation strategies can be implemented using the DDL approach. Note that for privacy reasons and given the relatively small cybersecurity

community, the identities of interview participants were anonymised using pseudonyms (see Appendix A).

The DDL framework is underpinned by the following principles. First, everyone in the organisation contributes to the digital transformation outcomes of the organisation (e.g. cybersecurity is everyone's business) with varying job role accountabilities and should be considered digital leaders in their own right. Second, every job role in the organisation requires digital leadership competencies at different levels of expertise depending on job role accountability. Third, for organisational outcomes to be met (e.g. safe use of AI), there must be an intentional alignment of job role accountability of digital leaders and adoption of shared competencies which are the building blocks of capability (McClelland & Boyatzis, 1980; Peppard & Ward, 2004). Finally, given the lack of competencies in niche areas, agencies across the public sector can contribute to and share the collective capabilities across the sector based on each agency's areas of expertise and digital leadership.

4. Findings and Discussions

We categorised AI risk in government into five broad risk areas namely, data risks, privacy risks, data sovereignty and jurisdictional risks, technology risks and AI strategy and adoption risks as shown in Appendix A. Data risks are predominantly around data leakage and exposure of government data through the use of AI tools. A senior cybersecurity architect puts it this way:

> "*There's lots of instances where people have taken their work and put it into a large language model, AI, and said do my job for me, not realising that it's the internet. That thing[data] now is out there for everyone to see. you've just data breached yourself.*" (PCA6).

Privacy risks are associated with privacy breaches and the exposure of personal information to unauthorised parties. Cybersecurity practitioners are concerned that AI tools would make it easier for privacy breaches to occur. Technology risks are associated with the underlying technical infrastructure and mechanisms of how AI works giving rise to bias, hallucinations, or vulnerabilities in AI models. Finally, AI strategy and adoption risks have to do with inadequate leadership and governance oversight of the adoption and implementation of AI tools resulting from a lack of AI strategy, regulation or guardrails. It should be noted that cybersecurity practitioners are also concerned about environmental and sustainability issues with the adoption of AI. Some of these concerns include the cost of adoption of AI for agencies (PCA2) and the environmental impact of vendors' hyperscale data centres that are required to run AI (see LCA2, PCA2, PCA3 in Appendix A). Whilst these concerns are not necessarily cybersecurity risks, if not managed, may impact the adoption or perception of AI in government as Toll et al. (2019) suggested. These risks are mitigated by strategies categorised into four broad areas including AI strategy and policies, AI best practice standards & guidelines, AI risk assessments & security controls and finally, AI awareness & education as shown in Figure 1 below.

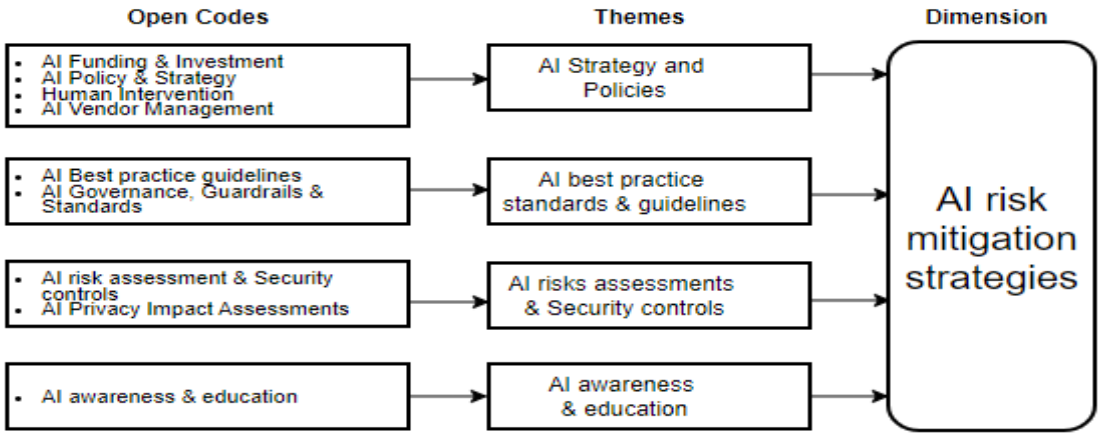


Fig. 1 – AI risk mitigation strategies.

AI strategies and policies primarily relate to people and process (and some governance) controls. They set the stage for how AI is to be used in the organisation and should include requirements for funding and investment, appropriate use, risk management, vendor management and guardrails that must be adhered to. AI strategy and policies need to be socialised, monitored against standards and measures and supported by top management for implementation and adherence to be effective.

AI best practice standards & guidelines touch on process, technology and data controls and are technical documents that are targeted at those tasked with the implementation of AI tools within the organisation. These standards and guidelines could come from technical subject matter experts within the organisation, vendor support documentation or public sector-wide compliance regulations and legislation (Beltran et al., 2024). A cybersecurity practitioner puts it this way "those foundational guardrails really need to be documented or taught about before we go off. Because once you've got those, they can apply to any of those [AI] solutions. [We should be]

prioritizing those guardrails over implementing AI use cases" LCA1. Again, competent monitoring and support are essential.

Conducting AI risk assessments & enforcing security controls is primarily a process control but touches on other areas as risk assessments also involve people, technology and data risks. Risk assessment is probably the most significant AI risk mitigation strategy as signified by the following statements from cybersecurity practitioners – "[conduct] risk assessment, and make sure we have related controls in place which are specific to AI" (LCA5), "the risk appetite of different organisations is quite different" (PCA1), "Do we know what data we are giving away or sharing? Do we know who's going to have access to it?" (PCA7), "Someone needs to monitor and track the AI [tool]. It needs all of those deep level security assessments. regular assessments and regular assurance" (PDT1). Risk assessment for AI should not only be limited to the underlying technology, but it should also cover privacy impact assessments (LDT3, PDT1) and data risk assessment (PCA4) and it should assess the organisational capability and readiness for AI adoption based on their risk appetite and the operational effectiveness of their people, process, technology and data controls.

AI awareness & education are people and process controls that should be tailored to all job roles within the organisation. From general AI awareness programs for all staff to technical training programs provided to those in specialist roles like data management, cybersecurity and architecture. AI training and awareness programs must be determined at the start, needs-based, continuous and updated to keep pace with the ever-changing landscape of the technology (PCA2, PDT2). Some AI vendors offer training and hands-on support in addition to technical documentation and guidelines that can be made available as part of their contractual obligations and vendor support. Microsoft, for example, provide Copilot training programs and technical documentation for the use of Microsoft Copilot in an organisation (Microsoft, 2025d).

These risk mitigation strategies require the deployment of technical and non-technical capabilities (Khisro, 2025) both within an agency and across agency boundaries for public sector-wide AI risk mitigation. However, for DDL to work optimally, the capability of agency leaders to lead, monitor and direct transformation involving AI becomes pivotal (Adie et al., 2024a; Valentine, 2016) as discussed in the next section.

5. Distributed digital leadership approach to AI risk mitigation

Managing cybersecurity risks in the public sector needs a collaborative approach and AI risk mitigation is no different. If cybersecurity is everyone's responsibility – from frontline staff to senior executives - everyone is required to at the very least know how to identify phishing emails and ensure personally identifiable information (PII) is handled according to the agency's privacy policies. Working collaboratively for risk mitigation within the organisation and across the public sector is at the heart of DDL. Cybersecurity practitioners said the following "*It doesn't matter what role you're in, but everyone has been employed because they've got something to bring to the table, so …it is important to be able to work collaboratively to get the best outcome*" (PDT5), "*There is no way that everybody should be an expert and a master in everything*" (LCA2), "*I don't think one person can do it all and I think exactly like you said, a team should play to its strengths and so an organization should play to its strengths*" (PCA5). Whilst specialist cybersecurity, privacy and data management teams ensure that AI risk mitigation strategies are in place and operating effectively, everyone in the organisation contributes to risk mitigation in one way or another. This is shown in Figure 2 which examines common AI risks by type and provides a 2PTD (people, processes, technology and data) approach to mitigation across each risk.

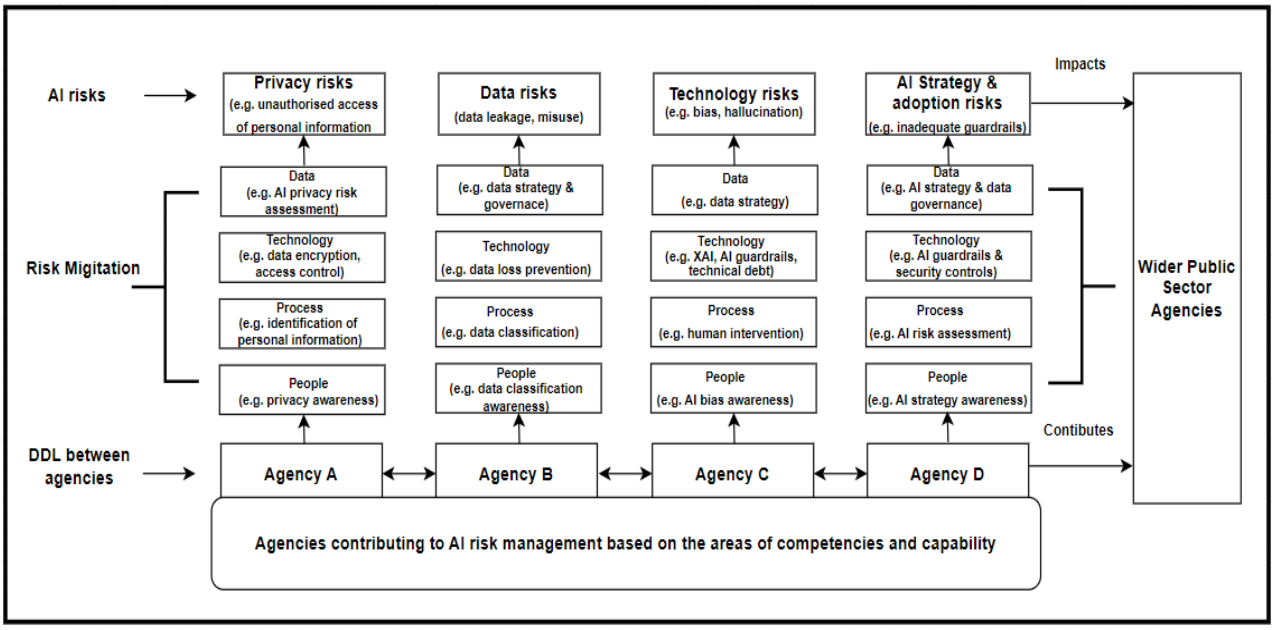


Fig. 2 – Distributed digital leadership approach to AI risk management.

AI risks can be categorised into privacy risks, data risks, technology risks and AI adoption risks. Privacy risks relate to unauthorised access or disclosure of personal information, and these can eventuate when AI agents and models are able to access and surface personal information without prior authorisation and consent. Data risks include data leakage, misuse and exposure of sensitive information especially when effective data governance and access controls are not in place. Technology risks are risks inherent in the use of AI. These risks include AI bias, hallucinations, large language model (LLM) poisoning, et cetera. Finally, AI strategy and adoption risks are risks arising from poor adoption and use of AI in an organisation such as deploying AI without proper understanding of organisational context, use cases and risk mitigation strategies.

As introduced in Section 2, AI risk mitigation strategies must include the 2PTD (people, processes, technology and data) security controls (Duong et al., 2024) with clear roles and responsibilities for job roles across the organisation (Sattlegger & Bharosa, 2024) and the wider public sector – hence a DDL approach. As shown in Figure 2, taking a DDL approach has the potential to positively impact and contribute to improved outcomes across the public sector. There is a many-to-many relationship between risk mitigation controls in the 2PTD framework. For example, AI best practice standards & guidelines are primarily technology controls but are also related to people and processes because technology controls are enforced by technical teams (people) and do require documented processes (process) for continuous improvement and assurance. Similarly, conducting AI risk assessment is a process control but those assessments would usually include people, technology and data risks.

These risk-mitigating controls require capabilities from various teams in the organisation and across the wider public sector to support agencies within the sector, especially smaller agencies that may not have AI risk management capabilities in-house. In Table 2, we provide a summary of how a small sample of different roles contributes to AI risk mitigation using Microsoft Copilot. Microsoft 365 Copilot coordinates large language models (LLMs) which include pre-trained models like Generative Pre-Trained Transformers (GPT-4), integrated into Microsoft 365 productivity apps (e.g. Word, Excel, Teams, et cetera), providing real-time intelligence that enables users to complete tasks more efficiently and enhance their productivity (Microsoft, 2025c). Agencies in the New Zealand public sector that use Microsoft products would most likely have Microsoft 365 Copilot included in the enterprise licenses.

Tab. 2 – Job role contribution to AI risk mitigation using a DDL approach.

Job/role	Contribution to AI risk mitigation	AI risk mitigation strategy
Senior leaders and management teams	Senior management should develop and enforce the implementation of AI strategies, goals, measures of success and governance mechanisms (Valentine, 2016) that govern the use of AI in the organisation including the use of GenAI tools like Microsoft Copilot.	AI strategy and policies. 2PTD: primarily relating to ***people and process*** controls. Example: AI strategy and policies.
Technology, Architecture & Operations	Support the development and enforcement of AI strategy. Ensure alignment with the wider technology and organisational strategies. For Microsoft Copilot,	AI best practice standards & guidelines.

teams	Technology, Architecture & Operations teams should ensure implementation requirements align with organisational technology and AI strategies. Copilot prerequisites, permissions, integrations and guardrails are set up properly (Microsoft, 2025d) and are continuously managed.	2PTD: primarily relating to ***technology*** controls but touches on ***people*** and ***process.*** Example: AI strategy enforcement, AI guardrails, AI configuration, management of technical debt and technology integrations.
Data & Information management teams	Data teams design and govern organisational data strategy that stipulates data governance and management practices including the use of AI. Information management practices should include proper permissions management for sensitive documents, data management lifecycle, enforcement of data owner responsibilities et cetera. For Microsoft Copilot, this would mean ensuring that connections to organisational data sources are done following data governance settings, data risk assessment or regulatory obligations. For example, connections could be prohibited to certain data sources with sensitive or personal information.	AI best practice standards & guidelines. 2PTD: primarily relating to ***data*** controls but touches on ***people process,*** and ***technology.*** Example: Data strategy, data governance, data quality, data loss prevention policies, and data classification.
Cybersecurity teams	Cybersecurity practitioners undertake risk assessments on AI tools and underlying technology risks. They also manage and assess the operational effectiveness of tools that enforce security controls, e.g. access control, data loss prevention, et cetera. For Microsoft Copilot, Cybersecurity would ensure that adequate guardrails (Microsoft, 2025a) are in place (across people, processes, technology and data controls) following organisational risk appetite.	AI risk assessments & security controls. 2PTD: primarily relating to ***process*** controls but touches on ***people, technology and data.*** Example: AI risk assessments and security controls audit.
Privacy teams	Privacy teams undertake privacy impact assessments (PIA) on AI tools and ensure that appropriate controls are in place to mitigate against unauthorised access to personal information. This would mean conducting a PIA for Microsoft Copilot to ensure that access to personal information is done following privacy regulations and organisational requirements (Microsoft, 2025b).	AI (privacy) risk assessments & security controls. 2PTD: primarily relating to ***process*** controls but touches on ***people, technology and data.*** Example: AI privacy impact assessment and enforcement of privacy regulations.
Business analysts	Business analysts document business requirements for AI (Microsoft Copilot), ensuring it aligns with technology and AI strategies. Business Analysts could also help design, document and implement people and process controls including capability and competency analysis as well as establishing strategy-aligned measures of value, uptake and usability.	AI strategy & policies, AI awareness & education. 2PTD: primarily relating to ***people and process*** controls. Example: AI requirements gathering, process controls enforcement, and documentation.
All staff	Understand privacy risks, and data classification for Microsoft Copilot, AI awareness, data strategy, organisational strategy, et cetera. Individual job-role accountabilities are specified and performance standards established,	AI awareness & education. 2PTD: primarily relating to ***people and process*** controls. Example: Privacy awareness, proper data classification, AI bias & strategy awareness.

Every staff member in the organisation should be trained on AI- skills relevant to their job role contribution, with training including AI risks and mitigation strategies to ensure the responsible use of AI tools (Wirtz et al., 2019). As shown in Table 2, AI risk mitigation requires contributions from both technical and non-technical teams within

the organisation with strong oversight from senior leaders and their management teams. Senior leaders' understanding of data and digital transformation is a key digital leadership competence (Ushaka Adie et al.) that should be deployed in the creation of AI strategies that support organisational objectives and minimise risks, and this responsibility should not be left to the IT shop or cybersecurity teams alone.

AI risk mitigation capabilities can also be drawn from the wider public sector. It shouldn't matter what agency AI specialist skills and competencies are located in. Every other agency within the public sector should benefit from the capability they provide, thus, demonstrating DDL at an AoG scale. For example, if Agency A has Privacy Officers with specialist skills in privacy impact assessment for AI tools (e.g. Microsoft Copilot), their knowledge should be shared with the wider sector including artefacts that will enable other agencies on their privacy assessments. Technical teams in agencies that have safely deployed AI tools could share design artefacts or configuration details with other agencies deploying similar AI tools. Security risk assessments could also be shared to enable smaller agencies with no in-house capability to decide on their AI implementation strategy.

Agencies within the public sector can leverage specialist capabilities (across AI strategy, privacy, data, technology, et cetera), create synergies, and support each other to effectively manage AI risks in the public sector. In New Zealand, for example, this is demonstrated in the service modernisation roadmap by the digital leadership of the AoG System Leads for data, digital, procurement, cybersecurity, et cetera (Adie et al., 2024a; DIA, 2024a, 2024b). In the service modernisation roadmap, we find the following examples of how DDL is demonstrated. A) the Government Chief Data Steward (GCDS) leads the initiatives "using data standards more" and the "plan for administrative data pipeline" which both require working with key agencies to identify opportunities for implementing data standards across the sector and developing a plan to build a high-quality administrative data pipeline to provide improved data for service delivery. B) the Government Chief Information Security Officer (GCISO) leads the "Cybersecurity standards", "Cybersecurity guidance" (NCSC, 2025), "Threat and vulnerability management support", and "Secure infrastructure" across government. C) the Government Chief Digital Officer (GCDO) leads the "Government AI search assistant" initiative which involves developing an AI virtual assistant to search across government websites to make it easier for New Zealanders to find the information and services they need. The GCDO also leads the "AoG design system and service design" and "AoG AI work programme" contributing to and supporting agencies to use AI for its benefits while managing the risks (DIA, 2025a). They also lead the "Digital workforce planning" initiative which ensures that the public service can meet current and future service delivery needs. All of these agencies contribute to cybersecurity risk management and AI risk mitigation in the public sector.

We note that our findings and contributions can be applied to jurisdictions with similar public sector structure and democratic settings as New Zealand's, however, where a System Leads approach does not exist, inter-agency knowledge sharing and collaboration should still be encouraged for faster adoption of AI and risk management across the public sector given they all work toward the same outcomes – efficient, trust-worthy service delivery to citizens.

6. Conclusion

There has been a lot of focus on AI risks in the public sector but less on how these risks can be mitigated by leveraging capabilities from different teams within an agency and across the public sector. Our study focused on AI risk mitigation strategies and suggested that Distributed Digital Leadership competencies (Adie et al., 2024a) can be implemented as a risk mitigation strategy especially given and lack of skills and competencies as a risk factor for AI adoption. New technologies like AI provide benefits to the public sector (Bright et al., 2024; Toll et al., 2019) and also risks and barriers (Millan-Vargas et al., 2024) that need to be managed and governed properly (Ganapati & Desouza, 2024). Global Cybersecurity skills shortage (Franco et al., 2024) necessitates a DDL approach to AI risk management in the public sector allowing agencies to share the capabilities (Franco et al., 2024) required for effective risk mitigation of new and emerging technologies.

We have demonstrated that by focusing on the AI strategy, policy and risk management capabilities, agencies and teams (across data, strategy, privacy, business analysis, technology & architecture, et cetera) can contribute to AI risk mitigation based on their job roles accountabilities and capabilities, explaining how DDL is applied within an organisational setting. Also, by leveraging AI risk mitigation capabilities of different job roles both within an agency, and across the sector, government agencies can better manage AI risks across the public sector – thus, addressing our research question.

This study provides two contributions. First, from a theoretical perspective, AI risk management using a DDL approach illustrates the efficacy of AoG approaches to service delivery and technology management across the public sector. Our study emphasises the need for cross-sector collaboration not just for service delivery but for efficiency gains, effective resource utilization (during skills shortages) and for cost savings. Second, from a practical perspective, our study provides practical examples of how distributed digital leadership capabilities across the public sector can be deployed for effective AI risk management. High cost, sustainable implementation of AI,

financial resources and technological capabilities were identified as some of the barriers to the adoption of AI in the public sector (Millan-Vargas et al., 2024). Our study provides practical examples of how capabilities from different job roles across the public sector could be leveraged to address these barriers. A Cybersecurity practitioner captures it this way "*and I do think from a leadership side if we can share competencies across government departments there must be huge savings to be made*" (PDT6). Managing AI risks is indeed everyone's business (responsibility) and distributed digital leadership is one way to operationalise it.

6.1 Limitations and Future Research

Our research showed that DDL can be used to address AI risks and mitigations in the public sector especially as it relates to enabling the distributed deployment of capabilities both within the agency and across the public sector. However, the implementation of DDL may be faced with some challenges such as the lack of annual capability analysis across the public sector, information sharing between agencies and other organisational challenges that need to be addressed which have not been covered in this study. Future research is required to address these challenges and to identify cross-agency factors, processes, and organisational settings that will support the effective implementation of the DDL approach across agencies.

Acknowledgement

- **Contributor Statement**: Author 1: conceptualisation, methodology, formal analysis, writing – original draft. Author 2: supervision, writing – review & editing. Author 3: supervision, writing – review & editing. Author 4: supervision.
- **Use of AI**: During the preparation of this work, the authors used notta.ai for interview data transcription. After using this tool, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Adie, B. U., Tate, M., Valentine, E., & Cho, W. (2024a). Conceptualising Distributed Digital Leadership in the Public Sector. ACIS 2024 Proceedings. 44,

Adie, B. U., Tate, M., Valentine, E., & Cho, W. (2024b). Digital Leadership Competencies for Digital Government: Insights and Implications from New Zealand Government Agencies. Proceedings of the 25th Annual International Conference on Digital Government Research,

Beltran, M. A., Ruiz Mondragon, M. I., & Han, S. H. (2024). Comparative analysis of generative AI risks in the public sector. Proceedings of the 25th Annual International Conference on Digital Government Research,

Braun, V., & Clarke, V. (2012). Thematic analysis.

Bright, J., Enock, F., Esnaashari, S., Francis, J., Hashem, Y., & Morgan, D. (2024). Generative AI is already widespread in the public sector: Evidence from a survey of UK public sector professionals. Digital Government: Research and Practice.

DIA. (2020). Strategy for a Digital Public Service. D. o. I. Affairs. https://www.digital.govt.nz/digital-government/strategy/strategy-summary/strategy-for-a-digital-public-service/

DIA. (2024a). Digital Government Leadership. https://www.digital.govt.nz/digital-government/leadership/

DIA. (2024b). Service Modernisation Roadmap. DIA. https://www.digital.govt.nz/digital-government/strategy/strategy-summary/service-modernisation-roadmap

DIA. (2025a). Public Service AI Framework. DIA. https://www.digital.govt.nz/standards-and-guidance/technology-and-architecture/artificial-intelligence/public-service-artificial-intelligence-framework

DIA. (2025b). Research - AI in the public service. DIA. https://www.digital.govt.nz/standards-and-guidance/technology-and-architecture/artificial-intelligence/research-ai-public-service

Duong, D., Sarbazhosseini, H., Alsheikh, M. A., & Ma, W. (2024). Conceptualising People, Process, Technology, Data, Governance and Continuous Improvement (2PTDGC) as a Framework to Explore the Cybersecurity Awareness and Process of Australian Medical Practices.

Ferdynandus, F., Prihanto, J. N., & Winarno, W. (2024). Implementing NIST Framework and the People, Process, Technology Approach in Indonesian Financial Services. International Journal of Engineering Continuity, 3(1), 172-182.

Franco, E., Yin, R., & Sankaranarayanan, B. (2024). Building Critical Statewide Cybersecurity Capabilities: The Wisconsin Model. Proceedings of the 25th Annual International Conference on Digital Government Research,

Ganapati, S., & Desouza, K. (2024). Public Value Principles for Secure and Trusted AI. Proceedings of the 25th Annual International Conference on Digital Government Research,

Janowski, T. (2015). Digital government evolution: From transformation to contextualization. In (Vol. 32, pp. 221-236): Elsevier.

Khisro, J. (2025). AI in Digital Government: A Literature Review and Avenues for Future Research.
Knutsen, L. Z., Hannay, J. E., & Riegler, M. A. (2024). Artificial Intelligence in the Public Sector--An Agenda for Responsible Innovation through Learning. Proceedings of the 7th ACM/IEEE International Workshop on Software-intensive Business,
Kumar, A., Shankar, A., Hollebeek, L. D., Behl, A., & Lim, W. M. (2025). Generative artificial intelligence (GenAI) revolution: A deep dive into GenAI adoption. Journal of Business Research, 189, 115160.
Layne, K., & Lee, J. (2001). Developing fully functional E-government: A four stage model. Government Information Quarterly, 18(2), 122-136.
Leblanc, R., & Gillies, J. (2005). Inside the boardroom: How boards really work and the coming revolution in corporate governance. John Wiley & Sons.
Lindgren, I., & Van Veenstra, A. F. (2018, 2018-05-30). Digital government transformation. Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age,
McClelland, D. C., & Boyatzis, R. E. (1980). Opportunities for counselors from the competency assessment movement. The Personnel and Guidance Journal, 58(5), 368-372.
Medaglia, R., Gil-Garcia, J. R., & Pardo, T. A. (2023). Artificial intelligence in government: Taking stock and moving forward. Social Science Computer Review, 41(1), 123-140.
Mergel, I., Dickinson, H., Stenvall, J., & Gasco, M. (2024). Implementing AI in the public sector. Public Management Review, 1-14.
Microsoft. (2025a). AI security for Microsoft 365 Copilot. Microsoft. https://learn.microsoft.com/en-us/copilot/microsoft-365/microsoft-365-copilot-ai-security
Microsoft. (2025b). Data, Privacy, and Security for Microsoft 365 Copilot. https://learn.microsoft.com/en-us/copilot/microsoft-365/microsoft-365-copilot-privacy
Microsoft. (2025c). Microsoft 365 Copilot overview. Microsoft. https://learn.microsoft.com/en-us/copilot/microsoft-365/microsoft-365-copilot-overview
Microsoft. (2025d). Microsoft 365 Copilot requirements. Microsoft. https://learn.microsoft.com/en-us/copilot/microsoft-365/microsoft-365-copilot-requirements
Miles Matthew, B., Huberman, A. M., & Saldana, J. (2020). Qualitative data analysis: A methods sourcebook. In (4th ed.): Sage Publications.
Millan-Vargas, A. O., Sandoval-Almazan, R., & Valle-Cruz, D. (2024). Impact and barriers to AI in the public sector: the case of the State of Mexico. Proceedings of the 25th Annual International Conference on Digital Government Research,
Myers, M. D. (1997). Qualitative Research in Information Systems. MIS Quarterly, 21(2), 241-242. https://doi.org/www.qual.auckland.ac.nz (MISQ Discovery, archival version, June 1997)
NCSC. (2025). Joint Guidance: Principles for security-by-design and -default. NCSC. https://www.ncsc.govt.nz/news/security-by-design
O'Keeffe, J., Buytaert, W., Mijic, A., Brozović, N., & Sinha, R. (2016). The use of semi-structured interviews for the characterisation of farmer irrigation practices. Hydrology and Earth System Sciences, 20(5), 1911-1924.
Pathak, A., & Intratat, C. (2012). Use of semi-structured interviews to investigate teacher perceptions of student collaboration. Malaysian Journal of ELT Research, 8(1), 1.
Peppard, J., & Ward, J. (2004). Beyond strategic information systems: towards an IS capability. The Journal of Strategic Information Systems, 13(2), 167-194.
Peretz-Andersson, E., Lavesson, N., Bifet, A., & Mikalef, P. (2021). AI Transformation in the Public Sector: Ongoing Research. 2021 Swedish Artificial Intelligence Society Workshop (SAIS),
Persson, P., & Zhang, Y. (2025). Openness And Transparency by Design: Crafting an Open Generative AI Platform for the Public Sector. Proceedings of the 58th Hawaii International Conference on System Sciences. https://hdl.handle.net/10125/109067,
Sattlegger, A., & Bharosa, N. (2024). Beyond principles: Embedding ethical AI risks in public sector risk management practice. Proceedings of the 25th Annual International Conference on Digital Government Research,
Straub, V. J., Morgan, D., Bright, J., & Margetts, H. (2023). Artificial intelligence in government: Concepts, standards, and a unified framework. Government Information Quarterly, 40(4), 101881.
Tangi, L., Janssen, M., Benedetti, M., & Noci, G. (2021). Digital government transformation: A structural equation modelling analysis of driving and impeding factors. International Journal of Information Management, 60, 102356.
Toll, D., Lindgren, I., Melin, U., & Madsen, C. Ø. (2019). Artificial Intelligence in Swedish Policies: Values, benefits, considerations and risks. Electronic Government: 18th IFIP WG 8.5 International Conference, EGOV 2019, San Benedetto Del Tronto, Italy, September 2–4, 2019, Proceedings 18,
Ushaka Adie, B., Tate, M., & Valentine, E. Digital leadership in the public sector: a scoping review and outlook. International Review of Public Administration, 1-17. https://doi.org/10.1080/12294659.2024.2323847
Valentine, E. L. (2016). Enterprise technology governance: New information and technology core competencies for boards of directors Queensland University of Technology.
Wirtz, B. W., Weyerer, J. C., & Geyer, C. (2019). Artificial intelligence and the public sector—applications and challenges. International Journal of Public Administration, 42(7), 596-615.

Appendix A: AI risks and mitigation strategies

Below are the codes for AI risks and mitigation strategies analysed from the interview data.

References	Codes	Themes	Dimensions
LCA1, LCA2, LCA5, LDT1, LDT2, PCA1, PCA2, PCA4, PCA6, PDT2	Data Leakage	Data risks	**AI risks**
LCA3, LCA5, PCA3, PDT1	Privacy issues	Privacy risks	
PCA3, PCA7	Data Sovereignty and Jurisdiction issues	Data Sovereignty and Jurisdictional risks	
PCA3	Trusting big AI corporate vendors		
PDT4	Automated decision-making with no human intervention	Technology risks	
LCA2	No Moral Compass		
LCA4	Automation of existing risk (bad behaviour)		
LCA5, PCA4, PDT1	AI Bias		
LCA5, PCA1	AI Hallucination		
PCA1, PCA3	Loss of control when using AI		
PDT6	Trusting AI with big decisions		
PCA2	Human Error and Misuse		
LCA1, LCA5, PCA6, PDT2	Lack of understanding of AI risks	AI strategy and adoption risks	
LCA1, PCA3, PCA5, PCA6, PDT2	Lack of AI knowledge and effective use		
LCA2	Creating our own version (another technical debt)		
LCA3, LDT1, PCA7	Technology hype circle (buzzword)		
LCA4	Fear of adoption and use (risk-averse)		
LCA2, LCA3	No AI Guardrails in place		
LCA4	Lack of AI regulation		
LDT2	Lack of AI security assurance and policies		
PCA3	Lack of Transparency and Consent		
LCA2, PCA2, PCA3	Environmental Sustainability of AI Data Centres	Environmental and sustainability issues	**Other areas of concern**
PCA2	Cost of Adoption of AI		
LCA3, PCA4	AI Funding & Investment	AI Strategy, and policies	
LDT1, PCA1, PDT3, PDT4	AI Policy & Strategy		
PDT4	Human Intervention		**AI risk mitigation strategies**
PDT5	Vendor Management		
LCA1, PCA7	Best practice guidelines	AI best practice standards and guidelines	
LCA1, LCA2, LCA3,	Governance, Guardrails &		

LDT3, PCA7	Standards	
LCA4, LCA5, LDT1, LDT2, PCA1, PCA6, PCA7, PDT1, PDT4, PDT5, PDT6	AI risk assessment & Controls	AI risk assessments and security controls
LDT3, PDT1	Privacy Impact Assessments	
LCA2, LCA4, PCA2, PDT2, PCA5	AI Awareness & Education	AI Awareness & Education

Track 7: Digital Government for Stronger Society

Track Description

Traditionally, digital government research has been focused on improved service delivery, efficient administration, open decision-making, and engaged citizens. The research was mainly driven by problems internal to the government or by relationships between the government and citizens. More recently, the focus has been shifting to dealing with mega-problems like pandemics, war, climate change, migration, etc., that no government has the capacity to handle alone, and to problems of democratic breakup that require balancing government power with societal power. Addressing such problems requires institutions and individuals to work together for the well-being, security, and prosperity of all members of society, thereby building a stronger society grounded in cohesion, solidarity, resilience, equity, inclusion, and other values. This track aimed to examine the evidence for digital government strengthening societies and enabling whole-of-society responses. For example, using digital capabilities to monitor the needs of vulnerable groups, deliver targeted assistance to them, and, in turn, engage them in delivering that assistance to others. The track also aimed to examine evidence that digital government is actually making societies weaker and incapable of a whole-of-society response. For example, using digital capabilities to put groups against each other, e.g., farmers against consumers, to gain their votes, but disabling the prospects for a common climate action.

Track Chairs

D. Dueñas-Cid, Kozminski University, Poland
E. Estevez, Universidad Nacional del Sur,
T. Janowski, Gdańsk University of Technology, Poland; University for Continuing Education Krems, Austria

Contents

Assessing Challenges in the Implementation of Digital Services by the NUG: A Sociotechnical Framework Perspective 401
K. Lwin and M. S. Thwe

Crowdsourcing in Municipal Ombudsman Offices: A Systematic Literature Review 416
J. Zahn, E. Mourão, J. Viterbo, C. Maciel, and F. Bernardini

Is Digital Government Strengthening or Weakening Society? Exploratory Study 431
D. Dueñas-Cid, E. Estevez, T. Janowski, and G. Musiatowicz-Podbiał

Towards an empowered 'Platform State'? Digital Platforms, Infrastructural Power, and the Transformation of State Authority 446
G. Cristofari and P. Gerbaudo

Assessing Challenges in the Implementation of Digital Services by the NUG: A Sociotechnical Framework Perspective.

Kyaw Lwin [a], and Myat Su Thwe [b]

[a] School of Public Policy, Chiang Mai University, Chiang Mai, Thailand, kyawlwin_kyaw@cmu.ac.th, ORCID number https://orcid.org/0009-0006-2324-7454.

[b] Institute for Human Rights and Peace Studies, Mahidol University, Nakhon Pathon, Thailand, myat.thw@student.mahidol.edu

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. This research investigates the challenges encountered by the National Unity Government (NUG) of Myanmar in delivering digital services amidst the complex socio-political landscape shaped by the 2021 military coup. Employing a sociotechnical framework, the study examines the interplay of technical systems and social dynamics in NUG's initiatives across health, education, and financial services. Digital services such as Telekyanmar, Nway Oo University, and Spring Development Bank are analyzed as transformative tools for governance and public engagement. Despite their potential, these services face critical obstacles, including internet connectivity issues, cybersecurity threats, power shortages, resource constraints, and digital literacy gaps, particularly in rural and conflict-affected regions. The study also highlights the importance of inclusivity, with attention to ethnic and cultural diversity, emphasizing the need for localized solutions and multilingual accessibility. Using mixed-method research, the analysis incorporates in-depth interviews, surveys, and secondary data to capture diverse perspectives from stakeholders, technology experts, and the public. Findings reveal significant adoption barriers stemming from security concerns, trust issues, and lack of infrastructure. Moreover, the public's willingness to engage with NUG's digital services is deeply influenced by their perception of the government's legitimacy, inclusivity, and responsiveness to marginalized communities. The study underscores the importance of building trust and enhancing public access to digital platforms through community-centered approaches, targeted digital literacy initiatives, and robust cybersecurity measures. By addressing these challenges, the research offers actionable policy recommendations to optimize NUG's digital governance. It calls for investment in digital infrastructure, capacity-building programs, and international collaborations to support the sustainability and effectiveness of these services. The findings provide critical insights into how digital governance can serve as a tool for resilience, inclusivity, and legitimacy in the face of authoritarian oppression, advancing the broader goals of democracy and transitional justice in Myanmar.

Keywords. Digital Governance, National Unity Government (NUG), Sociotechnical Framework, Public Service Delivery, Digital Inclusion
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1058

1. Background

Immediately after the military coup in Myanmar, the Committee Representing Pyidaungsu Hluttaw (CRPH) swiftly emerged on February 5, 2021, comprising 17 elected parliament members with a mission to resist the illegitimate seizure of power. Building on the CRPH's mandate, the National Unity Government was formed on April 16, 2021, with 17 ministries to function as a parallel government. At the heart of the NUG's establishment of ministries is the inclusion of public servants and students who participated in the Civil Disobedient Movement (CDM) by integrating CDMers within the bureaucratic system of respective ministries.

These ministries aim to provide alternative governance services in opposition to the State Administration Council's controlled ministries, which aligns with the NUG's overarching objective of running a parallel government. These ministries are currently providing innovative public services in the digital space, as seen in services like Tele Kyan Mar (online clinic services) by the Ministry of Health, Spring Development Bank (online

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

banking service), NUG Pay (money wallet service), and Nway Oo Lottery (lottery service) by the Ministry of Planning, Finance, and Investment, and Myanmar Nway Oo University (alternative education services) by the Ministry of Education. However, as a parallel government, significant challenges and constraints are witnessed while delivering such public services in the digital space. Persistent security threats, resource constraints, public awareness gaps, and fear and concerns about utilizing such digital tools among the public hinder the capacity and effective deployment of NUG's e-services. Hence, in the current situation where SAC-controlled ministries are not providing fair and secure public services, in addition to people's unwillingness to cooperate with SAC's ministries, the public and international community need to understand alternative public services provided by NUG. Therefore, a comprehensive, detailed research report is necessary for the public to clearly understand NUG's services and the challenges and barriers hindering the effective deployment of NUG's digital services.

Innovations that improve service delivery to citizens pointed out the role of government in enhancing service delivery to improve public administration. Government services refer to the activities and functions governments undertake to address the needs of their citizens and improve societal welfare. This can underscore the importance of innovative practices in the public sector that make government operations more efficient and responsive to the needs of the public. By adopting new technologies and simplifying administrative processes, governments can enhance the quality and accessibility of public services, thereby increasing public satisfaction and trust in government institutions. These services are integral to building a healthy relationship between governments and citizens, focusing on transparency, efficiency, and the effective management of public resources. This Study emphasizes that improving government services is not only about enhancing operational efficiency but also about ensuring that these services are citizen-centered, addressing the specific needs and conditions of the population.

Digital government, also known as e-government or virtual government, involves the use of the internet and other information technologies to influence governance. It generally refers to the creation and provision of information and services within the government and between the government and the public, utilizing various information and communication technologies(Fountain JE.,2001). The post-coup political scenario is highly associated with digital arena where digital resistance is central with mobilization for movement and protesting are mostly done through online and on the other hand, the digital oppression is done by the SAC such as tracking, doxxing and misinformation campaigns. While traditional digital government services in other countries are developed either through expanding or accelerating the physical services out of well-structured physical state institutions, NUG and its digital services emerged initially from online without any well-structured physical state institutions.

The NUG has faced criticism for allegedly operating primarily online, which some argue could limit its effectiveness and outreach, especially in regions with poor internet connectivity or in rural areas where digital literacy is lower. This criticism highlights the challenge of providing governance and essential services through digital means alone, particularly in a country with diverse needs and varying levels of infrastructure. While many of the NUG's ministries provide services digitally, several crucial services, especially those related to health, home affairs, defense, and humanitarian efforts, are offered in person, which is vital for reaching all demographics and ensuring inclusivity(Appendix A). The strategic mix of digital and in-person services aims to leverage technology to enhance reach and efficiency while maintaining a physical presence in areas where it is most needed. This balanced approach is especially crucial in regions controlled or influenced by the NUG, where the provision of in-person services helps to cement its legitimacy and effectiveness as a governing body amidst challenging circumstances. According to research limitations, this paper focuses on only three ministries: the Ministry of Health, the Ministry of Planning, Finance, and Investment, and the Ministry of Education, which is currently at the forefront of providing public services in the digital space. The study will use a sociotechnical framework to examine how technological systems interact with Myanmar's current political and social environment. While digital governance in conflict-affected region is increasingly studied, there remains a significant gap in understanding how alternative governance structures like NUG in Myanmar deliver digital public services under authoritarian pressures. This paper addresses these gaps by explicitly examining both the socio-political and technological challenges through a sociotechnical framework.

2. Research Objectives

1. To examine the key digital services and initiatives implemented by the National Unity Government and their contributions to modernizing administrative functions and improving citizen service delivery.
2. To identify the challenges and barriers hindering the adoption and effectiveness of the National Unity Government's digital tools and services.

3. Methodology

This study employed a mixed-method approach integrating qualitative and quantitative data from primary and secondary sources. Primary data collection included semi-structured, in-depth interviews using purposive

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

sampling. Key informants comprised 1-2 representatives from each of the three targeted NUG ministries, selected based on their minimum six months' experience and active involvement in digital public service initiatives. Interviews were conducted both face-to-face in Maesot and Chiang Mai, Thailand, and online, reflecting practical considerations such as accessibility and security constraints. Additionally, two digital technology experts from relevant non-governmental organizations, each possessing at least one year of professional experience, provided specialized insights into technical and operational challenges. An online survey was administered to 100 participants across diverse age groups and geographical locations, aiming to gauge public perceptions and adoption barriers. Respondents were classified into two groups: those familiar and actively engaging with NUG's digital services, and those who were not. Subsequently, three respondents from each category were selected for follow-up interviews to delve deeper into their experiences, concerns, and the factors influencing their engagement with digital services. Secondary data analysis complemented primary data, utilizing reports from NUG ministries, CRPH, NUCC, and relevant academic articles and media sources. The integration of these diverse data sets facilitated a comprehensive analysis, clearly aligning methodological choices with the study's sociotechnical framework and objectives.

4. Understanding e-government and digital service delivery of governments

The evolution of e-government has changed how governments connect with individuals, providing better services and greater transparency. Various terms are used to characterize the phenomenon of government using Information and Communication Technology, such as 'e-governance,' 'online government,' 'one-stop government,' and 'digital government' (Andersen and Henriksen 2006). E-government is more than just a set of tools for citizens to interact with their government; it also changes the production structure, whether in services or information and reshapes communication across institutions. This creates new ways for governments to communicate with the people they serve (Gibreel and Hong, 2017). E-government entails using information technology to improve connections with residents, corporations, and other government entities. Its goals include improving the delivery of government services to residents, boosting communication with business and industry, empowering citizens through information access, and attaining more effective government administration (World Bank 2005, cited by Gibreel and Hong 2017). West (2004) described e-Government as "the delivery of information services online via the Internet or other digital means" (p. 16).E-government is the use of information and communication technologies to improve the delivery of government services, increase efficiency, and promote citizen participation (Heeks, 2006). E-government efforts provide various benefits, including more openness, decreased corruption, better public service delivery, and higher citizen engagement (Bekkers & Homburg, 2007). However, obstacles remain, such as the digital divide, cybersecurity threats, and opposition to change within government institutions (Dawes, 2008). According to Awen, et.al (2013), the definition of e-government is explained accordingly.

The success or failure of digital governance service initiatives can be evaluated through two primary dimensions, the implementation of these systems by government organizations and their subsequent adoption by citizens (Gil-Garcia & Flores-Zúñiga, 2020). Success, in this context, is often defined by the extent to which the digital service in the government system meets its intended objectives within the planned timeframe and budget (Fortune & Peters, 2005). However, the inherent complexity and multifaceted nature of digital service projects make them particularly challenging and susceptible to failure (Glyptis et al., 2020). Digital Services led by government projects are intricate due to their scale, the integration of various technological components, and the need for alignment with existing bureaucratic processes. This complexity introduces significant risks, making these projects prone to failure (Gunawong & Gao, 2017). Indeed, many digital services initiatives by the government fail to achieve their objectives, resulting in the inability to deliver the anticipated benefits (Madsen, Berger, & Phythian, 2014).

Numerous factors contribute to the high failure rate of e-Government projects. These include poor planning and inappropriate implementation, often linked to technical, social, organizational, cultural, and human behavioral aspects (Choi & Chandler, 2020). The United Nations has identified several specific reasons for these failures, such as a lack of understanding of citizens' needs, inadequate infrastructure, ineffective service delivery, lack of stakeholder trust, and issues related to marketing and confidentiality (United Nations, 2008). Additional factors include unclear objectives, failure to engage stakeholders, lack of cost-benefit analysis, and insufficient evaluation mechanisms (United Nations, 2020).The failure of digital government service projects can have several detrimental consequences, including loss of institutional credibility, wasted time and financial resources, increased costs, loss of trust, and persistent resistance to change in future public sector initiatives (Twizeyimana & Andersson, 2019). Heeks (2003) emphasizes that neglecting the environmental, organizational, and social contexts in which e-government systems operate often leads to unrealistic implementations and low acceptance by citizens, further increasing the likelihood of failure. It is important to adopt a comprehensive approach that considers both technical and social dimensions to mitigate these risks. Effective e-government projects require clear objectives, robust planning that ensures the audience feels secure about the direction and management of the project, and active engagement with all stakeholders. Understanding and addressing the specific needs of citizens, ensuring adequate infrastructure, and building trust through transparent and effective service delivery are essential components for success. Furthermore, continuous evaluation and adaptation based on feedback and changing circumstances can enhance the resilience and effectiveness of e-Government systems.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital government services are typically classified into four primary categories or dimensions government-to-government (G2G),government-to-citizen (G2C), government-to-employee (G2E), and government-to-business (G2B). Yildiz (2007) expanded this classification by introducing two additional categories: government-to-civil societal organizations (G2CS) and citizen-to-citizen (C2C). According to Joseph (2013), e-Government services are designed and categorized based on the stakeholders or stakeholder groups involved in interactions with the government for whom the particular service is provided. Furthermore, e-Government is often organized according to the level of administration, such as local, state, or federal in some countries, or municipal, county, or regional in others (Joseph, 2013). Governments implementation of digital services is a multifaceted challenge involving the interplay of social, technical, and political dimensions. The NUG, amidst its struggle for legitimacy and control, faces unique challenges in deploying digital services to its citizens.

To comprehensively address the gaps identified above, recent studies highlight additional critical considerations in digital governance during conflict scenarios. Recent literature highlights the critical role digital governance plays in conflict and fragile state contexts, stressing that digital transformation in such environments must consider social, political, and technological dimensions comprehensively (Gunawong & Gao, 2017; Glyptis et al., 2020). Studies by Twizeyimana and Andersson (2019) emphasize how digital governance initiatives can significantly enhance public trust and transparency but also underscore substantial risks, including cybersecurity threats, digital divides, and infrastructure deficits. Comparative research on digital service delivery during political crises further indicates that neglecting stakeholder trust, especially in conflict-affected areas, undermines the success and sustainability of digital services (Choi & Chandler, 2020; Shackelford, 2020). Furthermore, prior studies on digital government failures suggest that common causes include inadequate stakeholder engagement, insufficient infrastructure planning, and limited attention to sociopolitical dynamics (Madsen, Berger, & Phythian, 2014; Dawes, 2008). Additionally, Shackelford (2022) reinforces the need for robust cybersecurity and digital literacy interventions, critical for protecting digital communications in volatile political contexts. This body of literature collectively underlines that effective digital governance, particularly in politically unstable environments like Myanmar, necessitates a balanced sociotechnical approach, explicitly addressing trust, inclusion, infrastructure, and security simultaneously (Damodaran et al., 2005; Hussaini, 2021).

4. Socio-technical framework in e-government or digital services delivery of governments

In the context of digital government services, the socio-technical framework sheds light on the intertwined challenges of implementing digital initiatives. Governments face a balancing act involving technical infrastructure, human agents, and organizational processes, all operating within broader social and political contexts. For instance, the NUG of Myanmar confronts unique challenges in deploying digital services amidst ongoing struggles for legitimacy and control. This highlights the importance of addressing social dimensions like trust, inclusion, and engagement alongside technical innovations (Heeks, 2006; Baek, Kim, & Lee, 2018).Collaborative services, where individuals collectively fulfill unmet needs, illustrate the socio-technical framework in action. When bound by a sense of community, these interactions form a collaborative community, a socio-technical system where social and technical elements mutually reinforce one another in a “virtuous circle” (Trist, 1981; Baek, Kim, & Lee, 2018). For such systems to thrive, planning must encompass data collection, problem diagnosis, and co-design strategies, ensuring solutions are user-centered and culturally responsive (Choi & Chandler, 2020; Joseph, 2013).The socio-technical approach highlights critical challenges in digital governance. Overemphasis on technical elements such as interface design at the expense of social factors like community trust and engagement often leads to suboptimal outcomes (Heeks, 2003; United Nations, 2020). Additionally, human behavior’s variability complicates the design of predictable social interactions, necessitating conditions that foster organic relationship-building rather than attempting to control it (Dawes, 2009).

Despite these hurdles, the socio-technical framework offers significant opportunities. It provides a holistic methodology to evaluate social and technical variables, enabling the creation of sustainable, resilient, and inclusive solutions. For the NUG, this means addressing technical challenges like poor infrastructure and cybersecurity threats while fostering social dimensions such as digital literacy and cultural inclusivity (Goldfinch, 2007; United Nations, 2008). Literature on e-government often prioritizes technological aspects, neglecting the social dimensions critical to successful implementation. The socio-technical paradigm bridges this gap, advocating for a balanced approach where organizational culture, stakeholder engagement, and user behavior are integrated with technology infrastructure (Bostrom & Heinen, 1977). This perspective is essential for developing e-government initiatives that align with citizen needs and governmental goals. For instance, Damodaran et al. (2005, as cited in Hussaini, 2021) stress the importance of combining communication and technological procedures to meet both citizen expectations and local government requirements. Similarly, Hussaini (2021) identifies three key dimensions for e-government implementation environmental (e.g., policies and legislation), organizational (e.g., managerial capabilities and culture), and technological (e.g., readiness and data management) highlighting the need for a socio-technical lens in planning and execution. The socio-technical framework provides a robust foundation for designing e-government services that are resilient, inclusive, and effective. By addressing both social and technical dimensions, governments can create systems that not only meet technical benchmarks but also foster trust, engagement, and sustainability. For the NUG and other governments, embracing this framework

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

means learning from past failures, leveraging holistic methodologies, and navigating the complex interplay of societal, technical, and political factors.

5. The National Unity Government and its digital services delivery

On February 1, 2021, Myanmar's military conducted a coup, deposing the democratically elected government. In reaction, elected MPs and activists founded the National Unity Government in April 2021 to restore democracy and confront the military junta (International Crisis Group, 2021). The NUG has used digital tools to connect with citizens, organise resistance actions, and rally worldwide support. These initiatives adhere to e-government principles by utilising ICTs to improve governance and public involvement in extreme circumstances (Thawnghmung, 2021).The areas of control and influence are classified according to the governing groups that hold power over them. The areas under the major cities are primarily governed by the SAC .These areas typically encompass major urban centers like Yangon and Mandalay and government-based cities like Naypyidaw. In contrast, mixed areas experience a variable level of authority exerted by the SAC, local militias, PDF, and Ethnic Resistance Organizations(EROs), resulting in zones characterized by frequent conflict and instability. The NUG and PDF operating areas refer to the regions where the NUG composed of deposed legislators and their supporters, and their associated defense forces are currently active, for example, Sagaing Region, Magway Region, and some part of Mandalay Region. These areas are not publicly disclosed because of the covert nature of their activities and frequently coincide with EROs controlled area. Areas under the control of the EROs are governed by ethnic groups that have established their own administrative and security systems. The border areas are of utmost importance because of their strategic positioning along Myanmar's borders with neighboring nations. Gaining control over these regions can be exceptionally intricate, as it requires managing a combination of EROs, local PDFs, and Myanmar Military, and occasionally dealing with influences from neighboring states, such as Chin State-Mizoram/India,Karen/Kareni/Mon/Eastern Shan -Thailand, Northern Shan/Kachin- China.(Appendix - B) These regions are crucial due to factors such as trade and migration and are often characterized by security difficulties.

The NUG's usage of social media and encrypted communication platforms highlights the socio-technical concept of collaborative optimisation. These platforms have helped mobilise protesters, disseminate information, and coordinate operations across disparate networks (Gerbaudo, 2018).A socio-technical perspective emphasises the importance of comprehensive cybersecurity measures. The military dictatorship has targeted the NUG with cyber-attacks and monitoring, emphasising the necessity of securing digital communications and protecting critical information. This entails not just adopting technical solutions but also educating people on cyber hygiene and safe online behaviour. The digital gap presents a serious obstacle to the NUG's e-government projects. Access to technology varies greatly throughout Myanmar, with rural and marginalised people frequently missing dependable internet access (World Bank, 2021). To promote inclusive participation, the NUG address these discrepancies through digital literacy initiatives and measures to increase internet access. Before the coup, Myanmar was making progress towards e-government services. The government initiated a number of projects to digitise public services, improve internet infrastructure, and increase digital literacy among residents (UNDP Myanmar 2020). The emphasis was on promoting transparency, decreasing corruption, and improving public service delivery through digital means.

The 2021 coup drastically slowed Myanmar's progress towards a digital government. The SAC shut down the internet, limited access to social media platforms, and tightened surveillance of digital communications (Access Now, 2021). These policies hampered the NUG's and other pro-democracy organizational capacities to rally support and coordinate resistance efforts. The NUG has been able to keep its operations and communication channels running by utilising cloud-based technologies and decentralised networks. In order to gain foreign support, the NUG has created online platforms for citizen involvement, digital fundraising campaigns, and virtual diplomacy activities (Thawnghmung, 2021).To address the issues of the digital divide, efforts must be taken to improve Myanmar's digital infrastructure. This involves increasing broadband access, enhancing internet reliability, and providing affordable connectivity to all individuals. International relationships and investments can help achieve these objectives (World Bank, 2021). Digital literacy is required for effective citizen engagement in e-government efforts. Programmes targeted at developing digital skills, particularly in rural and marginalised populations, can empower residents to engage with digital government services and participate in the democratic process (UNDP Myanmar, 2020). The NUG and Myanmar's digital government projects continue to prioritise cybersecurity. Implementing strong cybersecurity procedures, cultivating a cyber-aware culture, and working with international specialists can all help to reduce cyber attacks and secure important information (Shackelford, 2022). The NUG's dependence on digital tools to support its governance and resistance operations exemplifies the actual use of e-government ideas in a crisis situation. By taking a socio-technical perspective, the NUG can optimize its digital strategy to improve public involvement, ensure cybersecurity, and bridge the digital gap. Future study should continue to investigate these patterns, particularly in circumstances of political instability.

5.1 NUG Ministry of Education's Efforts in Providing Alternative Education Services in Digital Way

Despite operational limitations, the Ministry of Education of the NUG continues to offer sustainable alternative education services to support students participating in the CDM. The NUG's interim educational services can be primarily divided into two categories: digital education and on-ground education, both of which are often interconnected. The enrollment of students in these services is largely dependent on their access to the internet

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and the security situation in their respective areas. Regarding on-ground education, it has been reported that more than four thousand schools have been established in liberated areas, providing in-person learning opportunities. While the SAC education system operates in major cities, the NUG's education system is active in liberated zones. It would be inaccurate to claim that students in urban areas are exclusively enrolled in SAC-affiliated schools and universities. At the outset of the Spring Revolution, SAC's education system was significantly disrupted by a large-scale CDM movement, leading to the establishment of interim education providers under the NUG and the development of alternative education systems. Many students in major cities, particularly at the higher education level, have actively resisted the education system of SAC by joining the CDM and enrolling in institutions affiliated with the NUG or other independent educational entities providing alternative services. The NUG's MoE offers education services across basic education, higher education, and vocational training. For basic education, schools in liberated and ethnic areas are providing in-person learning, while digital education services via online schools are also crucial for ensuring continuous access to education. The MoE oversees currently oversees sixty five online schools, which must be officially recognized and comply with the Ministry's information and technology security guidelines. These online schools offer education from kindergarten (KG) to grade 12, with curricula tailored to different regions of the country.

Admissions to NUG educational programs are carefully managed according to security protocols. Guardians or students can initiate contact via social media platforms, where they are required to submit documentation verifying their participation in the CDM. This verification process involves a recommendation letter from a CDM teacher, university, or student council. Students must also complete an admission form, and the Ministry provides video tutorials for each step, including how to anonymize identities and avoid sharing sensitive personal information. The curriculum provided by the MoE is designed for home-based learning, though schools have the academic freedom to adopt various curriculums. Some schools utilize non-formal curriculums, social science-focused syllabi, and others in ethnic areas adopt curricula that align with local languages, cultures, and political contexts. Many schools follow the curriculum recommendations of the NUG, which emphasize the development of good citizenship and respect for diversity. This decentralized and flexible approach to curriculum design contrasts sharply with the centralized, Burmanization-driven curricula of the SAC, which have faced widespread criticism.

The teaching methods in online schools are student-centered and highly innovative, utilizing digital tools. Traditional textbooks have been replaced by digital resources such as videos and animations. For example, in biology lessons, teachers use digital videos to explain concepts like plant growth, encouraging students to engage in hands-on activities such as planting and documenting their progress on a digital platform for teacher evaluation. This innovative, experiential approach contrasts with the rote memorization methods used in SAC's education system. For assessment and certification, students who complete grade 12 can take the Basic Education Completion Assessment (BECA), conducted by the MoE. This certification is essential for further educational or career opportunities. The BECA is conducted online with students required to use their cameras. In 2023, more than 60,000 students participated, with over 50,000 passing, though some faced challenges due to technical issues and instances of fraud(Interview with Headmaster of Myanmar Basic Online School,21 July 2024). For lower-grade assessments, mid-term and year-end exams are primarily conducted via Google Forms, with questions in multiple-choice, fill-in-the-blank, or short-answer formats. As for technical difficulties, exams may be provided in PDF format, and some are administered via Telegram calls. In addition to exams, students are assessed throughout the year through assignments, presentations, and homework submitted via Google Classroom and Google Drive. Student performance is evaluated holistically, factoring in test scores, attendance, participation, and overall conduct, which differs from SAC's system, which is heavily reliant on exam results alone.

The NUG's efforts to provide alternative higher education services are especially significant, as university students have played a central role in the CDM and the Spring Revolution. Student and teacher unions from various universities have established interim councils to offer alternative educational opportunities in collaboration with the MoE. These councils attempt to provide degree and certificate programs across various disciplines. In addition to pre-existing institutions such as arts and science universities, medical colleges, and technical colleges, new institutions affiliated with the NUG have been created. For the 2024-2025 academic year, 59 degree programs from 17 universities will be offered through online platforms, including a Learning Management System.

For assessment and quality assurance, students are required to earn credits by completing assignments, projects, and class participation. For instance, students at Wunzin Online University must submit a thesis under the supervision of their professors to earn credits for graduation. These students also have the opportunity to present their research at international conferences, such as those in the United States, in connection with their university. At vocational institutions like Spring Film Academy, students must complete 12 courses per year, earning 3 credits per course, with a final project, such as producing a film, required for graduation. To complete their studies, students must maintain 75% class attendance and meet credit requirements(Interview with a CDM Professor working at online higher education institution affiliated with the Ministry of Education, National Unity Government of Myanmar, 23 July 2024).To overcome the issue of CDM students' lacking opportunities to proceed to further education by bridging into international universities, the MoE is attempting to link and sign Memorandum of Understandings (MoUs) with international universities. The ministry has successfully signed MoUs with regional and international universities that results in allowing students to continue their education at such institutions. MoE's efforts in overcoming accreditation challenges via providing digital education service fills the gap of lacking further education and employment issues that a majority of youths are facing as a socio-economic issue happened after the post-coup scenarios.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Analyzing the digital education service of NUG through a sociotechnical lens highlights the interplay between technological strategies and socio-political contexts. The NUG's digital and on-ground education systems serve not merely as alternative educational platforms but also as tools of sociopolitical resistance, strengthening resilience amid political instability and security threats. The establishment of decentralized, flexible curricula and student-centered methodologies directly responds to the centralized and authoritarian of SAC education model, promoting academic freedom and educational integrity. Furthermore, digital platforms embody Education 5.0 principles by integrating adult learning methodologies, lifelong learning practices, and home-based education approaches, effectively adapting to Myanmar's diverse socio-cultural contexts. Nevertheless, the effectiveness of these services hinges critically on internet accessibility, digital literacy, and user trust, emphasizing the need to continuously balance technological innovations with social considerations to sustain engagement and legitimacy.

5.2 NUG Ministry of Health's Digital Healthcare Services

Driven by a robust population of healthcare workers participating in the CDM, the Ministry of Health (MoH) of NUG stands out as a pivotal institution in the provision of both digital and on-ground healthcare services. The NUG's Ministry of Health provides four interlinked healthcare services: on-ground, emergency, primary, and online care. Despite security challenges, it operates a structured health system reaching 198 townships (60% of Myanmar), especially in revolutionary-controlled areas. From April 2021 to March 2024, it treated over 1.1 million outpatients, performed 40,169 surgeries, and managed 4,140 referrals. Services are supported by 77 hospitals, 377 clinics, and 250 mobile units. Emergency care and the National Immunization Programme are key in conflict zones, with school health services reaching 962 schools. These efforts reflect the MoH's broad and resilient healthcare delivery. However, due to research limitations, this paper will focus specifically on the ministry's online healthcare services.

Telekyanmar, launched on 19 June 2021 by the NUG's Ministry of Health, is a fully online telemedicine service run by CDM healthcare workers. Accessible via Telegram and Facebook Messenger, it provides remote medical consultations to people in Myanmar and abroad. Patients book appointments through its Facebook page and are directed to general clinics via Telegram. Based on symptoms, they may be referred to one of 25 specialist clinics. Physical exams and diagnostic tests are done locally, with follow-up consultations conducted online. Telekyanmar offers a secure, innovative healthcare alternative amid ongoing conflict and limited physical access.

Telekyanmar has the policy of refusing to handle emergency situations, advising patients to contact local hospitals or clinics. However, in critical situations where patients cannot visit physical clinics, Telekyanmar's doctors provide guidance on how to manage the patient's condition. According to a CDM doctor working at Telekyanmar, most users seek initial discussions to understand their symptoms and receive treatment instructions rather than who would like to get medical services that can completely cure diseases such as surgeries. Following consultations, doctors provide prescriptions for patients to purchase medications at local pharmacies and offer ongoing monitoring and treatment in subsequent sessions (Interview with a CDM doctor working at Telekyanmar, the Ministry of Health, National Unity Government of Myanmar,27 July 2024). In its first year, Telekyanmar served patients from 298 townships in Myanmar, with usage increasing each year, reaching 319 townships in its second year (refer to Fig. 1 below). Over three years, the MoH reported that Telekyanmar provided more than 170,000 free consultations, covering 321 out of 330 townships nationwide and Myanmar citizens from 47 different countries.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



Fig. 1 – Map illustrating the reach of Telekyanmar users across 319 townships (highlighted in red) between June 19, 2021, and June 6, 2023.[1]

Telekyanmar provides a "Social Media Service," designed to respond to inquiries submitted by users through its social media platforms. This service is particularly suited for individuals seeking general information about diseases and conditions without requiring a detailed medical consultation. Common inquiries include symptoms, causes, and general treatment recommendations for minor conditions such as allergic reactions, constipation, or swollen eyes, etc. The service is especially beneficial for members of the PDF and internally displaced persons (IDPs) in conflict areas, where access to healthcare facilities is limited. When internet access is available, users in these areas can send questions to Telekyanmar, enabling them to receive essential medical guidance remotely.

Telekyanmar supports mental health through two key services: a Primary Mental Health Clinic and a Psychiatric Clinic, offering general and specialized care. It also runs the "Zero-Suicide Campaign," a hotline addressing psychological distress amid Myanmar's crisis. Inter-ministerial coordination enhances care, with the Ministry of Women, Youth and Children providing counseling for gender-based violence survivors via the "Tine Pin Phaw" program and referring severe cases to Telekyanmar. Patients with chronic illnesses are directed to relevant clinics, and those needing legal aid are referred to the Ministry of Justice's "Mhyata Lan Nyun" platform.

The post-coup socio-political landscape in Myanmar has created an urgent need for accessible and affordable public services, particularly in the healthcare sector. Digital health platforms such as TeleKyanmar have emerged as critical socio-technological interventions. A significant proportion of its users are individuals from economically vulnerable backgrounds, many of whom have been further impoverished by the economic instability induced by the coup. Another key user group includes populations residing in rural and conflict-affected areas, where access to conventional healthcare infrastructure such as hospitals and clinics is severely limited. In addition to physical health, mental health services have become increasingly vital in post-coup, especially for individuals affected by conflict and violence. NUG's digital services have stepped in to fill this gap by offering remote psychological support and counseling. Hence, the delivery of NUG's digital services fulfill the needs of post-coup Myanmar society by using technology as a bridge to these essential services. This socio-technological relevance was further witnessed during the April 2025 high-magnitude earthquake. In the wake of this disaster, the NUG's digital platforms deliver non- emergency healthcare, including mental health support, to victims and rescue workers. This eased pressure on SAC-run hospitals which are already overwhelmed with emergency patients, and showed how technology can bridge service gaps and ease the social needs in crisis.

[1] Two Years Activities by Ministry of Health, National Unity Government of Myanmar (From April 2021 to April 2023)https://moh.nugmyanmar.org/wp-content/uploads/2023/06/Eng-Ver_2-Year-Activities-by-MOH-NUG-2021-2023.pdf

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5.3 NUG's Ministry of Planning, Finance and Investment's Digital Financial Service Delivery

Digital financial services are another remarkable sector of NUG's digital service delivery. Currently, the Spring Development Bank (SDB) and the NUG pay are in service for bringing alternative financial platforms that are decentralized and operating in digital way. These digital financial services are revolutionary and innovative, established to contribute to the Spring Revolution by providing alternative financial services for the general public instead of saving in the banks in Myanmar, which are under the control of the junta back Central Bank of Myanmar. The public's choice to avoid moving funds into the military-based financial system can weaken that system, and hence, NUG's alternative financial services can be termed a "financial war". Moreover, since frequent cases of junta-controlled bank services monitor, track, and freeze the bank accounts of the users, choosing NUG's alternative financial services can provide safety and privacy.

The SDB, established by the NUG's Ministry of Planning, Finance and Investment and licensed by its Interim Central Bank, provides secure digital financial services to support the resistance and enhance financial access in Myanmar's crisis (Mizzima, 2023). Operating entirely online, SDB offers multi-currency transfers, fixed deposits, stablecoin withdrawals, and remittance services via authorized agents globally. Additional services include digital gold savings, e-lottery sales, and decentralized currency exchanges. It also facilitates real estate sales through the "End of Dictatorship" campaign and offers stock shares via Initial Coin Offering (Interview with SDB Executive, 26 July 2024). Complementing SDB, the blockchain-based NUG Pay mobile wallet enables users to save, transfer, and pay in various currencies, helping SMEs transition to a digital economy.

Under the sociotechnical perspective, the widespread adoption of the digital financial services of SDB and NUG Pay underscores a significant shift in public trust and financial behavior in Myanmar. People increasingly prefer these alternative platforms for their perceived security, privacy, and resilience against the SAC surveillance and control, reflecting a collective resistance through financial independence. Furthermore, the blockchain crowdfunding for 2025 April earthquake technology utilized by NUG not only ensures transparency, which is critical in managing humanitarian assistance and contributions to the earthquake and pro-democracy movement, but also enables citizens to contribute without the burdens imposed by traditional financial systems and also aids in protecting citizens from inflationary pressures driven by the military's economic mismanagement. Therefore, these digital financial services embody a dual sociotechnical purpose: empowering citizens economically and reinforcing socio-political resilience through technological innovation.

6. Challenges and Obstacles

Digital governance services under the NUG have emerged as a transformative approach to engaging with citizens, including those in conflict zones, border areas, and internally displaced persons. However, implementing these services is fraught with significant challenges. Due to security concerns, the NUG has largely shifted to online platforms to deliver services, avoiding physical locations that could be vulnerable to military airstrikes and surveillance. Yet, internet connectivity remains a critical obstacle, with widespread shutdowns across 313 townships and limited access in conflict-affected areas such as Sagaing, Magway, and parts of Tanintharyi, where military-controlled providers like Mytel dominate. This not only hinders the provision of digital services like banking, healthcare, and education but also raises concerns about surveillance and privacy. To mitigate these challenges, the NUG has turned to satellite-based internet services like Starlink, enabling connectivity in over 150 areas. However, the high cost of equipment, legality concerns, and inconsistent performance due to limited satellite coverage remain significant barriers. Furthermore, the military's crackdown on alternative connectivity solutions, such as seizing Starlink devices in Thailand, underscores the risks associated with using such technologies.

Myanmar's digital services face major challenges from frequent power outages, especially in cities like Yangon and Mandalay, disrupting device use and digital access. In NUG-controlled areas, reliance on solar panels and generators helps, but rising fuel costs and military fuel restrictions strain infrastructure. Power shortages also hinder basic education more than higher education, which can better adapt to online learning. Additionally, the military's post-coup restrictions blocking social media, VPNs, and surveilling users pose serious cybersecurity risks. NUG platforms like Spring Development Bank are frequent cyberattack targets. Weak digital literacy worsens user vulnerability, highlighting the need for better security measures and user education.

The shortage of skilled IT professionals further complicates the NUG's digital governance efforts. Effective digital transformation relies heavily on technical expertise to ensure secure and sustainable systems, yet Myanmar's digital literacy gap remains a critical barrier. Many public sector workers lack basic digital skills, and the exodus of IT professionals after the coup has significantly depleted the talent pool. Those who remain often work part-time or on a voluntary basis, limiting their capacity to contribute fully to digital governance initiatives. The Ministry of Communications, Information, and Technology (MoCIT) has attempted to fill these gaps by mobilizing volunteers and external technical support. However, the reliance on a small pool of skilled professionals and limited in-house expertise across other ministries underscores the urgent need for capacity-building programs. Long-term sustainability requires structured investments in digital literacy and skills development, alongside efforts to retain and support IT professionals in the face of financial and security challenges.

Security and control challenges are pervasive across digital governance services. The military regime's digital surveillance apparatus includes SIM card registration and mobile banking monitoring, enabling the tracking and targeting of individuals suspected of anti-regime activities. Pro-SAC groups have also weaponized social media

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

platforms like Telegram to dox and expose pro-democracy activists, leading to arrests and detentions. These actions have created an environment of fear, discouraging many citizens from engaging with NUG services out of concern for their privacy and safety. In response, the NUG has implemented cybersecurity protocols and digital safety training, yet the lack of a unified international database and fragmented digital infrastructure limits the effectiveness of these measures. Strengthening cybersecurity frameworks and promoting digital literacy across the population are critical steps in building resilience against these threats.

User adoption and digital literacy are central to the success of NUG's digital services. While platforms like Telekyanmar offer innovative solutions for healthcare delivery, gaps in digital skills and infrastructure hinder their accessibility. Many students and educators in conflict-affected regions face challenges in accessing online education due to the high cost of devices and data, as well as unreliable internet connectivity. In some cases, communities pool resources to purchase shared devices, while students travel long distances to access areas with better connectivity. Similarly, digital financial services like the Spring Development Bank play a crucial role in facilitating secure transactions, but users often struggle with unfamiliar blockchain technology and limited withdrawal options, undermining confidence in these platforms.

Trust and legitimacy are critical for the broader adoption of digital governance services. The NUG's ability to deliver effective and inclusive services is a key factor in establishing its credibility as a governing body. While the NUG has made progress in engaging ethnic minorities and marginalized groups, historical grievances and cultural barriers remain significant obstacles. Efforts to promote inclusivity through translation services and localized solutions, such as Telekyanmar's Chin Tele App, demonstrate the NUG's commitment to addressing these challenges. However, limited infrastructure and frequent displacement in ethnic areas continue to impede service delivery.

Tab. 1 – People Trust on Digital Governance Services.

Survey Aspect	**Percentage / Response**
Efficiency of NUG's Digital Services	65.7% highly trust , 22.9% moderately trust it
User trust on Security Protection of NUG Digital Services	62.9% express high trust, 25.7% moderately trust NUG Digital Services Security Protection
People access to NUG Digital Services	37.1% show moderate access, 37.1% show low access to Digital Governance Services
General Trust in NUG Digital Services	45.7% express moderate trust, 34.3% high trust, 8.6% no trust
Reasons for Non-Use of NUG Digital Services	47.1% cite security issues, 44.3% cite lack of internet access, 4.3% question service quality

These findings suggest that trust in digital governance, particularly in crisis contexts, is contingent on both service quality and accessibility. In Myanmar's conflict-ridden environment, trust is not only a matter of perceived efficiency but also hinges on the capacity of governance structures to ensure secure and equitable access. Analysis of the survey data reveals that users generally have greater confidence in the efficiency and security of the NUG's digital services compared to those who express distrust. In contrast, non-users primarily cite concerns over security, limited internet access, and poor service quality as reasons for not engaging with the services. Additionally, responses indicate an even distribution between moderate and low levels of access to the NUG's digital platforms. These findings suggest that, although there is a significant degree of trust in the NUG's digital initiatives, their long-term success hinges on addressing key practical barriers particularly in terms of security and accessibility which are essential for building and maintaining public trust.

International support plays a vital role in overcoming these challenges. The lack of strong international assistance has limited the NUG's capacity to expand its digital governance initiatives. While some capacity-building programs and training sessions have been offered by international organizations, these efforts remain sporadic and insufficient. Enhanced technical and financial support for internet infrastructure, capacity-building programs, and digital literacy initiatives could significantly strengthen the NUG's digital governance capabilities. Recognizing internet access as a fundamental right and fostering global partnerships would not only address existing gaps but also enhance the resilience and legitimacy of the NUG's efforts to govern effectively in a politically fragmented Myanmar. By addressing these interconnected challenges, the NUG can build a more inclusive and sustainable digital governance system to support the country's transition toward democracy and stability.

7. Conclusion

This research reveals the complex challenges faced by the NUG in implementing digital services within

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Myanmar's volatile socio-political landscape. Utilizing a socio-technical framework, this paper illustrates how technical and social factors interact to influence the success of digital governance initiatives. On the technical side, challenges such as inadequate internet infrastructure, frequent power outages, cybersecurity threats, and a shortage of skilled IT professionals hinder the scalability and accessibility of NUG's services. On the social side, barriers including low digital literacy, trust deficits, and cultural diversity, particularly in ethnic regions, impede user engagement. These challenges are compounded by Myanmar's conflict-ridden environment, where military surveillance and repression create a climate of fear that further discourages the adoption of digital tools. This section synthesizes the findings by explicitly linking the empirical evidence gathered from interviews, surveys, and secondary data with the theoretical components of the sociotechnical framework. Key barriers identified such as trust deficits, infrastructural inadequacies, and security challenges are discussed in direct relation to their impact on service adoption and legitimacy, thereby offering sharper and more coherent conclusions.

Despite these obstacles, the NUG has demonstrated remarkable resilience and innovation in its digital initiatives. Telekyanmar offers critical healthcare services, including mental health support and suicide prevention. Similarly, the Ministry of Education has provided alternative educational opportunities through digital platforms such as the Learning Management System and Moodle. These efforts have enabled students in conflict zones and ethnic areas to access flexible curricula tailored to their cultural and linguistic needs. Financial solutions such as the SDB and NUG Pay highlight the government's commitment to transparency and accountability, fostering trust among users despite the operational risks posed by cyberattacks and military control.

The research highlights how the NUG can strengthen its digital governance by improving internet access, cybersecurity, and digital literacy particularly in marginalized areas. Collaboration with ethnic groups and international partners is key to inclusivity and resource support. Despite security-related research limitations, the study underscores the NUG's progress in using technology to deliver essential services. A clear digital roadmap and transparent donor engagement are crucial to building legitimacy and attracting investment. These findings offer both practical strategies and broader insights into digital governance in conflict settings, showing how innovation can advance democracy and resilience amid crisis.

Acknowledgement

This research was supported by ICRC-CRID in partnership with Canada, and we are grateful for their assistance. During the process, data citation management was conducted manually, with some citations handled using Zotero software. Both authors contributed equally to all aspects of the research, including conceptualization, methodology, data analysis, and writing. Additionally, AI tools were used to polish the paper, locate relevant academic articles, and calculate specific percentages. The remaining work, including research design and content writing, was entirely completed by the researchers. We affirm that there is no conflict of interest related to this research.

References

Access Now. (2021). "Myanmar Coup: A Year of Internet Shutdowns, Censorship, and Arrests." Access Now.

Al Hussaini, Y. K. N. (2021). Implications of Socio-Technical Interactions for e-Government Implementation and its Success. Can Access https://livrepository.liverpool.ac.uk/3142921/1/201183436_Oct2021.pdf

Andersen, K. V., & Henriksen, H. Z. (2006). E-government maturity models: Extension of the Layne and Lee model. Government Information Quarterly, 23, 236–248.

Anthopoulos, L., Reddick, C. G., Giannakidou, I., & Mavridis, N. (2016). Why e-government projects fail? An analysis of the Healthcare.gov website. Government Information Quarterly, 33(1), 161-173. https://doi.org/10.1016/j.giq.2015.07.003

Awan, O., Amin, M., & Kirkby, K. (2013). Introduction to e-Governance. In E-governance in small states. London: Commonwealth Secretariat, pp. 1–3. Can Access https://search.worldcat.org/title/839388784

Baek, J., Kim, J., & Lee, Y. (2018). The impact of sociotechnical systems on the success of e-government implementation: Evidence from South Korea. Information Systems Frontiers, 20(4), 673-686. https://doi.org/10.1007/s10796-017-9763-1

Bekkers, V., & Homburg, V. (2007). The Myths of E-Government: Looking Beyond the Assumptions of a New and Better Government. Information Society, 23(5), 373-382.

Bostrom, R. P., & Heinen, J. S. (1977). MIS Problems and Failures: A Socio-Technical Perspective. MIS Quarterly, 1(3), 17-32.

Choi, T., & Chandler, S. M. (2020). "Knowledge, Communication, and ICT Adoption in Public Sector". Government Information Quarterly, 37(2), 101423.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Choi, H., & Chandler, S. M. (2020). E-government in the post-COVID-19 era: Challenges and opportunities. Journal of Public Administration Research and Theory, 30(4), 741-752. https://doi.org/10.1093/jopart/mua062

Damodaran, L., Nicholls, J., Henney, A., Land, F., & Farbey, B. (2005). "The Contribution of Sociotechnical Systems Thinking to the Effective Adoption of e-Government and the Enhancement of Democracy". The Electronic Journal of e-Government, 3(1), 1-12. (Cited in Hussaini, 2021).

Dawes, S. S. (2008). The Evolution and Continuing Challenges of E-Governance. Public Administration Review, 68(s1), S86-S102.

Dawes, S. S. (2009). Governance in the digital age: A research and action framework for an uncertain future. Public Administration Review, 69(2), 286-298. https://doi.org/10.1111/j.1540-6210.2008.01974.x

Fountain, J. E. (2001). Building the virtual state: Information technology and institutional change. Washington (DC): Brookings Institution Press, p. 256.

Fortune, J., & Peters, G. (2005). Information systems: Achieving success by avoiding failure. John Wiley & Sons.

Gerbaudo, P. (2018). Tweets and the Streets: Social Media and Contemporary Activism. Pluto Press.

Gibreel, O., & Hong, A. (2017). A holistic analysis approach to social, technical, and socio-technical aspects of E-Government Development. Sustainability, 9(12), 2181. https://doi.org/10.3390/su9122181

Gil-Garcia, J. R., & Flores-Zúñiga, M. L. (2020). E-Government success factors and the role of contextual conditions: Insights from the Mexican government experience. Government Information Quarterly, 37(1), 1-13. https://doi.org/10.1016/j.giq.2019.101409

Glyptis, L., Christofi, M., Vrontis, D., Giudice, M. D., Dimitriou, S., & Michael, P. (2020). E-Government implementation challenges in small countries: A comparative analysis of Cyprus and Malta. Technological Forecasting and Social Change, 151, 119811. https://doi.org/10.1016/j.techfore.2019.119811

Goldfinch, S. (2007). Pessimism, computer failure, and information systems development in the public sector. Public Administration Review, 67(5), 917-929. https://doi.org/10.1111/j.1540-6210.2007.00776.x

Gunawong, P., & Gao, P. (2017). Understanding e-government failure in the developing country context: A process-oriented study. Information Technology for Development, 23(1), 153-178. https://doi.org/10.1080/02681102.2016.1214575

Gunawong, P., & Gao, P. (2017). "Understanding e-Government Failure from an Actor-Network Perspective: The Demise of the Thai Smart ID Card". Government Information Quarterly, 34(2), 344-359.

Heeks, R. (2003). Most eGovernment-for-development projects fail: How can risks be reduced? Institute for Development Policy and Management, 14(1), 1-23.

Heeks, R. (2006). Implementing and managing eGovernment: An international text. Sage.

Hussaini, A. (2021). "Understanding Sociotechnical Barriers to Effective E-Government Implementation: Perspectives from Nigeria". Electronic Journal of e-Government, 19(1), 38-52.

International Crisis Group. (2021). Myanmar's Coup and its Aftermath. Crisis Group Asia Briefing No. 166.

Jaeger, P. T., & Bertot, J. C. (2010). Transparency and Technological Change: Ensuring Equal and Sustained Public Access to Government Information. Government Information Quarterly, 27(4), 371-376.

Joseph, R. C. (2013). A structured analysis of e-government studies: Trends and opportunities. Government Information Quarterly, 30(4), 435-443. https://doi.org/10.1016/j.giq.2013.05.002

Madsen, C., Berger, J. B., & Phythian, M. (2014). Lessons from the frontline: Do citizens have the right to e-government? Information Polity, 19(3), 165-180. https://doi.org/10.3233/IP-140333

Mizzima. (2023). "Myanmar's NUG holds a soft launch for its online bank". Mizzima. https://mizzima.com/article/myanmars-nug-holds-soft-launch-its-online-bank

Madsen, C. Ø., Berger, J. B., & Phythian, J. (2014). "The Challenges of e-Government Implementation in Developing Countries: A Literature Review". Electronic Journal of e-Government, 12(1), 87-98.

Nesti, G., & Graziano, P. (2019). The democratic anchorage of governance networks in smart cities: An empirical assessment. Public Management Review, 22, 1-20. https://doi.org/10.1080/14719037.2019.1588355

Shackelford, S. J. (2020). Governing new frontiers in the information age: Toward cyber peace. Cambridge

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

University Press. https://doi.org/10.1017/9781108562608

Trist, E. L. (1981). The evolution of socio-technical systems. Institute for Development Policy and Management. Retrieved from Research Gate.

Twizeyimana, J. D., & Andersson, A. (2019). The public value of E-Government – A literature review. Government Information Quarterly, 36(2), 167-178. https://doi.org/10.1016/j.giq.2019.01.001

United Nations. (2008). UN E-Government Survey 2008: From e-Government to Connected Governance. Retrieved from United Nations.

United Nations. (2020). UN E-Government Survey 2020: Digital Government in the Decade of Action for Sustainable Development. Retrieved from United Nations.

Appendix A

National Univerity Government Service area

Ministry	Service Mode	Details	Area Noted
Ministry of Defense	In-Person	Security services in controlled areas	NUG Controlled areas
Ministry of Health	Mixed (Digital/In-Person)	Physical hospitals, mobile health units, Tele Kyan Mar	Sagaing, Magway, Kayah, Karen, Kachin,Thanintharyi
Ministry of Planning, Finance, and Investment	Digital	Online lottery, banking, mobile wallet	Online
Ministry of Foreign Affairs	In-Person	Physical representative offices	International locations
Ministry of Education	Mixed (Digital/In-Person)	Physical basic education, online higher education, matriculation exam systems	NUG controlled areas/ Online
Ministry of Home Affairs and Immigration	In-Person	Birth certificates, local administration, security	NUG controlled areas
Ministry of Federal Union Affairs	Digital	Policy foundation and coordination	Online
Ministry of Humanitarian Affairs and Disaster Management	In-Person	Humanitarian aid	NUG controlled area,ERO controlled area and Border Area.
Ministry of Human Rights	Mixed (Digital/In-Person)	Human rights protection, data collection, online training, Human rights reporting, International Advocacy	NUG controlled area,ERO controlled area and Border Area.
Ministry of Natural Resources and Environmental Conservation	Mixed (Digital/In-Person)	Conservation efforts, forestry, online activities	NUG Controlled Area
Ministry of International Cooperation	Digital	International cooperation	N/A
Ministry of Women, Youths, and Children Affairs	In-Person	Gender-based violence, youth development, protecting and promoting women's rights	NUG controlled areas, ERO controlled areas and border areas
Ministry of Labour	Digital	Labour affairs, union coordination	online

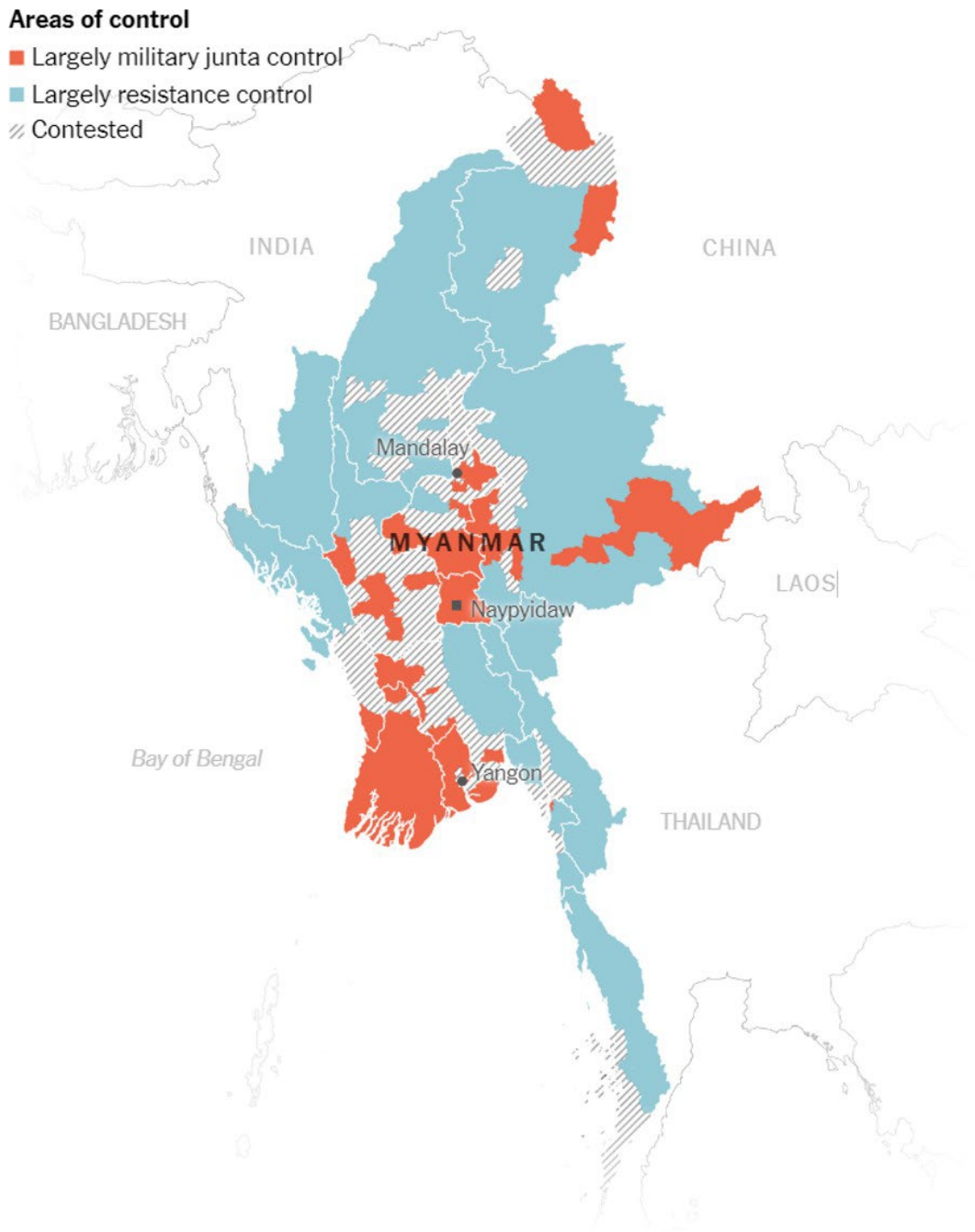
Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Ministry of Justice	Mixed (Digital/In-Person)	Court hearings, legal advice, marriage services	NUG controlled areas
Ministry of Communications, Information & Technology	Digital	Telecommunications and IT services	Online
Ministry of Electricity & Energy	Digital	Energy services	N/A
Ministry of Commerce	Digital	Online training	Online

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Appendix B

Areas of Controlled (Newyorktimes,2024)



Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Crowdsourcing in Municipal Ombudsman Offices: A Systematic Literature Review.

Jean Zahn[a*], *Erica* Mourão[a], *José* Viterbo[a], *Cristiano* Maciel[b], *Flávia* Bernardini[a]

[a]Institute of Computing, Universidade Federal Fluminense, Niterói-RJ, Brazil, {jzahn, ericamourao, viterbo, fcbernardini}@ic.uff.br, 0000-0002-6636-6836, 0000-0001-7916-0143, 0000-0002-0339-6624, 0000-0001-8801-827X

[b]Institute of Computing, Universidade Federal de Mato Grosso, Cuiabá-MT, Brazil, cristiano.maciel@ufmt.br, 0000-0002-2431-8457.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. Municipal ombudsman offices face challenges in managing increasing citizen demands and stimulating meaningful participation, despite legal frameworks guaranteeing citizen rights. Crowdsourcing presents a potential avenue to improve the efficiency of the Ombudsman office and the engagement of citizens. This systematic literature review (SLR) investigates the application of crowdsourcing in municipal ombudsman offices, synthesizing existing research to identify best practices, challenges, and research gaps. A comprehensive search of academic databases from 2010 to 2023 initially yielded 1590 papers. Following a rigorous five-stage filtering process, 24 relevant studies were selected for in-depth analysis. The findings reveal a growing trend of utilizing crowdsourcing primarily for feedback collection and complaint management, although its application in direct decision-making processes within ombudsman offices remains limited. While the literature reports benefits such as increased efficiency and faster problem resolution, significant challenges persist. These include digital inequality, which can exclude vulnerable populations; concerns about the credibility of citizen-submitted data; and institutional resistance to adopting new, crowdsourced approaches. This review indicates the need for further research into the long-term impacts of crowdsourcing on citizen empowerment and ombudsman office accountability. The study provides a valuable foundation for researchers and practitioners seeking to leverage crowdsourcing to strengthen municipal ombudsman services and promote citizen participation, emphasizing the importance of addressing these identified challenges to realize the full potential of crowdsourcing in this context.

Keywords. Systematic Literature Review, Ombudsman, Crowdsourcing, E-participation, Electronic Government.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.959

1. Introduction

Municipal ombudsman offices play a crucial role in safeguarding citizen rights and promoting government transparency and accountability (Zahn, Viterbo, et al., 2024). However, these offices often face significant challenges in managing the increasing volume of citizen demands and fostering meaningful participation, despite existing legal frameworks (Quintão, 2016). Crowdsourcing, the practice of obtaining contributions from a large group of people, emerges as a potential strategy to enhance the efficiency of ombudsman offices and engage citizens more effectively (Noh, 2022).

Given the importance of ombudsman offices as communication channels between citizens and the government, the reality is that many face limitations in resources, difficulties in processing large volumes of information, and barriers to promoting broad and representative citizen participation (Zahn, Mourão, et al., 2024).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

While crowdsourcing has shown potential in various public sector areas, its specific application within the context of Brazilian municipal ombudsman offices remains underexplored, lacking a systematic synthesis of existing knowledge (Bouzguenda et al., 2019).

In recent years, the field of e-Participation has witnessed a growing interest in the systematic exploration of existing knowledge (Boudjelida et al., 2016; Hassan and Hamari, 2019; Simonofski et al., 2017) as well as other fields (da Silva et al., 2022; Pincovsky et al., 2021) through a methodological approach known as Systematic Literature Review (SLR – Kitchenham and Charters, 2007). An SLR study includes identifying, evaluating, and interpreting all research relevant and provides empirical evidence. The main reasons to conduct the SLR are: to summarize the existing evidence, to identify any gaps in current research, and to provide a background to the appropriate position in research activities.

The execution of an SLR within the domain of Computing entails adherence to three fundamental phases: Planning, Conduction, and Reporting (Kitchenham and Charters, 2007). The planning phase includes the identification of the urgency for the review, commissioning thereof, articulation of research inquiries, formulation of a review protocol, and subsequent protocol evaluation. The conducting phase involves activities such as the identification of pertinent research, curation of primary studies, evaluation of study quality, data extraction and monitoring, and the synthesis of acquired information. The reporting phase includes the specification of dissemination mechanisms, formatting of the principal report, and its subsequent evaluation.

The main objective of this SLR is to investigate how crowdsourcing has been applied in municipal ombudsman offices, identifying best practices, key challenges, and existing research gaps. In this way, the outcomes will provide a knowledge base regarding the adoption of tools and technologies based on this paradigm, aiming to comprehend the state-of-the-art and the primary challenges faced by these local governments in implementing crowdsourcing.

The rest of this paper is organized as follows: Section 2 presents the theoretical foundations necessary to understand the remainder of this paper. Section 3 approaches our research methodology to support the execution of this systematic review. Section 4 presents the results of conducting the review, following the established protocol. Section 5 presents our findings aligned to our Research Questions (RQs). Section 6 discusses the findings, explores their implications, and addresses potential limitations. Finally, Section 7 presents the conclusions of this work.

2. Theoretical Background

Citizen participation is a cornerstone of democratic governance, allowing individuals to interact with, engage in, and contribute to government decision-making processes, policy design, and the assessment of public services (Simonofski et al., 2017). Achieving meaningful citizen participation, however, is a complex undertaking, requiring authorities to actively create mechanisms to motivate engagement over diverse social and technological landscapes (Bouzguenda et al., 2019).

The use of information and communication technologies (ICTs) to improve public service delivery and promote citizen participation (Polovchenko, 2019), offers a potential pathway to support this interaction and the digital transformation. Through digital platforms, online forums, and mobile applications, e-government aims to make public administration more efficient, transparent, accessible, and responsive to citizens' needs (Grönlund, 2004; Relyea, 2002). E-participation, a key component of e-government, specifically focuses on leveraging technology to facilitate citizen involvement in decision-making and governance (Boudjelida et al., 2016; Hassan and Hamari, 2019; Simonofski et al., 2017).

Within this context, ombudsman offices play a crucial role as intermediaries between citizens and government. Originating in Sweden in 1809, the ombudsman concept centers on an independent official tasked with investigating citizen complaints against government actions and promoting administrative accountability (Batalli, 2015). In Brazil, for example, the term *"Ouvidoria"* is commonly used to refer to institutions that handle citizen feedback and complaints within specific organizations, particularly in the public sector (Comparato, 2005; Quintão, 2016). Municipal ombudsman offices, therefore, serve as vital institutional mechanisms for facilitating citizen participation at the local level, promoting social and political inclusion, and mediating conflicts between citizens and the municipal administration (Antero, 2014). The *"Ouvidor"* (the public official respon-

sible for the *Ouvidoria*), acts as a conduit for citizen voices, receiving and processing demands, and facilitating their resolution by the relevant authorities (Alizadeh et al., 2019; Polovchenko, 2019; Simonofski et al., 2019).

Crowdsourcing, a term coined by Howe et al., 2006, represents a significant development in leveraging collective intelligence to address various challenges. It involves outsourcing a task traditionally performed by employees to a large, undefined network of people through an open call (Estellés-Arolas and González-Ladrón-de-Guevara, 2012). Citizen-sourcing, a specific application of crowdsourcing within the public sector, harnesses the knowledge, skills, and experiences of citizens to improve government services and decision-making (Grossman et al., 2018; Hammon and Hippner, 2012). Estellés-Arolas and González-Ladrón-de-Guevara, 2012 identified eight fundamental elements of crowdsourcing: a clearly defined group, a task with a clear goal, a specified reward for the group, a clearly identified crowdsourcing initiator, compensation for the group, an online and participatory process, an open call of variable reach, and the involvement of the Internet. Crowdsourcing projects can be classified based on various criteria, including the type of task (e.g., crowdcasting, crowdcollaboration, crowdcontent, crowdfunding, crowdopinion) and the initiator of the project (public institutions, citizens, or companies – Garrigos-Simon et al., 2015; Sánchez et al., 2015). This diverse range of approaches illustrates the adaptability of crowdsourcing to different contexts and objectives.

3. Research Methodology

This Systematic Literature Review (SLR) adheres to the guidelines proposed by Kitchenham and Charters Kitchenham and Charters, 2007 to ensure a rigorous, transparent, and replicable research process. The methodology is structured around a detailed review protocol, developed a priori, which guides the three main phases: Planning, Conducting, and Reporting.

The planning phase begins with the identification of the need for a review, justifying its relevance by suggesting a gap in the existing literature or a lack of consolidated knowledge. This is followed by the formulation of precise Research Questions (RQs), structured using frameworks such as PICO (Population, Intervention, Comparison, Outcome) where appropriate, to define the scope of the investigation. The core of the planning phase is the development of the review protocol itself. This protocol specifies the research questions, the comprehensive search strategy (including database selection, search term development, search string construction, and search limits), the study selection criteria (inclusion and exclusion criteria for title/abstract and full-text screening), the quality assessment procedures (using standardized checklists or tools), the data extraction strategy (using a generic form), and the data synthesis methods (narrative synthesis, thematic analysis, or meta-analysis, as appropriate).

The conducting phase implements the protocol. A systematic search is performed across relevant electronic databases using the predefined search strings and limits. Study selection proceeds in stages, typically involving title and abstract screening followed by full-text screening, with independent reviewers at each stage and mechanisms for resolving disagreements. Included studies undergo quality assessment to evaluate their methodological rigor and potential for bias. Data extraction systematically collects key information from each study using the predefined data extraction form. Finally, data synthesis integrates the findings, identifying patterns, themes, and relationships to answer the research questions.

The reporting phase, detailed in the subsequent sections of this paper, disseminates the findings in a clear, comprehensive, and transparent manner, following the structure recommended by the guidelines. This structured approach ensures that the SLR is conducted systematically and that the conclusions are based on a thorough and unbiased assessment of the available evidence.

3.1. Research Goal and Questions

Grounded in the Goal-Question-Metric (GQM) paradigm (Basili et al., 1994), this research aims to analyze scientific publications on crowdsourcing in municipal ombudsman offices. The goal is to identify and characterize the mechanisms (processes, methods, tools, and frameworks) used to enhance citizen participation through crowdsourcing. This analysis is conducted from the perspective of researchers and aims to provide insights relevant to both academia and public administration. To achieve this goal, the following RQs were formulated:

RQ 1. What types of crowdsourcing and citizen-sourcing approaches are employed in municipal ombudsman offices? This inquiry aims to identify and categorize specific crowdsourcing methodologies employed, transcending the mere listing of "techniques".

RQ 2. How have crowdsourcing and citizen-sourcing been applied to enhance citizen participation and engagement in municipal ombudsman offices, and what are the key processes involved? This question goes beyond simply asking if crowdsourcing has been applied. It aims to understand the specific applications and processes used to enhance participation and engagement.

RQ 3. What are the reported benefits and drawbacks of using crowdsourcing and citizen-sourcing in municipal ombudsman offices? This question seeks to identify both the positive and negative outcomes associated with crowdsourcing in this context. It's crucial to consider not only benefits (e.g., increased efficiency, improved transparency) but also potential drawbacks (e.g., unequal access, biased participation, data quality issues).

RQ 4. What are the main limitations, challenges, and ethical considerations associated with the use of crowdsourcing and citizen-sourcing in municipal ombudsman offices? This question expands on the previous one by explicitly focusing on the challenges and ethical considerations. This includes issues such as digital inclusion, data privacy, security, representativeness of participants, and potential for manipulation or misuse of crowdsourced data.

RQ 5. What methodological approaches and evaluation metrics are employed in assessing the use of crowdsourcing and citizen-sourcing in municipal ombudsman offices? This question focuses on how the impacts of crowdsourcing are being measured and evaluated. It's important to understand not only what the outcomes are, but also how researchers are determining those outcomes (e.g., surveys, case studies, quantitative analysis of platform data). Adding "evaluation metrics" clarifies that we are looking for the specific measures used.

By addressing these questions, this review aims to synthesize current knowledge, identify key trends, challenges, and best practices, and ultimately contribute to a deeper understanding of how crowdsourcing can be effectively leveraged to enhance citizen participation and improve public service delivery in this context. The following section details the methodology employed to answer these research questions.

3.2. Search String

To design the search string, we used PICO (Population, Intervention, Comparison, and Outcomes) criteria as described in Kitchenham and Charters, 2007. The elements are as follows:

- **Population**: Ombudsman;
- **Intervention**: Crowdsourcing, citizen-sourcing, and related concepts (e.g., e-participation, collaborative systems);
- **Comparison**: No specific comparison was defined, as the focus is on describing and analyzing existing approaches rather than comparing specific interventions;
- **Outcome**: A broad range of outcomes was considered, including but not limited to: efficiency, citizen engagement, service quality, transparency, accountability, and the development of frameworks or models;

Based on these PICO elements, a comprehensive search string was constructed using a combination of keywords, synonyms, and related terms. Wildcards and truncation were used where appropriate to broaden the search and capture variations in terminology. The search string was designed to be sensitive (capturing a high proportion of relevant studies) while also striving for reasonable precision (avoiding an excessive number of irrelevant studies).

The search string was applied to the title, abstract, and keywords fields in the selected databases (detailed in Section 3.3). The following is the base search string used, adapted as necessary for the specific syntax of each database:

("Ombudsman" AND ("Crowdsourcing" OR "E-Government" OR "citizen-sourcing" OR "Citizen-participation" OR "e-participation" OR "electronic participation" OR "collaborative systems" OR "collective intelligence" OR "user-powered systems" OR "community systems" OR "user-generated content"))

This comprehensive search strategy, combining a structured PICO-based approach with a carefully constructed and iteratively refined search string, aimed to identify all relevant studies on the use of crowdsourcing in municipal ombudsman offices published within the specified timeframe and language parameters. The subsequent stages of the review, including study selection, quality assessment, and data extraction, are detailed in the following sections.

3.3. Databases

The databases used to obtain primary studies that aim to answer the research questions were: ACM Digital Library website[1], IEEE Digital Library[2], Scopus[3], and Springer Link[4]. Due to limited time, we decided to use the *Database Search* (set of digital libraries) and leave the use of the hybrid search strategy (Mourão et al., 2020) to search for relevant articles for an update of this work. The publication period considered was determined between 2010 and 2023.

3.4. Inclusion and Exclusion Criteria

We defined specific criteria that determine which articles will be considered eligible for analysis and which will be excluded from the scope of the research. We present the criteria, classified as Inclusion Criteria (IC) as shown in Table 1 and Exclusion Criteria (EC) as shown in Table 2:

Tab. 1 – Criteria adopted to include papers in the study.

	Inclusion Criteria
IC01	Studies for which the full text is accessible, ensuring a comprehensive and thorough analysis of the content.
IC02	Qualitative and quantitative research studies, as well as mixed-methods approaches, that provide relevant insights into the functions, challenges, and best practices of Municipal Ombudsman offices.
IC03	Peer-reviewed journal articles and conference papers.
IC04	Studies conducted in different regions or countries to capture a wide range of perspectives and contexts.
IC05	Studies that investigate the impact or effectiveness of implementing Crowdsourcing or Citizen-Sourcing in Municipal Ombudsman offices in promoting accountability, transparency, citizen empowerment, or improvement in service delivery.

Tab. 2 – Criteria adopted to exclude papers from the study.

	Exclusion Criteria
EC01	Multiple publications based on the same dataset or research project should not be included, selecting only the most comprehensive or recent publication.
EC02	Non-peer-reviewed sources such as blog posts, opinion articles, newspaper articles, and editorials.
EC03	Studies for which the full-text or adequate information is not available, preventing a comprehensive analysis and data extraction.
EC04	Studies published before the specified period (i.e., before 2010).
EC05	Studies published in languages other than English, as specified in the inclusion criteria.
EC06	Studies that do not address Crowdsourcing or Citizen-Sourcing in Municipal Ombudsman offices in promoting accountability, transparency, citizen empowerment, among other aspects.
EC07	Studies that do not focus on Municipal Ombudsman services or related concepts.

These meticulously defined inclusion and exclusion criteria, presented in Tables 1 and 2, served as the foundation for a rigorous study selection process. By applying these criteria systematically during both the title/abstract and full-text screening stages, we ensured that only the most relevant and appropriate studies

[1]http://portal.acm.org/
[2]http://ieeexplore.ieee.org
[3]http://www.scopus.com
[4]http://link.springer.com

were included in this review. This careful selection process enhances the validity and focus of the subsequent analysis. The next step in the methodology involved assessing the quality of the included studies, as detailed in the following section.

3.5. Criteria for Quality Assessment

We established 8 criteria for Quality Assessment (QA) of the selected studies. These criteria are essential to ensure the validity and reliability of the conclusions of the selected studies. Below is presented the set of 8 defined criteria, ranging from QA01 to QA08 as shown in Table 3.

Tab. 3 – Quality Assessment

	Quality Assessment
QA01	**Crowdsourcing or citizen-sourcing approach**: verifies whether the approach of the studies involves Crowdsourcing or Citizen-Sourcing techniques.
QA02	**Relevance and applicability to the Ombudsman context**: evaluates the relevance and applicability of the findings and conclusions of the studies concerning Ombudsman practices.
QA03	**Presentation of limitations**: checks whether the selected studies adequately present their limitations. This analysis is critical to ensure the transparency and integrity of the reviews.
QA04	**Discussion of results**: assesses whether the studies provide an in-depth discussion of the obtained results, contextualizing and interpreting the findings to provide additional suggestions.
QA05	**context description**: checks whether the studies provide sufficient information to understand the environment in which the research was conducted.
QA06	**Proposal validation**: examines the possibility that the techniques proposed in the studies were validated in a simulated environment, laboratory, or case study.
QA07	**Specification of proposed techniques**: checks the clarity and specificity of the techniques proposed in the studies, ensuring that the methodologies are detailed.
QA08	**Presentation of study objectives**: it examines whether the study objectives were presented clearly and comprehensively, allowing readers to understand the purposes of the research.

To ensure the rigor of this systematic literature review, a comprehensive quality assessment of the included studies was conducted. This assessment was guided by a set of eight criteria (QA01-QA08), detailed in Table 3, designed to evaluate both the methodological soundness of the studies and their relevance to the specific context of crowdsourcing in municipal ombudsman offices. These criteria encompass fundamental aspects of research quality, such as the clear presentation of study objectives (QA08), adequate description of the research context (QA05), and a thorough discussion of results and limitations (QA03, QA04).

Beyond general methodological considerations, the criteria also specifically address the core themes of this review. QA01 verifies the explicit involvement of crowdsourcing or citizen-sourcing approaches, acting as a crucial final check on the alignment with the inclusion criteria. QA02 directly assesses the relevance and applicability of the findings to the ombudsman context, ensuring that the synthesized knowledge is directly pertinent to the research questions. This criterion is particularly important for bridging the gap between general crowdsourcing research and the specific needs and challenges of municipal ombudsman offices.

For studies proposing novel crowdsourcing techniques or systems, criteria QA06 (Proposal Validation) and QA07 (Specification of Proposed Techniques) were applied. These criteria assess the extent to which proposed solutions have been empirically validated and whether the technical details are sufficiently described to allow for replication or adaptation. While not all included studies propose new techniques, these criteria are critical for evaluating the practical applicability and potential impact of the research. The collective application of these quality assessment criteria allows for a nuanced understanding of the strengths and weaknesses of the existing evidence base, informing the subsequent synthesis and interpretation of findings.

3.6. Data Extraction

Data extraction is a stage in the SLR where the goal is to systematically collect critical information from selected studies, transforming complex texts and results into organized data ready for analysis. For each of the analyzed papers, information was extracted to contribute to the analysis and address the raised questions.

We used the Parsifal[5] tool to provide a structured and organized SLR protocol. The details and the dataset collected that support the findings of this study are available at *Zenodo* in the link https://doi.org/10.5281/zenodo.10719418.

In the next Section, the execution will effectively take place, applying the search string to the selected databases, implementing the inclusion and exclusion criteria, applying quality attributes, and finally, extracting information according to the presented form.

4. Conducting the Review

After applying the search strings to their respective databases, the SLR protocol was executed to ensure that only studies of interest were among the selected ones.

4.1. Search in Databases and Collections

To facilitate an understanding of how the process unfolded, we will propose naming the stages, calling them steps. At this point, we present the details of our SLR process in the selected databases for the execution of this study, as well as the results obtained after the application of specific steps. As detailed earlier, certain criteria are used in the work selection process. The initial 5 steps eliminate articles that meet the requirements stipulated in the SLR protocol.

- **Step 1**: Consider only papers obtained through application of the search string in the databases;
- **Step 2**: Only papers published from 2010 onwards were considered;
- **Step 3**: Discard papers classified as Gray Literature (Short Papers, Theses, Dissertations, among others);
- **Step 4**: Consider only papers published in the English language;
- **Step 5**: Consider only papers published in the field of Computer Science.

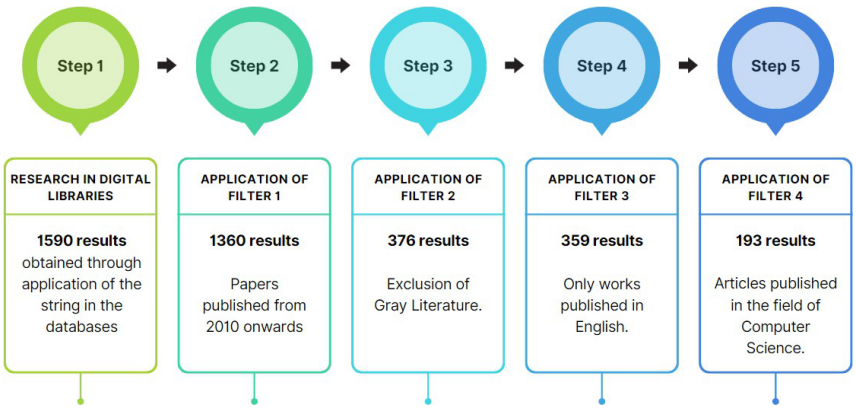


Fig. 1 – Steps applied during the search for articles in the databases.

The conduct of the SLR on all databases resulted in a total of 1.590 results. To ensure that the analysis focused on more contemporary studies, a filter was applied to include only works published from 2010 onwards (step 2 – 1), reducing the set to 1.360 articles. Next, the gray literature exclusion filter was applied, further reducing the number of results to 376 papers.

The language of publication was restricted to English, retaining the 359 articles already found. Additionally, we filtered the results, selecting only articles in the field of computer science, maintaining the set of 193 articles. These 193 articles resulting from this refinement process represent a foundation for the literature review. They will undergo an analysis based on the inclusion and exclusion criteria, as defined earlier.

[5]https://parsif.al/

4.2. Applying Inclusion and Exclusion Criteria

After refining the results obtained in the systematic literature mapping phase in all the databases surveyed, it was essential to conduct a quick assessment of the articles to ensure that only those meeting the final criteria were included in the systematic literature review.

In this stage of the process, the 193 articles resulting from the previous steps were subjected to an initial assessment. This assessment focused on the key elements of each article, including the title, abstract, introduction, and conclusion. Through this quick analysis, it was possible to identify articles that were not aligned with the inclusion criteria established earlier.

Inclusion and exclusion criteria are applied so that only articles that satisfy these criteria are kept within the scope of the mapping, while those that did not meet the final criteria were rejected for the next phase of the review. One of the exclusion criteria, for example, is the removal of duplicate articles. In this process, 25 articles that were imported were duplicates (the same article was found in at least two distinct databases).

This quick assessment approach ensured that only articles directly or indirectly related to and aligned with the research objectives were considered in the systematic literature mapping. Out of the 193 subjected to the criteria, only 24 satisfied them and will proceed to the detailed evaluation.

4.3. Temporal Distribution of Included Studies

The investigation of the timeline of studies helps to understand how the research field has evolved and how crowdsourcing and citizen-sourcing practices in municipal ombudsman offices have been addressed in academic literature. Figure 2 show the years 2017 and 2018 marked a period of substantial growth in research on the subject, with a total of seven articles published in these two years. The subsequent years, from 2019 to 2023, maintained a consistent level of interest.

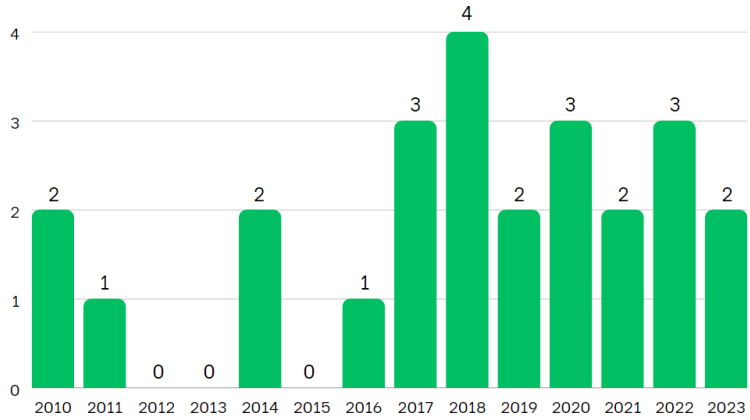


Fig. 2 – Temporal distribution of articles identified in the SLR.

Analysis of the publication timeline reveals a fluctuating but growing interest in crowdsourcing within municipal ombudsman offices. Initial interest was modest, with three articles published between 2010 and 2011. Following a period of inconsistent publication (two articles in 2014, one in 2016), a significant increase occurred in 2017-2018, with seven articles. The subsequent years (2019-2022) saw a sustained publication rate, with nine articles, suggesting continued relevance. Three articles were identified for 2023; however, this figure is partial due to potential indexing delays. This overall trend indicates an evolving field of inquiry.

Overall, the temporal distribution suggests an initial exploratory phase, followed by a period of increased research activity, and a subsequent stabilization, indicating an ongoing and evolving field of inquiry.

5. Answering the Research Questions

In this section, we answer the research questions defined in Section 3.1 and discuss them.

RQ1. *What are the main techniques of crowdsourcing and citizen-sourcing used in municipal ombudsman offices?*

The techniques of crowdsourcing and citizen-sourcing can be employed in municipal ombudsman offices to engage citizens in the process of information collection, problem-solving, and policy making (Certomà and Rizzi, 2017). These techniques leverage the collective wisdom of citizens to enhance governance and the delivery of public services (Grossman et al., 2018; Hammon and Hippner, 2012).

Among the accepted articles, Alenezy and Akhlaq, 2023; de Azambuja et al., 2014; Juk et al., 2021; Phatak, 2017, explicitly articulate a crowdsourcing-based solution for local government. While not functioning explicitly as ombudsman systems, they are deployed as a service connecting citizens with local government. Consequently, it can be inferred that the development of these solutions considered regional issues relevant to each area.

The approach presented in de Azambuja et al., 2014, describes "156 – Fala Porto Alegre," a channel used to address the demands of municipal citizens. It investigates how this channel integrates with the dimensions of a "Smart City Initiatives Framework." Although not explicitly using the terms "crowdsourcing" or "citizen-sourcing," the article discusses the integration of citizens' contributions into smart city initiatives, fitting the concept of citizen-sourcing.

The approach found in Phatak, 2017, explores the evolution of the public grievance resolution sector (PGRS) in Pakistan, emphasizing the use of information and communication technology in the complaint-handling process. The study examines how digital technologies are being used to address public complaints and improve the customer service process.

In Juk et al., 2021, the impact of the Covid-19 pandemic on public service delivery is discussed, along with the adoption of digital solutions. This article addresses digital transformation in complaint management and how services were adapted to meet citizens' needs during the pandemic.

Finally, Matos et al., 2021, describes a public complaint management system called "Fix-It," which utilizes an Android application to enable citizens to report incidents and issues to the public administration. The system involves citizens directly in communicating problems and improving public services, representing a form of citizen-sourcing.

These articles demonstrate various approaches to involving citizens in information collection, participation in problem-solving, and contributing to the improvement of municipal-level public services, even if the terms "crowdsourcing" and "citizen-sourcing" are not explicitly mentioned.

RQ2. *How have crowdsourcing and citizen-sourcing been applied to enhance citizen participation and engagement in municipal ombudsman offices?*

Crowdsourcing and citizen-sourcing have been applied to enhance citizen participation and engagement in municipal ombudsman offices in various ways. However, it is important to note that not all articles specifically address the use of these techniques in municipal ombudsman offices. Below, we highlight how these approaches are applied to improve engagement and citizen participation and which articles discuss these applications.

Crowdsourcing and citizen-sourcing are often used to collect feedback and complaints from citizens regarding public services and municipal issues. Citizens can report problems such as faulty infrastructure, lack of basic services, and environmental issues using digital platforms. Articles Adenskog et al., 2017; Alenezy and Akhlaq, 2023; Bonacin et al., 2010; Cho and Chun, 2011; Faber and Budding, 2018; Juk et al., 2021; Maciel et al., 2016; Matos et al., 2021; Phatak, 2017, mention similar approaches to **collecting feedback and complaints**.

Some municipal ombudsman offices employ crowdsourcing and citizen-sourcing to involve citizens in public consultations and decision-making processes. Citizens can contribute ideas, opinions, and suggestions through online platforms. Articles Bonacin et al., 2010; Cho and Chun, 2011; Pathmanathan and Poulier, 2017, address **public consultations and citizen participation**.

Crowdsourcing is used for the real-time **monitoring of public services**, where citizens report issues such as road potholes or lack of public lighting. This helps improve the accountability of municipal authorities. Articles Alenezy and Akhlaq, 2023; de Azambuja et al., 2014; Juk et al., 2021; Lanza et al., 2017; Matheus et al., 2010; Matos et al., 2021; Phatak, 2017; Przeybilovicz et al., 2014, mention the monitoring of public services.

Crowdsourcing and citizen-sourcing also **contribute to increased transparency** in government actions. Citizens have access to information about projects, budgets, and government activities through digital platforms. Article Villao et al., 2023 discusses the importance of transparency.

Citizen engagement is strengthened by improving communication between municipal authorities and citizens. Articles Adenskog et al., 2017; Alenezy and Akhlaq, 2023; Faber and Budding, 2018 mention **enhanced communication** through technologies.

In summary, the use of crowdsourcing and citizen-sourcing in municipal ombudsman offices has been applied to actively engage citizens, improve feedback collection, promote transparency, monitor public services, and strengthen communication between authorities and citizens. However, it is important to note that not all articles address these applications, and some focus on broader aspects of e-governance.

RQ3. *What are the reported results and benefits of using crowdsourcing and citizen-sourcing in municipal ombudsman offices?*

The selected studies in this research reveal various outcomes and benefits associated with the use of crowdsourcing and citizen-sourcing in municipal ombudsman offices. Some of the key identified outcomes and benefits include the improvement of citizen participation and engagement, increased transparency and accountability, identification of issues and solutions, among other points.

Articles Adenskog et al., 2017; Alenezy and Akhlaq, 2023; Bonacin et al., 2010; Cho and Chun, 2011; Juk et al., 2021; Maciel et al., 2016; Pathmanathan and Poulier, 2017; Ribeiro et al., 2018, cite how the use of citizen-sourcing often results in a significant increase in citizen participation, allowing more citizens to engage in solving municipal problems and policymaking. On the other hand, increased efficiency and problem resolution are discussed in Alenezy and Akhlaq, 2023; de Azambuja et al., 2014; Karkin and Janssen, 2020; Lanza et al., 2017; Phatak, 2017; Przeybilovicz et al., 2014, where it is demonstrated that real-time feedback collection and the ability of citizens to report issues directly to municipal authorities can lead to quicker and more efficient resolution of local issues.

The use of these techniques can enhance the transparency of municipal activities, making governmental information and processes more accessible to citizens. Articles Faber and Budding, 2018; Ingrams, 2018; Villao et al., 2023, discuss how these approaches can contribute to transparency. Contributions from citizens through crowdsourcing and citizen-sourcing provide feedback to municipal authorities, allowing them to better understand the needs and concerns of the community. Discussions presented in articles Bernardes et al., 2018; Matheus et al., 2010; Sharma et al., 2021 highlight the importance of feedback.

The ability for citizens to report issues directly can help authorities allocate resources more effectively and direct efforts where they are most needed, as discussed in Juk et al., 2021; Phatak, 2017; Przeybilovicz et al., 2014. Additionally, crowdsourcing and citizen-sourcing can also help identify emerging issues or trends that may not have been detected through traditional data collection methods, as mentioned in Maciel et al., 2016.

Lastly, by allowing citizens to actively participate in solving municipal problems, the use of crowdsourcing can promote citizen empowerment. The approaches Alenezy and Akhlaq, 2023; Bernardes et al., 2018; Cho and Chun, 2011; de Azambuja et al., 2014; Lanza et al., 2017 discuss how this can occur. These are some of the benefits found in the target articles studied so far.

RQ4. *What are the main limitations and challenges associated with the use of these practices in municipal ombudsman offices?*

The practices of crowdsourcing and citizen-sourcing in municipal ombudsman offices also face various limitations and challenges, as evidenced in several of the selected articles. Some of the key challenges and limitations identified are described in the next paragraph.

i **Digital Inequality**: Studies such as Przeybilovicz et al., 2014; Villao et al., 2023 highlight digital inequality as a significant challenge. Not all citizens have equal access to technology or digital skills, which can exclude vulnerable and marginalized groups from the participation process;
ii **Security and Privacy**: Articles Apleni and Smuts, 2020; Lanza et al., 2017 point out concerns about security and privacy in the use of crowdsourcing and citizen-sourcing. The collection and sharing of sensitive information can expose citizens to security risks and privacy breaches;
iii **Language and Cultural Barriers**: Maciel et al., 2016; Matheus et al., 2010; Villao et al., 2023 mention linguistic and cultural barriers as obstacles to effective participation. Ensuring that tools are accessible in different languages and culturally sensitive is a challenge;
iv **Credibility of Contributions**: Articles Adenskog et al., 2017; Ávila et al., 2022; Bernardes et al., 2018; Bonacin et al., 2010; Ingrams, 2018; Juk et al., 2021; Karkin and Janssen, 2020; Maciel et al., 2016; Matheus et al., 2010; Seidel, 2019; Villao et al., 2023 raise concerns about the credibility of citizens' contributions. It is important to distinguish between legitimate information and misleading or malicious content;
v **Institutional Resistance**: Bonacin et al., 2010; de Azambuja et al., 2014; Karkin and Janssen, 2020; Matheus et al., 2010; Sharma et al., 2021 point out that institutional resistance can be a challenge. Changes introduced by these practices may encounter resistance within existing government structures;
vi **Data Volume Management**: Articles like Faber and Budding, 2018; Pathmanathan and Poulier, 2017; Seidel, 2019 mention the challenge of managing large volumes of data generated by crowdsourcing and citizen-sourcing. Analyzing and interpreting this data can be time-consuming and require significant resources;
vii **Training and Capacity Building**: Studies including Adenskog et al., 2017; Bernardes et al., 2018; Bonacin et al., 2010; de Azambuja et al., 2014; Ingrams, 2018; Karkin and Janssen, 2020; Maciel et al., 2016; Matheus et al., 2010; Matos et al., 2021; Villao et al., 2023 emphasize the importance of training and capacity building for municipal staff to deal effectively with these practices. Lack of adequate skills can be a barrier;
viii **Legislation and Regulation**: Some articles, such as Adenskog et al., 2017; Bernardes et al., 2018; Juk et al., 2021; Pathmanathan and Poulier, 2017; Phatak, 2017; Villao et al., 2023, mention challenges related to legislation and regulation. Clear policies and regulations need to be developed to govern the use of crowdsourcing and citizen-sourcing;
ix **Platform Maintenance**: Studies like Alenezy and Akhlaq, 2023; Pathmanathan and Poulier, 2017 indicate that the continuous maintenance of digital platforms can be expensive and challenging. Ensuring that tools remain functional and up-to-date is crucial;
x **Exclusion of Marginalized Groups**: Most articles express concerns about the exclusion of marginalized groups—who may not have access to mobile devices or the Internet. This includes articles such as Bonacin et al., 2010; Durachman et al., 2020; Lanza et al., 2017; Matheus et al., 2010; Matos et al., 2021; Phatak, 2017; Przeybilovicz et al., 2014.

These challenges and limitations emphasize the importance of a careful and balanced approach when implementing crowdsourcing and citizen-sourcing in municipal ombudsman offices, considering the needs and concerns of all segments of society.

RQ5. *What methodological approaches are employed in evaluating the use of crowdsourcing and citizen-sourcing in municipal ombudsman offices?*

Various methodological approaches have been employed in assessing the use of crowdsourcing and citizen-sourcing in municipal ombudsman offices. Table 4 presents the identified methodological approaches and the articles that employ them.

These methodological approaches provided several perspectives and data to assess the use of crowdsourcing and citizen-sourcing in municipal ombudsman offices, enabling a more comprehensive understanding of their impacts and challenges.

6. Open Issues and Discussion

This systematic literature review has synthesized the current state of knowledge regarding the application of crowdsourcing in municipal ombudsman offices, revealing both promising opportunities and significant

Tab. 4 – Methodological approaches employed by each assessed paper.

Methodology	Approachs
Qualitative Research	Adenskog et al., 2017; Alenezy and Akhlaq, 2023; Ávila et al., 2022; Cho and Chun, 2011; Karkin and Janssen, 2020; Pathmanathan and Poulier, 2017; Phatak, 2017; Seidel, 2019
Quantitative Research	Faber and Budding, 2018; Lanza et al., 2017; Przeybilovicz et al., 2014; Ribeiro et al., 2018; Villao et al., 2023
Case Studies	Apleni and Smuts, 2020; Bernardes et al., 2018; Bonacin et al., 2010; de Azambuja et al., 2014; Juk et al., 2021; Matheus et al., 2010; Matos et al., 2021
Documentary Analysis	Ingrams, 2018; Maciel et al., 2016; Sharma et al., 2021
Content Analysis	Durachman et al., 2020; Sharma et al., 2021
Action Research	Pathmanathan and Poulier, 2017
Theoretical Models	Bernardes et al., 2018; Ingrams, 2018; Sharma et al., 2021
Platform Evaluation Methods	Alenezy and Akhlaq, 2023; Villao et al., 2023

challenges. While the findings demonstrate the potential of crowdsourcing to enhance citizen participation, improve service delivery, and promote government transparency, several key issues require further consideration and research.

A persistent theme across the reviewed literature is the challenge of the digital divide. Crowdsourcing initiatives, relying heavily on digital technology, can inadvertently exclude vulnerable and marginalized populations who lack access to the internet, necessary devices, or digital literacy skills (Przeybilovicz et al., 2014; Villao et al., 2023). This raises serious concerns about equity and representativeness, as simply deploying a crowdsourcing platform does not guarantee that all citizens will be able to participate equally. Future research must prioritize strategies to mitigate this digital exclusion.

The credibility and reliability of citizen-submitted data are also paramount for the success of crowdsourcing in ombudsman offices. The reviewed studies suggest the need for robust mechanisms to verify information, prevent the spread of misinformation, and address potential biases in participation (Adenskog et al., 2017; Ávila et al., 2022; Bernardes et al., 2018; Bonacin et al., 2010; Ingrams, 2018; Juk et al., 2021; Karkin and Janssen, 2020; Maciel et al., 2016; Matheus et al., 2010; Seidel, 2019; Villao et al., 2023). While some studies mention data validation techniques, there is a distinct lack of in-depth research on the effectiveness of different approaches within the specific context of ombudsman services. Future investigations should explore optimal strategies for data quality assurance.

The successful implementation of crowdsourcing requires seamless integration with existing ombudsman office workflows and processes. The literature reveals a wide range of integration levels, from standalone platforms to fully integrated systems (de Azambuja et al., 2014; Matos et al., 2021; Phatak, 2017). However, there is limited understanding of the organizational factors that facilitate or hinder this integration. Future research should investigate the impact of organizational structure, staff training and capacity building, and interdepartmental collaboration on the effectiveness of crowdsourcing initiatives. Comparative case studies examining different integration approaches could provide valuable, actionable insights for practitioners.

Beyond initial implementation, the long-term sustainability and scalability of these initiatives are often overlooked. Maintaining citizen engagement over time, ensuring ongoing platform maintenance and updates, and securing adequate funding are crucial, yet often under-researched, challenges (Alenezy and Akhlaq, 2023; Pathmanathan and Poulier, 2017). Future research should explore sustainable funding models (e.g., public-private partnerships, citizen-funded initiatives), strategies for fostering long-term citizen participation (e.g., gamification, feedback loops, community building), and the scalability of different crowdsourcing approaches to accommodate growing demands and evolving citizen needs.

The reviewed studies employ a variety of metrics to assess the impact of crowdsourcing, including participation rates, response times, and citizen satisfaction (Faber and Budding, 2018; Lanza et al., 2017; Przeybilovicz et al., 2014; Ribeiro et al., 2018; Villao et al., 2023). However, there is a lack of standardized metrics and a need for more rigorous evaluation methodologies. Future research should prioritize the development of

robust and meaningful indicators of success, considering both quantitative and qualitative measures. This includes exploring the impact of crowdsourcing on citizen empowerment, trust in government, and the overall effectiveness of ombudsman services.

Furthermore, research should move beyond short-term evaluations and investigate the long-term effects of crowdsourcing on ombudsman office performance and citizen-government relations. There are also several discussions involving how to empower citizens to take action, how those actions will impact their lives and how governments can enhance the use of those actions (Alenezy and Akhlaq, 2023; Bernardes et al., 2018; Cho and Chun, 2011; de Azambuja et al., 2014; Lanza et al., 2017).

7. Final Remarks and Future Works

After examining the studies addressing crowdsourcing and citizen-sourcing in municipal ombudsman offices, following the SLR protocol, it is possible to identify several trends and important conclusions. These studies provide insight into how these practices are being implemented, their implications, and the challenges faced in a municipal context.

One notable aspect when analyzing these studies is the diversity of methodological approaches adopted. This is indicative of the complexity and multidimensionality of the topic. One of the main motivations behind the adoption of these practices is to improve citizen participation and engagement in public policies and municipal services. The studies highlight that the use of these tools can enable citizens to actively participate in problem identification, provide feedback, and co-create solutions. This can strengthen the relationship between municipal government and its citizens, making the administration more responsive and transparent.

The examined studies suggest that crowdsourcing and citizen-sourcing have the potential to continue playing a significant role in municipal governance. However, for this to happen, it is crucial that municipal governments proactively address challenges and constraints, promote digital inclusion, and ensure the reliability and transparency of platforms.

While this systematic literature review offers a valuable synthesis of current knowledge, it has limitations that suggest future research directions. Our search, focused on specific databases and English publications, may have missed relevant studies. Quality assessment relied on the completeness and objectivity of reported information, and the limited research specifically on crowdsourcing in municipal ombudsman offices calls for further investigation. Specifically, future work should prioritize the longitudinal impacts of crowdsourcing on citizen empowerment and ombudsman effectiveness, enabling researchers and practitioners to refine implementation strategies and fully realize its transformative potential

References

Adenskog, M., Åström, J., Ertiö, T., Karlsson, M., Ruoppila, S., & Thiel, S.-K. (2017). Balancing potential and risk: The living lab approach in mobile participation research. *Electronic Participation: 9th IFIP WG 8.5 International Conference, ePart 2017, St. Petersburg, Russia, September 4-7, 2017, Proceedings 9*, 12–23.

Alenezy, F. A., & Akhlaq, M. (2023). Fix-it: Design and implementation of a public complaint management system. *2023 International Conference on Computer Science, Information Technology and Engineering (ICCoSITE)*, 858–862.

Alizadeh, T., Sarkar, S., & Burgoyne, S. (2019). Capturing citizen voice online: Enabling smart participatory local government. *Cities*, *95*, 102400.

Antero, S. (2014). Evaluating the participatory potential of the brazilian active model in the federal executive branch: An implementation perspective (2014).

Apleni, A., & Smuts, H. (2020). An e-government implementation framework: A developing country case study. *Responsible Design, Implementation and Use of Information and Communication Technology: 19th IFIP WG 6.11 Conference on e-Business, e-Services, and e-Society, I3E 2020, Skukuza, South Africa, April 6–8, 2020, Proceedings, Part II 19*, 15–27.

Ávila, T. J. T., Santos, D. G. d., & de Oliveira, R. S. (2022). Intergovernmental relations in the implementation of the public service user defense code in brazil: State capabilities and institutional arrangements. *DG.O 2022: The 23rd Annual International Conference on Digital Government Research*, 425–436.

Basili, V. R., Caldiera, G., & Rombach, H. D. (1994). Goal, question metric paradigm. encyclopedia of software engineering, vol. 1.
Batalli, M. (2015). Role of ombudsman institution over the administration. *Academic Journal of Business, Administration, Law and Social Sciences*, *1*(3).
Bernardes, M. B., de Andrade, F. P., Novais, P., & Lopes, N. V. (2018). Participatory governance of smart cities: A study upon portuguese and brazilian government portals. *Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance*, 526–536.
Bonacin, R., Melo, A. M., Simoni, C. A., & Baranauskas, M. C. C. (2010). Accessibility and interoperability in e-government systems: Outlining an inclusive development process. *Universal Access in the Information Society*, *9*, 17–33.
Boudjelida, A., Mellouli, S., & Lee, J. (2016). Electronic citizens participation: Systematic review. *Proceedings of the 9th international conference on theory and practice of electronic governance*, 31–39.
Bouzguenda, I., Alalouch, C., & Fava, N. (2019). Towards smart sustainable cities: A review of the role digital citizen participation could play in advancing social sustainability. *Sustainable Cities and Society*, *50*, 101627.
Certomà, C., & Rizzi, F. (2017). Crowdsourcing processes for citizen-driven governance. *Citizen empowerment and innovation in the data-rich city*, 57–77.
Cho, J.-S., & Chun, S. A. (2011). Towards transparent policy decision making process: A case study for seoul metropolitan government. *Proceedings of the 12th Annual International Digital Government Research Conference: Digital Government Innovation in Challenging Times*, 219–224.
Comparato, B. K. (2005). As ouvidorias de polícia no brasil: Controle e participação. *PhD diss., Universidade de São Paulo*.
da Silva, L. C. B., Loureiro, A. C., Magoni, F. M., & Gonçalves, V. M. B. (2022). Active methodologies and digital technologies in learning: A systematic literature review. *2022 17th Iberian Conference on Information Systems and Technologies (CISTI)*, 1–5.
de Azambuja, L. S., Lheureux-De-Freitas, J., Moreira, C. R., & Macadar, M. A. (2014). A smart city initiative: A case study of porto alegre 156. *Proceedings of the 15th annual international conference on digital government research*, 245–252.
Durachman, Y., Harahap, D., Rodoni, A., Bakti, A. M. F., Mansoer, M., et al. (2020). Analysis of factors that affect the quality of e-government services: A case study in ombudsman of the republic of indonesia. *2020 8th International Conference on Cyber and IT Service Management (CITSM)*, 1–7.
Estellés-Arolas, E., & González-Ladrón-de-Guevara, F. (2012). Towards an integrated crowdsourcing definition. *Journal of Information science*, *38*(2), 189–200.
Faber, A., & Budding, G. (2018). How to be open about spending: Innovating in public sector reporting in the information age. *Information Technology Science*, 137–147.
Garrigos-Simon, F. J., Gil-Pechuán, I., & Estelles-Miguel, S. (2015). *Advances in crowdsourcing*. Springer.
Grönlund, Å. (2004). State of the art in e-gov research–a survey. *International Conference on Electronic Government*, 178–185.
Grossman, G., Platas, M. R., & Rodden, J. (2018). Crowdsourcing accountability: Ict for service delivery. *World Development*, *112*, 74–87.
Hammon, L., & Hippner, H. (2012). Crowdsourcing. *Business & Information systems engineering*, *4*, 163–166.
Hassan, L., & Hamari, J. (2019). Gamification of e-participation: A literature review.
Howe, J., et al. (2006). The rise of crowdsourcing. *Wired magazine*, *14*(6), 176–183.
Ingrams, A. (2018). Public values in the age of big data: A public information perspective. policy and internet, 11 (2), 128–148.
Juk, Y., Valotto, D., Lanza, B., & Jose Tavares Avila, T. (2021). An overview of on-site contact centers in subnational governments in brazil. *DG. O2021: The 22nd Annual International Conference on Digital Government Research*, 363–375.
Karkin, N., & Janssen, M. (2020). Structural changes driven by e-petitioning technology: Changing the relationship between the central government and local governments. *Information Technology for Development*, *26*(4), 837–855.
Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering.
Lanza, B. B. B., Gil-Garcia, J. R., & Gimenez, F. A. P. (2017). Understanding the potential of mobile government in developing countries: The case of short message service (sms) use by a brazilian state government. *Proceedings of the 18th Annual International Conference on Digital Government Research*, 436–445.

Maciel, C., Cappelli, C., Slaviero, C., & Garcia, A. C. B. (2016). Technologies for popular participation: A research agenda. *Proceedings of the 17th international digital government research conference on digital government research*, 202–211.

Matheus, R., Ribeiro, M. M., Vaz, J. C., & de Souza, C. A. (2010). Internet use for social control and participation: What are local governments doing in latin america? *Proceedings of the 4th international conference on theory and practice of electronic governance*, 333–338.

Matos, E., BB Lanza, B., & D. Lara, R. (2021). Mobile government in states: Exploratory research on the development of mobile apps by the brazilian subnational government. *DG. O2021: The 22nd Annual International Conference on Digital Government Research*, 351–362.

Mourão, E., Pimentel, J. F., Murta, L., Kalinowski, M., Mendes, E., & Wohlin, C. (2020). On the performance of hybrid search strategies for systematic literature reviews in software engineering. *Information and Software Technology*, *123*, 106294.

Noh, I. H. (2022). Crowdsourcing platform acting as an intermediary role in collaborative governance. *DG. O 2022: The 23rd Annual International Conference on Digital Government Research*, 474–476.

Pathmanathan, P., & Poulier, R. (2017). A comprehensive citizen engagement framework for effective resolution of public complaints in cities. *2017 International Conference On Smart Technologies For Smart Nation (SmartTechCon)*, 1128–1133.

Phatak, S. A. (2017). 14 public complaint handling process and the usage of ict in public sector: An exploratory study of ombudsman sector of pakistan. *Pakistan Journal of Engineering and Applied Sciences*.

Pincovsky, M., Falcão, A., Nunes, W. N., Furtado, A. P., & Cunha, R. C. (2021). Machine learning applied to credit analysis: A systematic literature review. *2021 16th Iberian Conference on Information Systems and Technologies (CISTI)*, 1–5.

Polovchenko, K. A. (2019). Role of ombudsman in human rights protection in a contemporary state. *Opción: Revista de Ciencias Humanas y Sociales*, (35), 637–665.

Przeybilovicz, E., da Silva, W. V., & Cunha, M. A. (2014). Profile of the municipalities of paraná state, brazil, concerning ict infrastructure and use: A cluster analysis. *Proceedings of the 15th Annual International Conference on Digital Government Research*, 290–299.

Quintão, T. T. (2016). Parliamentary ombudsman (ouvidoria) and its democratic potential: The brazilian case. *Politikon: The IAPSS Journal of Political Science*, *31*, 5–25.

Relyea, H. C. (2002). E-gov: Introduction and overview. *Government information quarterly*, *19*(1), 9–35.

Ribeiro, M. M., Cunha, M. A., & Barbosa, A. F. (2018). E-participation, social media and digital gap: Challenges in the brazilian context. *Proceedings of the 19th annual international conference on digital government research: Governance in the data age*, 1–9.

Sánchez, D. Á., Gimilio, D. P., & Altamirano, J. I. (2015). Crowdsourcing: A new way to citizen emporwermen. *Advances in crowdsourcing. London: Springer*, 73–86.

Seidel, N. (2019). Democratic power structures in virtual communities. *Proceedings of the 24th European Conference on Pattern Languages of Programs*, 1–8.

Sharma, S., Kumar Kar, A., & Gupta, M. (2021). Unpacking digital accountability: Ensuring efficient and answerable e-governance service delivery. *Proceedings of the 14th International Conference on Theory and Practice of Electronic Governance*, 260–269.

Simonofski, A., Serral Asensio, E., De Smedt, J., & Snoeck, M. (2019). Hearing the voice of citizens in smart city design: The citivoice framework. *Business & Information Systems Engineering*, *61*, 665–678.

Simonofski, A., Snoeck, M., Vanderose, B., Crompvoets, J., & Habra, N. (2017). Reexamining e-participation: Systematic literature review on citizen participation in e-government service delivery. *AMCIS*.

Villao, D., Vera, G., Duque, V., & Mazón, L. (2023). Opportunities and challenges of digital transformation in the public sector: The case of ecuador. *International Conference on Computational Science and Its Applications*, 3–15.

Zahn, J., Mourão, E., Bernardini, F., Maciel, C., & Viterbo, J. (2024). Mapping the communication channels in the general ombudsman offices of state capitals in brazil. In Á. Rocha, C. Ferrás, J. Hochstetter Diez, & M. Diéguez Rebolledo (Eds.), *Information technology and systems* (pp. 435–445). Springer Nature Switzerland.

Zahn, J., Viterbo, J., Maciel, C., & Bernardini, F. (2024). A framework for implanting citizen-sourcing platforms in municipal ombudsman offices. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 542–554. DOI: https://doi.org/10.1145/3657054.3657118.

Is Digital Government Strengthening or Weakening Society? Exploratory Study

David Dueñas-Cid [a], Elsa Estévez [b], Tomasz Janowski [c], Grażyna Musiatowicz-Podbiał [d]*

[a] Public Sector Data-Driven Technologies Research Center, Kozminski University, Poland, dduenas@kozminski.edu.pl, https://orcid.org/0000-0002-0451-4514

[b] Departamento de Ciencias e Ingeniería de la Computación, Universidad Nacional del Sur, Argentina, ece@cs.uns.edu.ar, https://orcid.org/0000-0002-2596-4397

[c] Department of Informatics in Management, Gdańsk University of Technology, Poland and University for Continuing Education Krems, Austria, tomasz.janowski@pg.edu.pl, https://orcid.org/0000-0001-8950-5782

[d] Department of Informatics in Management, Gdańsk University of Technology, Poland, grazyna.podbial@pg.edu.pl, https://orcid.org/0000-0002-9343-1883

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. Governments are facing technical, organizational, political, financial, etc. limitations on their capacity to tackle major policy problems like pandemics, climate change, migration, etc. that endanger societal well-being, security, and development. Overcoming such limitations requires a collective response, where different members of the society – individuals and institutions – are working with government and each other to address the problem. The aim of this paper is to examine the digital transformation of government and whether the outcome – digital government – makes society stronger or weaker, thus facilitating or undermining such collective response. To this end, we examine six qualities of social development – inclusion, equality, justice, collectivism, order and democracy – which presence or absence make societies stronger or weaker, and collect the evidence from scientific literature of digital government impacting such qualities, leading to inclusive vs. exclusive societies, equal vs unequal societies, just vs. unjust societies, etc. The result of this research is a landscape of different approaches, experiences, and designs, through which digital government contributes to the presence or absence of these qualities. This result has both research and policy implications.

Keywords. Digital technology, digital government, social development, policy-relevance
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1059

1. Introduction

Traditionally, digital government research has been focused on improved service delivery, efficient administration, open decision-making, and engaged citizens. The research was mainly driven by the problems that were internal to the government or the relationships between the government and citizens. More recently, the focus has been shifting to dealing with wicked problems like pandemics, climate change, migration, etc., that no government has the capacity to handle alone, and to problems of democratic breakup that require balancing government power with societal power. Addressing such problems requires institutions and individuals to work together for the well-being, security and prosperity of all members of the society i.e., a stronger society based on cohesion, solidarity, resilience, equity, inclusion and other values.

In view of such problems and various limitations facing governments – technical, organizational, political, financial etc. to tackle them alone, whether digital government strengthens or weakens collective capacity to tackle such problems is of significant social and policy concern. Both outcomes are possible. For example, while digital government can open different electronic and traditional channels to deliver digital public services, making them more accessible to people with disabilities, by enabling automation it can also increase the burden on receiving such services especially by the vulnerable groups, including the disabled (Estevez et al., 2024). The former makes

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

society more inclusive, the latter more exclusive. Another example, by improving civic engagement and access to public services, digital government can enhance social justice (Hulstijn et al., 2024) but not having enough digital literacy and capabilities to access digital government can also lead to inequitable treatment and disenfranchisement (McNeal et al., 2008). The former makes society more just, the latter more unjust.

Based on the above, the aim of the paper is to explore the impact of digital government on society. The research question pursued is stated in the title: Does digital government strengthen or weaken society? However, the concept of the strong or weak society depends on the discipline and context. It is not easy to define. Thus, we refine this notion in terms of six qualities of social development which presence or absence make societies stronger or weaker: inclusion, equality, justice, collectivism, order, and democracy. Thus, depending on the presence or absence of these qualities, we have six contrasting statements on the impact of digital government on social development: inclusive vs exclusive society, equal vs unequal society, just vs unjust society, collaborative vs individualistic society, orderly vs disorderly society, and democratic vs undemocratic society. We are not just looking at binary answers, e.g. whether digital government leads to inclusive or exclusive society; as demonstrated above, both outcomes are possible. Instead, we aim at discovering different approaches, experiences, evidence and mechanisms through which digital government contributes to the presence or absence of these qualities. We approach this aim by systematically searching through and exploring the body of scientific literature. The main outcome is the landscape of the impact of digital government on social development, structured along the eight social qualities.

The rest of this paper is organized as follows. Section 2 presents the background, including theoretical constructs for categorizing social development. Section 3 explains the main research question and the approach adopted to address it. Section 4 describes the findings – the impact of digital government on the six qualities of social development, one subsection per quality. Finally, Section 5 discusses the findings and their implications for research and practice, and concludes the study through highlights, limitations, and directions for future research.

2. Background

Many public administrations face the challenges of adapting to the rapid social change driven and facilitated by technological developments. Since such developments go beyond the mere adoption of technological novelties and generate (positive or negative) impacts on the functioning of our societies, many expectations are posited into this process. The impact of technology adoption on the functioning of public administrations to increase their efficiency (Hilhorst et al., 2022), transparency (Matheus et al., 2021), collaboration (Gil-Garcia et al., 2023), smartness (Estevez et al., 2021), etc. are well studied. However, the societal impact of government technology adoption have not received the same level of attention (Eom & Lee, 2022) or, when it does, the focus is either on trust creation using rather simplistic approaches (Dueñas-Cid & Calzati, 2023) or reflects a significant expectation-impact gap (MacLean & Titah, 2021). This contradiction has been highlighted in the academic literature. While texts focusing on the potential impact of technology to increase participatory and deliberative capacity of citizens (Mäkinen, 2006) or the speed of service delivery (Bekkers & Zouridis, 1999) are common, research on factual impacts uncovers lack of inclusivity in participatory use of technology (Loignon et al., 2021) or biases in service delivery (Clark et al., 2013). Thus, a paper approaching such contradictions and the discussion whether digital government strengthens or weakens societies is lacking in the literature.

Nevertheless, prior to such analysis, it is necessary to pose a question: what makes a society stronger or weaker? The question is not easy to tackle since might be different definitions of stronger or weaker society put forward by different academic disciplines. The approach to that question has traditionally been indirect, focusing on related concepts with a narrower and, therefore, easier to define scope. Social science classics, such as Émile Durkheim (1893), approached the “strength” of societies through the existence and meaning of social bonds between individuals. In traditional and simpler societies, societal ties are sustained by the similarity of their members and their feeling of pertinence to strong communities. In contrast, in modern societies, societal ties are more structural, stemming from the interdependence required to deliver wellbeing (Dueñas-Cid et al., 2023). Similarly, Tönnies (2012) is linking the strength of societies to the degree of interpersonal ties and collective consciousness, that in complex societies is formalized in laws and contracts by the state. Differently, Dahrendorf (1968) argued that societal strength is influenced by the ability to deal with and institutionalize conflict. Stronger societies find a better balance between consensus and conflict, which makes them more stable and adaptable. More recently, Putnam (1995) linked the decline in civic engagement and social networks to weakening social bonds and “weaker” societies. In contrast, strong social ties and active community participation indicate "strong" societies. Alexander (2012) put the focus of strong (civil) societies on the capacity to develop solidarity, inclusiveness, and a shared commitment to democratic values.

Thus, by providing laws and contracts, and adjudicating conflicts, the state is defined as the provider of societal strength. This is especially the case with the decline and weakening of interpersonal connections. According to Kirlin (1996), the role of governments is creating institutional frameworks to shape human activities. This

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

materializes in three activities: 1) creating conditions for collective decisions, 2) making decisions to define and protect communities, and 3) delivering services (Janowski, et.al., 2018). Referring to technological adoption, the role of the state is providing conditions to facilitate such adoption as well as fostering innovation and adjusting it to the regulatory and societal frameworks where they are to be implemented (Kattel et al., 2022). The state institutions should help adopt and implement technologies, lead innovation and regulate technology used by citizens, and ensure that the technological impact is meaningful and contributes to strengthening societies (OECD, 2024). But, how to measure this impact? And how to understand what is a stronger or weaker society?

The definition of stronger or weaker society might fall into the category of concepts with symbolic meaning but open to interpretation depending on the context (Laclau, 2018). For this reason, and given the reflexive nature of this academic piece, we approached the impact of digital government on stronger or weaker societies by separately discussing such impact on six qualities that characterize such societies: inclusion, equality, justice, collectivism, order, and democracy. A strong society is one where the quality is present. A weak one is where the quality is absent. This leads to six corresponding dichotomies in Table 1: inclusive vs exclusive, equal vs unequal, just vs unjust, collaborative vs individualistic, orderly vs disorderly, and democratic vs undemocratic.

Tab. 1 - Societal dichotomies

Quality	Dichotomy	Sources	
Inclusion	Inclusive vs exclusive society	An inclusive society "actively involves all individuals in social, political, and economic processes, ensuring that diverse perspectives are valued and represented" (Marmot, 2005)	An exclusive society creates "barriers that prevent certain groups from accessing resources and opportunities, often leading to marginalization and disenfranchisement" (Young, 1990)
Equality	Equal vs unequal society	An equal society is where "all individuals have equal rights and opportunities, and where disparities in wealth and power are minimized" (Sen, 1999)	In unequal societies "the concentration of wealth and power in the hands of a few [leads] to systemic disadvantages for large segments of the population" (Piketty, 2014)
Justice	Just vs unjust society	A just society is "structured to ensure that the basic rights and liberties of all its members are protected" (Rawls, 1971)	An unjust society "fails to provide its least advantaged members with the resources and opportunities necessary to thrive" (Rawls, 1971)
Collectivism	Collaborative vs individualistic society	A collaborative society is where "individuals recognize that they are part of a larger community and that their actions can significantly affect others" (Ostrom, 1990)	An individualistic society is where "individuals are expected to take care of only themselves and their immediate families" (Hofstede, 1984)
Order	Orderly vs disorderly society	An orderly society possesses "collective consciousness that ensures that individual actions are aligned with the norms and values of the community" (Durkheim, 1893)	In disorderly societies "social norms are challenged, leading to a state of anomie where individuals feel disconnected from the collective" (Weber, 2019)
Democracy	Democratic vs undemocratic society	A democratic society allows "citizens to participate in the political process, including the right to vote and the right to run for public office" (Dahl, 1998)	In undemocratic society there is "absence of competitive elections, the suppression of political opposition, and the restriction of civil liberties" (Diamond, 2008)

3. Methodology

The research question guiding this work is "Does digital government strengthen or weaken a society?". The question was motivated and justified in section 1 and grounded and theoretized based upon existing literature in section 2. In the current section, we explain how we approached developing an answer to this question. We followed a three-step approach based on qualitative research and secondary literature data.

First, we searched the literature for different social qualities and in what sense their presence or absence make societies stronger or weaker. In this step, we used the descriptive literature review (Paré et al., 2015) to identify representative work on different qualities of social development, and inform the scoping review in step 2. The process and result are presented in section 2 and summarized in Table 1.

Second, for each quality identified in step 1, we conducted two searches in the Scopus database to gather evidence in what sense and how exactly digital government can contribute to the presence or absence of this quality, and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

thus to making the society stronger or weaker. Each search used a conjunction of two terms. One representing "digital government" and its various synonyms such as "digital governance", "e-government", "e-governance", "electronic government" or "electronic governance". Another representing the presence or absence of a given quality in society. For example, the presence of "inclusion" is expressed by: "inclusive", "equitable", "non-discriminatory", "non-racist", "unbiased" and "unprejudiced", the absence of "inclusion" is expressed by: "exclusive", "biased", "discriminatory", "inequitable", "prejudiced" and "restricted". To provide an initial indication of the size and scope of the literature, we followed the scoping literature review (Arksey, 2005).

Third, data analysis proceeded as follows. For each quality, we considered two sets of digital government-related papers, one representing the presence and another the absence of this quality. After reading the titles, abstracts and keywords, we selected the papers that most meaningfully document how digital government can contribute to the presence or absence of this quality, thus making society stronger or weaker. Based on the selected papers, we synthesized different approaches, experiences, evidence and mechanisms – policies, strategies, programs, projects, systems, etc. through which digital government contributes to the presence or absence of the quality. The findings are presented in the six subsections of Section 4, one subsection for each quality.

4. Findings

This section presents the research findings on the impact of digital government on the six qualities of social development presented in Table 1, one section each: inclusion – Section 4.1, equality – Section 4.2, justice – Section 4.3, collectivism – Section 4.4, order – Section 4.5, and democracy – Section 4.6.

4.1 Digital government for inclusive vs exclusive society

An inclusive society is "a society for all" in which every individual has rights and responsibilities, and an active role to play (United Nations, 1995). According to UNDESA (2016), five out of 11 principles of effective governance for sustainable development focus on inclusiveness – leaving no one behind, non-discrimination, participation, subsidiarity, and intergenerational equity. Social exclusion occurs on three levels – "economic exclusion from labour markets, social exclusion between people in civil society and the ever-expanding exclusionary activities of the criminal justice system and private security" giving rise to the "movement from an inclusive society of stability and homogeneity to an exclusive society of change and division" (Young, 1999).

Digital government enables reaching out to more citizens using multiple channels to deliver public services, where people can opt for the channels most suitable for them, and can shape the delivery format to make it more accessible to people with disabilities (Estevez, et al., 2024). Pro-inclusion digital government include the India Digital Ecosystem of Agriculture (Abhishek, 2022) which places farmers at the centre to promote their financial inclusion (Acharya et al., 2024). Another example is the provision of non-bureaucratic and transparent public services to citizens to supports their social inclusion and non-discrimination in Romania (Pripoaie et al., 2024). The contribution of digital government to a more inclusive society covers: 1) leaving no one behind – addressing the "needs and aspirations of all segments of society"; 2) non-discrimination – delivering "public services on general terms of equality, without distinction of any kind"; 3) participation – involving all political groups in matters that directly affect them so they can influence policy; 4) subsidiarity – being responsive to the needs and aspirations of all people; and 5) intergenerational equity – promoting prosperity and quality of life balancing the short- and long-term needs of today and future's generations (UNDESA, 2016).

According to the UNDESA (2024), governments overlook the importance of inclusivity and when public service delivery mostly relies on digital technologies, "those deprived of digital access, digital tools or digital literacy face obstacles in navigating the promises and potential of the digital era". Similarly, the automation of government can lower government decision quality. This includes street-level algorithms producing suboptimal decisions for borderline cases due to rules simplification, and the removal of exceptions to force binary decision. The most affected are the vulnerable groups who face increased bureaucracy for receiving services (Estevez, et al., 2024). For example, in South Korea, most web- and app-based information, financial, e-participation, and social welfare services are not inclusive for citizens of all ages and income levels (Kim et al., 2024). Excluding groups from accessing the Internet, increasing the burden for accessing public services to already marginalized persons, and not considering them in government decision-making are all building more exclusive societies (UNDESA, 2016).

4.2 Digital government for equal vs unequal society

Social equality means that individuals receive roughly the same resources and opportunities, while the "poorest 50% of the global population share just 8% of total income [and] the richest 10% […] earn over 50% of total income" (IISC, 2016). Economic inequalities depend on place of residence, gender, age, education, migration status, etc. Digital inequalities reflect historical patterns of inequality, such as employed vs. self-employed vs. unemployed, primary vs. secondary vs. tertiary education, urban vs. rural, men vs. women, etc. (ITU, 2018). Equality is intertwined with equity, which recognizes that people have different circumstances and allocates the resources

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and opportunities to achieve equal outcomes (SSIR, 2025). Policy interventions can reduce or exacerbate inequalities (Zach et al., 2023), including digital government.

A study from Florida, USA, showed how the 311 number provided information and services to citizens and engaged them in service coproduction, contributed to equity in power restoration after the Hurricane Michael (Xu et al., 2020). Using this number, minority groups having greater needs but less political capital were able to raise government attention, narrowing the service delivery gap. Additionally, a study of 64 Asian and African countries, part of the One Belt One Road initiative, showed that globalization and digital government improve income equality by leveraging investments, job creation, and wage increases of unskilled staff (Ullah et al., 2021).

Digital government enabling automated government decisions may lead to societal inequality. For instance, computational algorithms relying on biased data may produce discriminatory results that disadvantage people based on their race (Fountain, 2022). Thus data quality and the algorithms establishing public service eligibility, acting on such data, are potential sources of biased decisions. Data quality strategies can guard against this effect (Udoh 2020). An example from Nepal, poor accountability, and weak digital governance and institutionalisation of policies can cause inequity in universal coverage of maternal and newborn health services (Khatri et al., 2023).

4.3 Digital government for just vs unjust society

According to Rawls (1971), social justice is grounded on three principles: liberty of everyone's inalienable rights, equal opportunity, and ensuring rights for disadvantaged groups on the distribution of economic benefits. Justice is expressed by the fairness of public institutions, their management and service provision, ensuring that every citizen experiences similar outcomes (Frederickson, 2015; Ruijer et al., 2023) and cannot be compromised by efficiency gains or convenience of the privileged (Rawls, 2017). Injustice exists in two forms: moral wrongs and the denial of equal rights, and disparities in the possession or access to information and knowledge (Fricker, 2007) resulting in unfair treatment of certain people or groups (Hulstijn et al., 2024).

Digital government is enhancing justice by improving civic participation, and extending access to electronic public services (Hulstijn, 2024). The latter can reduce the distance between the public and institutions as well as among members of the public (Sanchez et al., 2013). I also offers platforms for online engagement, allowing citizens to be heard (Welby, 2019), including traditionally excluded voices, overcoming their disadvantaged positions and yielding social justice (Harrison et al., 2011). The type and quality of participation play a key role in the distribution of power and counteracting inequality and enhancing justice (Donoghue, 2017). This facilitates access to those who due to social, cultural and economic reasons cannot benefit from those liberties (Cappelletti, 1993). Thanks to open data platforms, *s*takeholders have a greater influence on the outcomes that are in their collective interest (Sanchez et al., 2013). Technology can reduce barriers to information exchange and generate stronger social bonds, partnerships and connections (Sanchez et al., 2013).

Digital government also frequently generates inequality (Hulstijn et al., 2024). Individuals lacking digital literacy and Internet connection are denied the advantages of online services (van Dijk, 2005) and subjected to inequitable treatment and disenfranchisement (McNeal et al., 2008). AI-based decision-making use rules based on the patterns found in historical data which may contain stigmatization and prejudice, producing decisions that disproportionately affect marginalized groups (Lippert-Rasmussen, 2023). Algorithms and rules are difficult to monitor and control, also for public employees or courts (Lundberg, 2019) and may contain errors that cause unjust treatment and negatively affect people's lives (Citron, 2007). Lacking human control, they expose citizens to fraud and wrong decisions (SNO, 2020). Additionally, people who lack knowledge, skills, or power to demand service are vulnerable to unfair treatment (Hulstijn et al., 2024). Technology can even amplify inequalities, as the eID system using identification through fingerprints (physical workers may be missing them) or irises (unscannable due to malnutrition), denying essential subsidies to many (Taylor, 2017).

4.4 Digital government for collaborative vs individualistic society

The complexity of modern societies is triggering the individualizing process, abandoning ways of functioning of traditional societies (Durkheim, 1893; Simmel, 1903). This effects the American society (Putnam, 1995), where individuals are constantly negotiating their identities (Giddens, 1990), and society reevaluates how institutions transmit norms of social action (Martuccelli, 2009). Increasingly, individuals are given more space to make sense of their life trajectories, expanding their capacity for self-reflection (Dubet, 1994). Technology, both a driver and a result of social transformation, acts as a catalyst for this individualization and lays the foundation for collaboration renewal. Both run in parallel but follow different rhythms: while technology's contributions to individualization are constant and latent, its contributions to collaboration are sporadic and deliberate. Technologies used in public administration, hence, can contribute in both directions. Technologies aligning with individualization are looking for user convenience and tailored service provision, while technologies fostering collaboration look for engagement and respond to the ideals of the common good.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital administration does make conscious efforts to create spaces for collaboration among individuals, aiming to connect them with common activities (Hammerschmid et al., 2023). Initiatives related to citizen participation often use digital technologies to encourage physical participation or to channel participation digitally, without direct contact but facilitating exchange and deliberation (Borge et al, 2023). Other forms of open government seek to engage the population in co-creation and co-management of administrative tasks (Nikiforova et al., 2023). However, these efforts face challenges similar to in-person initiatives. These include participants' segmentation, where only the most active engage, and the challenges of attracting certain groups even when they are central to the topic at hand. Many individuals feel ignored by the administration or lack the digital skills to participate.

Digital government has not escaped the individualistic trend. The availability of data on individual activity enables personalized forms of interaction, with governments being a major collector of such data. This facilitates personalized services, tailored to individual needs and driven by available data (Maksimova et al., 2021). This need not mean promoting individualization but adapting to the social process and reflecting the consumerization of digital government (Gaß et al., 2015). Other areas include the fragmentation of previously collective processes, such as social or electoral participation, which become remote (Unt et al., 2017), running in parallel with other processes that reduce interpersonal contact by depersonalizing service provision (Pieterson et al., 2007). The local administration which played a central role in social life, has its influence weakened due to digitalization. Digital government does not appear to be a primary driver of individualization, it adapts to this trend.

4.5 Digital government for orderly vs disorderly society

According to Durkheim (2018), social order entails the establishment of commonly shared beliefs, values, norms, practices, and interactions of daily life. Social order can be imposed (Kurawa, 2012) or part of "social contract" that transfers individual liberties to a coercive state in return for security of persons and their properties, and the establishment of dispute-resolution mechanisms (Hechte & Horne, 2003). Conversely, "disorder" is the non-compliance of norms (Weber, 2019) or delinquency of individuals against established rules (Wilson et al., 1982), resulting in unrest, crime, polarization, protests, etc. Not every disagreement is a disorder, e.g. worker strikes, but rigid response to unrest can lead to escalating levels of disorder. A certain degree of disorder may represent a democratic and inclusive society (Marshall, 2010) or give a rise to new order (Kurawa, 2012).

Digital government is recognized for its potential to enhance social order. Adequate service quality provisioned by government enhances stability and accountability (Amiantova et al., 2021). Enhanced efficiency and transparency represent predictability, a key element in social order (Janssen et al., 2015). Against citizen disappointment resulting in unrest, accessible and efficient services build trust and confidence (Bell et al., 2022). So is improved two-way interaction between government and citizens (Drummond et al., 2023). Digital government platforms (Bonina et al., 2021) facilitate collaboration, from information sharing through co-production to self-governance (Linders, 2012). They also channel dispute resolution, reducing dissatisfaction (Lukman et al., 2024), defusing collective action (Hu, et al., 2024), and enhancing respect to rules.

Governments can also use technology-based means to tighten social control through surveillance technologies like in China (Lee, 2019) or India (Rao et al., 2019). Using predictive policing (Graham, 1998), governments introduce 'data politics' (Ruppert et al., 2017) or 'digital authoritarianism' (Dragu et al., 2021) for political dominance and control (Bulman et al., 2021). Monitoring political opponents through technology-based mechanisms, so-called preventive repression (Dragu & Przeworski, 2019), results in extensive surveillance and control and destabilizing the balance of power between the state and citizens (Schlæger, 2013; Rao et al., 2019). The wide use of surveillance infrastructure increases the exposure to cyber-attacks, which ultimately destabilize society. In 2007, Estonia experienced cybersecurity incidents disrupting government and business institutions, heightening tensions among ethnic groups and raising social instability (Evron, 2008).

4.6 Digital government for democratic vs undemocratic society

Responding to political disaffection of citizens, recent years were prolific in technologies to improve democracy (Torcal, 2003). According to Fierro et al. (2022), this disaffection is the result of the lack of citizen engagement and responsiveness by the authorities. Technology, hence, has been called to help improve the capacity of citizens to engage with institutions and the institutions' capacity to interact with citizens (Sandoval-Almazán et al., 2017). We can also see how some technologies fail to produce the expected outcomes for technical (Dueñas-Cid, 2024), organizational (Dueñas-Cid et al., 2020) or societal (Toots, 2019) reasons. Certain technologies also challenge the democracy (Musiani, 2014) or are exploited by nondemocratic regimes (Romanov & Kabanov, 2020).

The evidence of technology use to improve the democracy is diverse. Some efforts are centred on increasing user convenience and lowering the participation barriers, the assumption being that those interested will participate (Dueñas-Cid et al., 2025). The search for usability has been quite successful, and technology increased inclusivity (Bricout et al., 2021) and reduced the cost of participation (Ford, 2021). Technology also enriched participatory practices (Stein, 2025), and forms of engagement (James et al., 2023) and interaction with representatives (Scacco

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

et al., 2021). The COVID-19 pandemic forced a rethink of democratic practices and considering alternatives (Rodríguez-Pérez et al., 2020). One example is internet voting, i.e. casting election ballots online, which several countries consider for voting abroad and, increasingly, domestically.

Technology is also partly blamed for democratic decline. Some argue that it desacralizes democratic rituals and makes participation less social (Unt et al., 2017). Concerns are also raised that voting in non-supervised environments might facilitate coercion (Kulyk et al., 2020) or buying (Benoist et al., 2007) as happens with postal voting (Shenker et al., 2014). However, technology also provides preventive measures. Voting technologies are adopted by countries with dubious democratic standards, raising the risk of external attacks and manipulating results. The use of social media by political agents, including government, is also contributing to political tensions and undermining the democratic functioning (Reisach, 2021). Governments are generally unable to reduce the harm created by social media while political agents take advantage to gain influence (Gupta-Carlson, 2016) or use data irregularly to tailor their political campaigns (Hinds et al., 2020).

5. Conclusions

The main research question pursued in this article was: Does digital government strengthen or weaken society? To answer this question, we identified a rich body of literature documenting the impact of digital government, with varying direction, nature, scope and origin of impact, on six qualities of social development. We uncovered the use of many technologies – artificial intelligence, cybersecurity, digital identification, digital platforms, internet voting and social media; and design concepts – digital authoritarianism, co-creation and co-production, dispute resolution, multi-channel service delivery, open data platforms, predictive policing, self-governance, service personalization, street-level algorithms, surveillance, two-directional interaction, and unattended AI-based decision-making. We also uncovered system analysis – 311 number, electronic identification using fingerprints and iris scanning, and cybersecurity incidents; as well as national initiatives from China, Estonia, India, Nepal, Romania and South Korea, and international ones like the One Belt One Road. Table 2 summarizes some examples from Section 4 how digital government impacts the six qualities of social development.

Tab. 2 – Digital government impact on the six qualities of social development

Quality	Digital government impact on the quality	
	Positive impact	Negative impact
Inclusion	Delivering public services through multiple channels to reach out, shaping the delivery format to fit the needs of the audience.	Excluding groups lacking digital access or skills, increasing burden on the vulnerable from automated services.
Equality	Service coproduction by minority groups with greater needs but less political capital can narrow the service delivery gap.	Algorithms relying on historical data may be sources of bias, causing inequality treatment of different social groups.
Justice	Platforms for online engagement, allow excluded voices to be heard, and yield decisions characterized by social justice.	Closed algorithms and the rules/data on which they act expose citizens, especially the vulnerable, to wrongful decisions.
Collectivism	Creating personalized services, tailored to individual needs and driven by available data, depersonalizing service provision.	Creating collaboration spaces by connecting citizens with common activities – exchange, deliberation, co-creation, etc.
Order	Platforms channel dispute resolution, reduce dissatisfaction, and defuse collective actions, facilitate social order.	Digital surveillance, repression and authoritarianism destabilize the balance of power between the state and citizens.
Democracy	Increasing user convenience, new forms of engagement, and lowering the barriers to participation in democratic processes.	The use of social media contributing to political tension and undermining the functioning of the democratic life.

This work has four main research implications. Against predominant focus in digital government research on digital transformation of public administration and government-citizen relationships, it sets forth to study the impact of digital government on citizen-citizen relationships and social development in general. It outlines a methodology to tackle the research question based on qualitative research and literature review. It uncovers six qualities of social development – inclusion, equality, justice, collectivism, order and democracy, to measure the impact of digital government. It offers initial results on the nature of that impact - approaches, experiences, and designs, uncovering the complex nature of the relationship between digital government and social development.

This work also has some policy implications. First, digital government exerts a significant and wide-ranging impact on social development, documented across all six qualities of such development. Second, the evidence confirms positive and negative impact, strengthening or weakening society by ensuring the presence or absence of the qualities. Third, to impact societal development, digital government employs a wide range of technologies, designs and policy contexts. Fourth, this diversity may explain radically different outcomes and highlight the importance

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of explicit social impact goals, and technology, design and policy decisions to match them.

This research has some limitations. The first its limited theoretical background and thus the coverage of relevant qualities of social development; some qualities like, e.g. coherence – integrated vs polarized society, and freedom – free vs oppressed society are missing from the study. The second is not strictly following the systematic literature review and employing rather liberal decisions about excluding certain literature positions. Thus, the documented impact of digital government on social development falls short of being comprehensive. The third is the analysis not accounting for different qualities influencing each other, e.g. inclusion influencing equality, equality justice, justice order, etc. and vice-versa. Thus, some qualities may share literature. The fourth is the lack of policy analysis to complement literature analysis, to establish measurable impact of digital government on social development in various national and sectoral contexts.

Future work might focus on overcoming some of these limitations. One direction of future research is pursuing a study of the qualities of social development impacted by digital government, aimed at producing a theoretical framework able to measure the nature, direction, source and scale of the impact. The second is applying this framework to landscape the impact of digital government on social development based on the systematic review of the scientific and policy literature. The third is focusing the impact studies on specific countries or regions, to inform digital government design for achieving the expected social development outcomes. How such outcomes (and indirectly digital government) can enable the whole-of-society response to major policy problems like pandemics, climate change, migration, etc. is yet another direction. Finally, the complex nature of the societal impact limits the mitigation/reinforcement strategies to be valid for every technology, administration or society. Thus the fifth direction is examining specific cases of technology use for concrete administrations and societies to assess their impact and inform relevant mitigation/reinforcement strategies for the negative/positive impact.

Funding or Grant

The work of David Dueñas-Cid has been funded by the Polish National Research Center (Grant OPUS-20 - 2020/39/B/HS5/01661).

Use of AI

During the preparation of this work, the authors used ChatGPT and Grammarly to revise and ensure the correctness of the text. The authors take full responsibility for the content of the publication.

References

AAbhishek, B. (2022). *India Digital Ecosystem of Agriculture and Agristack: An initial assessment* (ICT Indian Working Paper No. 68). Center for Sustainable Development, Earth Institute, Columbia University. https://csd.columbia.edu/sites/default/files/content/docs/ICT%20India/Papers/ICT_India_Working_Paper_68.pdf

Acharya, S., & Swadimath, U. C. (2024). Digital financial inclusion and economic empowerment of farmers in India. In *Utilizing technology for sustainable resource management solutions*. https://doi.org/10.4018/979-8-3693-2346-5.ch019

Alexander, J. C. (2012). *The civil sphere*. Oxford University Press.

Amiantova, I. S., Ivanova, E. A., & Glebov, V. A. (2021). Information technologies as growth factor in political stability. In I. V. Kovalev, A. A. Voroshilova, & A. S. Budagov (Eds.), *Economic and social trends for sustainability of modern society (ICEST-II 2021)* (Vol. 116, pp. 1744–1751). European Publisher. https://doi.org/10.15405/epsbs.2021.09.02.19

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology*, 8(1), 19–32.

Bağcı, İ. (2018). Understanding of sovereignty in the establishment of social order and freedom of the individual according to Thomas Hobbes. *International Journal of Eurasia Social Sciences*, 9(31), 440–463.

Bekkers, V. J. J. M., & Zouridis, S. (1999). Electronic service delivery in public administration: Some trends and issues. *International Review of Administrative Sciences*, 65(2), 183–195. https://doi.org/10.1177/0020852399652004

Benoist, E., Anrig, B., & Jaquet-Chiffelle, D. O. (2007). Internet-voting: Opportunity or threat for democracy? In A. Alkassar & M. Volkamer (Eds.), *E-voting and identity. Vote-ID 2007* (Lecture Notes in Computer Science, Vol. 4896, pp. 41–56). Springer. https://doi.org/10.1007/978-3-540-77493-8_3

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Bell, K., & Reed, M. (2022). The tree of participation: A new model for inclusive decision making. *Community Development Journal*, 57(4), 595–614. https://doi.org/10.1093/cdj/bsab01

Bonina, C., Koskinen, K., Eaton, B., & Gawer, A. (2021). Digital platforms for development: Foundations and research agenda. *Information Systems Journal*, 31(6), 869–902. https://doi.org/10.1111/isj.12326

Borge, R., Brugué, Q., & Dueñas-Cid, D. (2022). Technology and democracy: The who and how in decision-making. The cases of Estonia and Catalonia. *El Profesional de la Información*, 31(3). https://doi.org/10.3145/epi.2022.may.11

Borge, R., Balcells, J., & Padró-Solanet, A. (2023). Democratic disruption or continuity? Analysis of the Decidim platform in Catalan municipalities. *American Behavioral Scientist*, 67(7), 926–939.

Bricout, J., Baker, P., Moon, N., & Sharma, B. (2021). Exploring the smart future of participation: Community, inclusivity, and people with disabilities. *International Journal of E-Planning Research (IJEPR)*, 10(2), 94-108.

Bulman, D. J., & Jaros, K. A. (2021). Localism in retreat? Central-provincial relations in the Xi Jinping era. *Journal of Contemporary China*, 30(131), 697–716. https://doi.org/10.1080/10670564.2021.1889228

Cappelletti, M. (1993). Alternative dispute resolution processes within the framework of the world wide access to justice movement. *Modern Law Review*, 56(3), 282-296.

Citron, D. K. (2007). Technological due process. *Washington University Law Review*, 85, 1249-1313.

Clark, B. Y., Brudney, J. L., & Jang, G. (2013). Coproduction of government services and the new information technology: Investigating the distributional biases. *Public Administration Review*, 73(5), 687–701. https://doi.org/10.1111/puar.12092

Czosseck, C., Ottis, R., & Talihärm, A. M. (2013). Estonia after the 2007 cyber attacks: Legal, strategic and organisational changes in cyber security. In *Case studies in information warfare and security: For researchers, teachers and students* (pp. 72–82). IGI Global.

Dahl, R. A. (1998). *On democracy*. Yale University Press.

Dahrendorf, R. (1968). *Essays in the theory of society*. Routledge.

Diamond, L. (2008). *The spirit of democracy: The struggle to build free societies throughout the world*. Macmillan.

Donoghue, J. (2017). The rise of digital justice: Courtroom technology, public participation and access to justice. *The Modern Law Review*, 80(6), 995–1025.

Dragu, T. & Lupu, Y. (2021). Digital Authoritarianism and the Future of Human Rights. *International Organization*. 75(4), 991-1017. https://doi.org/10.1017/S0020818320000624

Dragu, T., & Przeworski, A. (2019). Preventive repression: Two types of moral hazard. *American Political Science Review*, 113(1), 77–87. https://doi.org/10.1017/S0003055418000552

Drummond, C., McGrath, H., & O'Toole, T. (2023). Beyond the platform: Social media as a multifaceted resource in value creation for entrepreneurial firms in a collaborative network. *Journal of Business Research*, 158, Article 113669. https://doi.org/10.1016/j.jbusres.2023.113669

Dubet, F. (1994). La sociologie de l'expérience. Seuil.

Dueñas-Cid, D., Krivonosova, I., Serrano, R., Freire, M., & Krimmer, R. (2020). Tripped at the finishing line: The Åland Islands Internet Voting Project. In R. Krimmer et al. (Eds.), *Electronic Voting: 5th International Joint Conference, E-Vote-ID 2020, Bregenz, Austria, October 6–9, 2020, Proceedings* (pp. 36–49). Springer.

Dueñas-Cid, D., & Calzati, S. (2023). Dis/Trust and data-driven technologies. *Internet Policy Review, 12*(4). https://doi.org/10.14763/2023.4.1727

Dueñas-Cid, D., Estevez, E., & Janowski, T. (2023). Conceptualizing digital government for social solidarity. In D. Dueñas-Cid et al. (Eds.), *Proceedings of the 24th Annual International Conference on Digital Government Research* (pp. 669–670). ACM. https://doi.org/10.1145/3598469.3598552

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Dueñas-Cid, D. (2024). Trust and distrust in electoral technologies: What can we learn from the failure of electronic voting in the Netherlands (2006/07). In H. Ch. Liao et al. (Eds.), *Proceedings of the 25th Annual International Conference on Digital Government Research* (pp. 669–677). ACM. https://doi.org/10.1145/3657054.3657262

Dueñas-Cid, D., & Loeber, L. (2025). Election and voting technologies. In H. A. Garnett & T. James (Eds.), *Oxford Handbook of Electoral Integrity* (In press). Oxford University Press.

Durkheim, É. (1893). *De la division du travail*. FB Editions.

Durkheim, É. (2018). The division of labor in society. In *Social stratification* (pp. 217–222). Routledge.

Eom, S., & Lee, J. (2022). Digital government transformation in turbulent times: Responses, challenges, and future direction. *Government Information Quarterly, 39*(2), https://doi.org/10.1016/j.giq.2022.101690

Estevez, E., Pardo, T., & Scholl, H. (2021). *Smart cities and smart governance*. Springer. https://doi.org/10.1007/978-3-030-61033-3

Estevez, E., Janowski, T., & Roseth, B. (2024). *When does automation in government thrive or flounder?* Inter-American Development Bank. https://publications.iadb.org/en/when-does-automation-government-thrive-or-flounder

Evron, G. (2008). Battling botnets and online mobs: Estonia's defense efforts during the internet war. *Georgetown Journal of International Affairs, 9*(1), 121–126.

Fierro, P., Aroca, P., & Navia, P. (2022). Political disaffection in the digital age: The use of social media and the gap in internal and external efficacy. *Social Science Computer Review, 41*(5), 1857-1876.

Ford, B. (2021). Technologizing democracy or democratizing technology? A layered-architecture perspective on potentials and challenges. In L. Bernholz et al. (Eds.), *Digital technology and democratic theory* (pp. 274–321). University of Chicago Press. https://doi.org/10.7208/9780226748603-011

Fountain, J. (2022). The moon, the ghetto and artificial intelligence: Reducing systemic racism in computational algorithms. *Government Information Quarterly, 39*(2). https://doi.org/10.1016/j.giq.2021.101645

Frederickson, H. G. (2015). *Social equity and public administration: Origins, developments, and applications*. Routledge. https://doi.org/10.4324/9781315700748

Fricker, M. (2007). *Epistemic injustice: Power and the ethics of knowing*. Oxford University Press.

Friedkin, N. E. (2004). Social cohesion. *Annual Review of Sociology,* 30(1), 409–425.

Gaß, O., Ortbach, K., Kretzer, M., Maedche, A., & Niehaves, B. (2015). Conceptualizing individualization in information systems – A literature review. *Communications of the Association for Information Systems, 37*. https://doi.org/10.17705/1CAIS.03703

Giddens, A. (1990). *The consequences of modernity*. Stanford University Press.

Gil-Garcia, J. R., Gasco-Hernandez, M., & Pardo, T. A. (2023). Making sense of open government: A conceptual framework and ideas for future research. *Perspectives on Public Management and Governance, 6*(2–3), 80–93. https://doi.org/10.1093/ppmgov/gvad005

Graham, S. (1998). Spaces of surveillant simulation: New technologies, digital representations, and material geographies. *Environment and Planning: Society and Space, 16*(4), 483–504. https://doi.org/10.1068/d160

Gupta-Carlson, H. (2016). Re-imagining the nation: Storytelling and social media in the Obama campaigns. *PS: Political Science & Politics, 49*(1), 71–75.

Hammerschmid, G., Palaric, E., Rackwitz, M., & Wegrich, K. (2023). A shift in paradigm? Collaborative public administration in the context of national digitalization strategies. *Governance, 37*(2), 411–430. https://doi.org/10.1111/gove.12778

Harrison, T. M., Guerrero, S., Burke, G. B., Cook, M., Cresswell, A., Helbig, N., ... & Pardo, T. (2011). Open

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

government and e-government: Democratic challenges from a public value perspective. In *Proceedings of the 12th Annual International Digital Government Research Conference* (pp. 245–253).

Hechter, M., & Horne, C. (2003). *Theories of social order: A reader*. Stanford University Press.

Hilhorst, C., Behrens, C., Brouwer, E., & Sneller, L. (2022). Efficiency gains in public service delivery through information technology in municipalities. *Government Information Quarterly, 39*(4). https://doi.org/10.1016/j.giq.2022.101724

Hinds, J., Williams, E., & Joinson, A. (2020). "It wouldn't happen to me": Privacy concerns and perspectives following the Cambridge Analytica scandal. *International Journal of Human-Computer Studies, 143*. https://doi.org/10.1016/j.ijhcs.2020.102498

Hofstede, G. (1984). *Culture's consequences: International differences in work-related values* (Vol. 5). Sage.

Hu, J., & Zhang, X. (2024). Digital governance in China: Dispute settlement and stability maintenance in the digital age. *Journal of Contemporary China, 33*(148), 561–577. https://doi.org/10.1080/10670564.2023.2261877

Hulstijn, J., Dong, H., & Markovich, R. (2024). Epistemic injustice and government information systems: Lessons from two cases. In M. Janssen et al. (Eds.), *Electronic Government. EGOV 2024* (Vol. 14841, pp. 419-437. Springer. https://doi.org/10.1007/978-3-031-70274-7_26

Interaction Institute for Social Change (IISC). (2016). *Illustrating equality vs equity*. https://interactioninstitute.org/illustrating-equality-vs-equity/

ITU. (2018). *Measuring the information society report 2018* (Vol. 1). https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2018/MISR-2018-Vol-2-E.pdf

Janowski, T., Estevez, E., & Baguma, R. (2018). Platform governance for sustainable development: Reshaping citizen-administration relationships in the digital age. *Government Information Quarterly, 35*(4), S1–S16. https://doi.org/10.1016/j.giq.2018.09.002

James, T. S., & Garnett, H. A. (2023). The determinants of electoral registration quality: A cross-national analysis. *Representation, 60*(2), 279–302. https://doi.org/10.1080/00344893.2023.2207194

Janssen, M., & Wimmer, M. A. (2015). Introduction to policy-making in the digital age. In *Policy practice and digital science: Integrating complex systems, social simulation and public administration in policy research* (pp. 1–14). Springer.

Karmaker, C. L., Al Aziz, R., Palit, T., & Bari, A. M. (2023). Analyzing supply chain risk factors in the small and medium enterprises under fuzzy environment: Implications towards sustainability for emerging economies. *Sustainable Technology and Entrepreneurship, 2*(1), Article 100032. https://doi.org/10.1016/j.stae.2022.100032

Kattel, R., Drechsler, W., & Karo, E. (2022). *How to make an entrepreneurial state: Why innovation needs bureaucracy*. Yale University Press.

Keyes, C. L. M. (1998). Social well-being. *Social Psychology Quarterly*, 61(2), 121–140.

Khatri, R. B., Assefa, Y., & Durham, J. (2023). Multidomain and multilevel strategies to improve equity in maternal and newborn health services in Nepal: Perspectives of health managers and policymakers. *International Journal for Equity in Health, 22*(1), 105. https://doi.org/10.1186/s12939-023-01905-7

Kim, Y., & Lee, J. (2024). Digitally vulnerable populations' use of e-government services: Inclusivity and access. *Asia Pacific Journal of Public Administration, 46*(4), 422–446. https://doi.org/10.1080/23276665.2024.2321569

Kirlin, J. (1996). What government must do well: Creating value for society. *Journal of Public Administration Research and Theory, 6*(1), 161–185. https://doi.org/10.1093/oxfordjournals.jpart.a024298

Kulyk, O., & Neumann, S. (2020). Human factors in coercion resistant internet voting – A review of existing solutions and open challenges. In R. Krimmer et al. (Eds.), *Fifth International Joint Conference on Electronic Voting (E-Vote-ID 2020)*. TalTech Press.

Kurawa, S. S. (2012). Social order in sociology: Its reality and elusiveness. *Sociology Mind, 2*(1), 34–40.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

http://dx.doi.org/10.4236/sm.2012.21004

Laclau, E. (2018). *On populist reason*. Verso.

Larsson, K. K. (2021). Digitization or equality: When government automation covers some, but not all citizens. *Government Information Quarterly, 38*(1), 101547. https://doi.org/10.1016/j.giq.2020.101547

Lee, C. S. (2019). Datafication, dataveillance, and the social credit system as China's new normal. *Online Information Review, 43*(6), 952–970. https://doi.org/10.1108/OIR-08-2018-0231

Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Government Information Quarterly, 29*(4), 446–454. https://doi.org/10.1016/j.giq.2012.06.003

Lippert-Rasmussen, K. (2023). Using (un)fair algorithms in an unjust world. *Res Publica, 29*(2), 283–302.

Loignon, C., Dupéré, S., Leblanc, C., et al. (2021). Equity and inclusivity in research: Co-creation of a digital platform with representatives of marginalized populations to enhance the involvement in research of people with limited literacy skills. *Research Involvement and Engagement, 7*, 70. https://doi.org/10.1186/s40900-021-00313-x

Lukman, S., & Hakim, A. (2024). Agile governance, digital transformation, and citizen satisfaction moderated by political stability in Indonesia's socio-political landscape. *Journal of Ethnic and Cultural Studies, 11*(1), 210–228.

Lundberg, E. (2019). Automated decision-making vs indirect discrimination: Solution or aggravation? [Master's thesis, Umeå University]. https://umu.diva-portal.org/smash/record.jsf?pid=diva2%3A1331907&dswid=-2708

MacLean, D., & Titah, R. (2021). A systematic literature review of empirical research on the impacts of e-government: A public value perspective. *Public Administration Review, 82*(1), 23–38. https://doi.org/10.1111/puar.13413

Mäkinen, M. (2006). Digital empowerment as a process for enhancing citizens' participation. *E-Learning and Digital Media, 3*(3), 381–395. https://doi.org/10.2304/elea.2006.3.3.381

Maksimova, M., Solvak, M., & Krimmer, R. (2021). Data-driven personalized e-government services: Literature review and case study. In N. Edelmann et al. (Eds.), *Electronic participation (ePart 2021), Lecture Notes in Computer Science* (Vol. 12849, pp. 151-165). Springer. https://doi.org/10.1007/978-3-030-82824-0_12

Marmot, M., & Wilkinson, R. (Eds.). (2005). *Social determinants of health*. Oxford University Press.

Marshall, J. (2010). Social disorder as a social good. *Cosmopolitan Civil Societies: An Interdisciplinary Journal, 2*(1), 21–46. https://doi.org/10.5130/ccs.v2i1.1337

Martuccelli, D. (2009). Qu'est-ce qu'une sociologie de l'individu moderne? Pour quoi, pour qui, comment? *Sociologies et société des individus, 41*(1), 15–33.

Matheus, R., Janssen, M., & Janowski, T. (2021). Design principles for creating digital transparency in government. *Government Information Quarterly, 38*(1). https://doi.org/10.1016/j.giq.2020.101550

McNeal, R., Hale, K., & Dotterweich, L. (2008). Citizen–government interaction and the Internet: Expectations and accomplishments in contact, quality, and trust. *Journal of Information Technology & Politics, 5*(2), 213–229.

Musiani, F. (2014). Avant-garde digital movement or "digital sublime" rhetoric? The Movimento 5 Stelle and the 2013 Italian parliamentary elections. In B. Pătruț & M. Pătruț (Eds.), *Social media in politics: Case studies on the political power of social media* (pp. 127–140). Springer.

Nikiforova, A., Flores, M. A. A., & Lytras, M. D. (2023). The role of open data in transforming the society to Society 5.0: A resource or a tool for SDG-compliant smart living? In M. D. Lytras et al. (Eds.), *Smart cities and digital transformation* (pp. 219–252). Emerald Publishing Limited. https://doi.org/10.1108/978-1-80455-994-920231011

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

OECD. (2024). *OECD agenda for transformative science, technology and innovation policies* (OECD Science, Technology and Industry Policy Papers No. 164). OECD Publishing. https://doi.org/10.1787/ba2aaf7b-en

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press.

Paré, G., Trudel, M.-C., Jaana, M., & Kitsiou, S. (2015). Synthesizing information systems knowledge: A typology of literature reviews. *Information & Management, 52*(2), 183–199.

Pieterson, W., Ebbers, W., & van Dijk, J. (2007). Personalization in the public sector: An inventory of organizational and user obstacles towards personalization of electronic services. *Government Information Quarterly, 24*(1), 148–164. https://doi.org/10.1016/j.giq.2005.12.001

Piketty, T. (2014). *Capital in the twenty-first century* (A. Goldhammer, Trans.). Belknap Press.

Pripoaie, R., Schin, G. C., & Matic, A. E. (2024). Post-pandemic exploratory analysis of the Romanian public administration digitalization level in comparison to the most digitally developed states of the European Union. *Sustainability, 16*(11), Article 4652. https://doi.org/10.3390/su16114652

Putnam, R. (1995). Bowling alone: America's declining social capital. *Journal of Democracy, 6*(1), 65–78.

Rao, U., & Nair, V. (2019). Aadhaar: Governing with biometrics. *South Asia: Journal of South Asian Studies, 42*(3), 469–481. https://doi.org/10.1080/00856401.2019.1595343

Rawls, J. (1971). *A theory of justice*. Harvard University Press.

Reisach, U. (2021). The responsibility of social media in times of societal and political manipulation. *European Journal of Operational Research, 291*(3), 906–917.

Rodríguez-Pérez, A., & Puiggalí, J. (2020). Con el voto (telemático) no es suficiente: Herramientas digitales para el funcionamiento remoto de parlamentos y asambleas. In J. Reniu & J. Meseguer (Eds.), *¿Política confinada? Nuevas tecnologías y toma de decisiones en un contexto de pandemia* (pp. 195–216). Aranzadi Thomson Reuters.

Romanov, B., & Kabanov, Y. (2020). The oxymoron of the Internet voting in illiberal and hybrid political contexts. In R. Krimmer et al. (Eds.), *Electronic voting. E-Vote-ID 2020. Lecture Notes in Computer Science* (Vol. 12455). Springer. https://doi.org/10.1007/978-3-030-60347-2_12

Ruijer, E., Porumbescu, G., Porter, R., & Piotrowski, S. (2023). Social equity in the data era: A systematic literature review of data-driven public service research. *Public Administration Review, 83*(2), 316–332.

Ruppert, E., Isin, E., & Bigo, D. (2017). Data politics. *Big Data & Society, 4*(2). https://doi.org/10.1177/2053951717717749

Sanchez, T. W., & Brenman, M. (2013). Public participation, social equity, and technology in urban governance. In *Citizen e-participation in urban governance: Crowdsourcing and collaborative creativity* (pp. 35–48). IGI Global.

Sandoval-Almazán, R., Luna-Reyes, L., Luna-Reyes, D., Gil-Garcia, J. R., Puron-Cid, G., & Picazo-Vela, S. (2017). Fostering citizen engagement. In R. Sandoval-Almazán et al. (Eds.), *Building digital government strategies: Principles and practices* (pp. 95–106). Springer. https://doi.org/10.1007/978-3-319-60348-3_8

Scacco, J., & Coe, K. (2021). *The ubiquitous presidency: Presidential communication and digital democracy in tumultuous times*. Oxford University Press. https://doi.org/10.1093/oso/9780197520635.001.0001

Schiefer, D., & Van der Noll, J. (2017). The essentials of social cohesion: A literature review. *Social Indicators Research, 132*, 579–603.

Schlæger, J. (2013). *E-government in China: Technology, power and local government reform*. Routledge. https://doi.org/10.4324/9780203760550

Sen, A. (1999). *Development as freedom*. Oxford University Press.

Shenker, J., & Álvarez, M. (2014). Mitigating coercion, maximizing confidence in postal elections. *USENIX Journal of Election Technology and Systems, 2*(3), 57–73.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Simmel, G. (1903/1950). The metropolis and mental life. In K. Wolff (Ed.), *The sociology of Georg Simmel* (pp. 409–424). Free Press.

Swedish National Audit Office (SNO). (2020). *Audit reports 2020: Automated decision-making in public administration*. https://www.riksrevisionen.se/en/audits/audit-reports/2020/automated-decision-making-in-public-administration---effective-and-efficient-but-inadequate-control-and-follow-up.html

Stanford Social Innovation Review (SSIR). (2025). Bringing equality to implementation: Incorporating community experience to improve outcomes. https://ssir.ebookhost.net/ssir/digital/75/index.php?e=75&open=1

Stein, C. (2025). The devil is in the details? Investigating 3D visualization types for e-participation in urban planning. In T. X. Bui (Ed.), *Proceedings of the 58th Hawaii International Conference on System Sciences*. (pp. 2071-2080). ScholarSpace.

Taylor, L. (2017). What is data justice? The case for connecting digital rights and freedoms globally. *Big Data & Society, 4*(2). https://doi.org/10.1177/2053951717736335

Tönnies, F. (2012). *Community and civil society*. Oxford University Press.

Toots, M. (2019). Why e-participation systems fail: The case of Estonia's Osale.ee. *Government Information Quarterly, 36*(3), 546–559. https://doi.org/10.1016/j.giq.2019.02.002

Torcal, M. (2003). *Political disaffection and democratization history in new democracies*. University of Notre Dame Press.

Udoh, E. S. (2020). Is the data fair?: An assessment of the data quality of algorithmic policing systems. In *Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance (ICEGOV '20)*. ACM. https://doi.org/10.1145/3428502.3428503

Ullah, A., Kui, Z., Ullah, S., Pinglu, C., & Khan, S. (2021). Sustainable utilization of financial and institutional resources in reducing income inequality and poverty. *Sustainability, 13*(3), 1038. https://doi.org/10.3390/su13031038

United Nations. (1995). *Report of the World Summit for Social Development, Copenhagen, 6–12 March 1995*. https://docs.un.org/en/A/CONF.166/9

UN Department of Economic and Social Affairs (UNDESA). (2016). *Principles of effective governance for sustainable development*. https://publicadministration.desa.un.org/intergovernmental-support/cepa/principles-effective-governance-sustainable-development

UN Department of Economic and Social Affairs (UNDESA). (2024). *UN e-Government Survey – Accelerating Digital Transformation for Sustainable Development*. https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2024

Unt, T., Solvak, M., & Vassil, K. (2017). Does internet voting make elections less social? Group voting patterns in Estonian e-voting log files (2013–2015). *PLOS ONE, 12*(5). https://doi.org/10.1371/journal.pone.0177864

van Dijk, J. A. G. M. (2005). *The deepening divide: Inequality in the information society*. Sage Publications.

Weber, M. (2019). *Economy and society: A new translation*. Harvard University Press.

Welby, B. (2019). *The impact of digital government on citizen well-being* (OECD Working Papers on Public Governance). OECD. https://dx.doi.org/10.1787/24bac82f-en

Wilson, J. Q., & Kelling, G. L. (1982). Broken windows. In *Critical issues in policing: Contemporary readings*. Waveland Press.

Xu, C. K., & Tang, T. (2020). Closing the gap or widening the divide: The impacts of technology-enabled coproduction on equity in public service delivery. *Public Administration Review, 80*(6), 962–975. https://doi.org/10.1111/puar.13222

Young, I. M. (1990). *Justice and the politics of difference*. Princeton University Press.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://doi.org/10.2307/j.ctvcm4g4q

Young, J. (1999). *The exclusive society: Social exclusion, crime and difference in late modernity*. Sage.

Zach, C., & Hayley, L. (2023). Inequality: Global trends. https://devinit.github.io/resources/inequality-global-trends/

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Towards an empowered 'Platform State'? Digital Platforms, Infrastructural Power, and the Transformation of State Authority

Gianmarco Cristofari [a*] and Paolo Gerbaudo[b]

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. Over the last decade much of the scholarly discussion about the digital transformation of the state has focused on the notion of "platformization". This term serves to refer to the way in which governments and public services are ever more strictly associated with the operation of various digital platforms, thus seemingly acquiring some of their properties. Despite this centrality of the notion of platformization of the state, to date there has been surprisingly little theoretical reflection about the underlying organizational logic of the "platform state". Why is the state becoming "platformized"? Is it simply an attempt by government to update its functioning by absorbing the prevailing social logic of organization, as it has already been popularized by various companies; or is there something more structural and profound to this trend? We argue that in fact states and platforms – while pertaining to different categories and domains – share important organizational logics: an "ambient-making" power; a meta-organizational capacity; a centralizing drive; and most importantly a strong "infrastructural" power, to follow the terms of US sociologist Michael Mann. Using this concept we explain the reason why digital platforms appear to have progressively encroached on a variety of functions that tended to be typically state functions: functions that concern identification; the setting up of fundamental conditional operations of society; the affording of various "enabling" systems, lacking which individuals and collective actors cannot operate. Hence, the convergence between governments and platforms is not just a "marriage of convenience". Rather the process of platformization is for states an opportunity to reclaim some of their state capacity and practical power – and in particular infrastructural power – that they seem to have previously lost.

Keywords: Digital Government; Platforms; Platformization; Infrastructural Power
Research paper, DOI: https://doi.org/10.59490/dgo.2025.958

[a] Law Department, University of Palermo, Italy, gianmarco.cristofari@unipa.it, ORCID https://orcid.org/0000-0002-2599-1678

[b] Political History, Theories and Geography, Complutense University, Madrid, Spain, paolo.gerbaudo@ucm.es, ORCID https://orcid.org/0000-0002-5319-7279

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1. Introduction

One of the fundamental aspects that need to be developed to capture the digital transformation of government concerns the trend of "platformization of the state". This phrase has often been used to capture the transformation of governments and public services in a direction similar to that of global digital platforms that have become a mainstay of the present digital society (see for example, Chevallier, 2018; Bender & Heine, 2021; Iaione, 2020; Tammpuu et al., 2022). It indicates how governments create a variety of interconnected online services, through which citizens can perform different tasks, such as filing their tax returns or claiming benefits, and the progressive integration between these variety of state functions. In this sense, the platformization of the state appears as a trend that parallels other processes of platformization that are taking place in other domains and sectors of what is generally described as a "platform society" (van Dijck and Poell, 2018).

This transformation of the state towards the model of digital platforms is a trend that evidently carries major consequences for society, given the centrality of the state in our social structure. In their review of the different trends of social transformation led by digital technology, Hendrikse et al. (2022) have highlighted that the rise of the "platform state" is one of the most significant factors. Yet, while we know much about the consequences of platformization in other social domains – such as consumption, social relationships, patterns of labour, media audiences (Poell, Nieborg and Duffy, 2022), as well as forms of political organization (Gerbaudo, 2019) – we still know relatively little about the implications of the platformization of the state. More generally, we seem to lack a clear definition of what is meant by the phrase "platform state" or "platform government". The phrase's meaning has not yet been explicitly defined, rather it is mostly alluded to in a metaphorical way, by suggesting the existence of an analogy between the process of digital transformation of the state and a discussion of what happens in other domains. This lack of clear definition seriously limits our understanding of the term and our ability to deploy it in a rigorous way as an analytical category, to develop empirical research on the digital transformation of the state.

We aim at filling this gap by developing a definition of the platform state which draws on the similarities and convergences between the internal logic of states and platforms. We use the notion of infrastructural power developed by US sociologist Micheal Mann (1984) as a means to explain what state and digital platforms share. In so doing, we approach the *platform state as a historically specific manifestation of the state form which avails itself of the logic of the digital platform* (Cristofari, 2022) and that is the result of a proactive policy by state actors aiming at adapting the state to the challenges of the digital era (Chevallier 2018) as a *means of recuperating state capacity by tapping into the infrastructural potential of digital platforms*. It is in fact true that given the broad meaning of the word 'platform', the state can be considered as a platform *ante litteram*, given the way in which it has traditionally provided some key foundations for the functioning of society as a whole, which enable all sorts of other social functions. In turn commercial platforms have *de facto* come to acquire an infrastructural power, which we understand as a power of "ambient-creation" setting the environment for all sorts of other operations and transactions that traditionally was attributed to the state. Hence, the convergence between the state and digital platforms in the form of the platform state is more than a technical modification of the state form or a pure marriage of convenience, but as it were a redoubling of the fundamental logic of the state and its adaptation to the technological conditions of the digital era.

In our analysis we contend with those authors who see the power of the state as declining or bound to decline in the digital era, as a result of the power of digital platforms and the way in which they are stealing away forms of sovereignty that were previously the preserve of the state (Castells, 2000; Owen 2015; Zuboff 2019; Ledonvirtha, 2022). We suggest that the platform state embodies a reassertion of authority of government power by means of digital platforms. We make this argument in a two-pronged way. First, we propose that while private platform companies acquired forms of "infrastructural power" that were previously the preserve of the state, they have done so under the auspices of the governments of their country of incorporation and often serving implicitly as a means of state projection – as seen most clearly in the case of the US, and the relationship between Silicon Valley corporations and the defence and security apparatus of the state. Second, we suggest that now many states have realized the infrastructural importance of platform technologies and are trying to deploy it in the territories they control, leading to new forms of control, surveillance, and direction which raise new political and ethical issues. We conclude arguing that these changes call for a fundamental redirection of debates on the state and on digital transformation.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

2. The state as a platform *ante litteram*

To make sense of the nature of the "platform state" entails approaching this phenomenon as one of many historical manifestations of the state form and exploring the similarities between the logic of the state and that of digital platforms. In this sense, the platform state is a concept whose logic of signification is analogous to notions such as the "welfare state" or the "regulatory state" (Moran, 2002, Pildes and Sunstein, 1995), or the "carceral state" (Weaver and Lerman, 2010); namely it is a term that indicates a specific logic of statecraft. More specifically, the platform state is a form state whose nature is fundamentally defined by the information communication infrastructure (ICI) that enables it.

Speaking of the general organizational logic of the state seems at the outset to be an almost insurmountable challenge due the almost all-encompassing power of the notion. The term is customarily utilized as a short-hand to define the varied complex of public institutions, ranging from government (sometimes used as a more reductive synonym) to the other fundamental public powers such as the legislative and the judiciary; police and the armed forces various public services, such as education, health, and the sprawling welfare state that emerged during the post-war decades. What matters for the understanding of the "state-form" is not just an identification of its disparate functions, but also an appreciation of their overarching logic. For Italian political scientist d'Entreves there are three ways we can approach the state as force, as power and as authority (1967). The first one is the most obvious; it is the definition embedded in Max Weber's famous assertion that the state possesses the "monopoly over legitimate violence". The second level, power instead focuses on the nature of the state as an organization bestowed with legitimacy emanating from the laws which the state itself emanates and based on which the state operates: the state is not just power; it is legitimate power. Finally, the element of authority instead highlights the political nature of the state, the fact that it relies on a certain ability to persuade its citizens and mobilize public opinion.

From Hobbes's discussion of the Leviathan as a centre of authority, to Locke's discussion of government and later Max Weber's discussion of bureaucracy, a variety of authors coincide in attributing to the state this centralizing power of control over a territory and population, which is usually condensed in juridical debates by the notion of *sovereignty of the state*. However, when it comes to developing an understanding of the historical transformation of the state-form in a digital era, what is most interesting is not much the principle of sovereignty as a normative entity, but rather its practical application and its enabling conditions, or what is often described as "state capacity". This is where Michael Mann's notion of "infrastructural power comes particularly handy.

The notion of "infrastructural power" was first put forward by Michael Mann, who understood it as the "institutional capacity of a central state […] to penetrate its territories and logistically implement decisions" (1984, 113). This concept has been traditionally associated with the state, but we believe that it also applies to platforms because of their dual roles as service enablers and as regulatory authorities. In the case of Mann, he distinguished the 'weberian' concept of infrastructural power from 'despotic power' and raw coercion linked to the marxist tradition. Building on Mann's work, Hillel Soifer defined infrastructural power as 'the aspect of the state that determines how far its bureaucracy can reach to exert control and regulate social relations' (Soifer 2008, 234). Mann (2008) presents income tax as the purest form of infrastructural power, "whereby our salaries are assessed and taxed 'at source' every month without our being able to intervene in the process." He further observes that income taxes only became major sources of state revenue in the twentieth century, whereas earlier, states were largely limited to "taxing things that visibly moved around" (Mann 2008). Similarly, other examples of infrastructural power include state practices of identification, employing technologies such as fingerprinting, retinal scans, and passports (Soifer, 2008).

We can use the notion of infrastructural power as a key term in exploring the similarities between the state and digital platforms (Tab. 1). As we show, there are key parallelisms between the operations of the state and digital platforms as sources of infrastructural power. The state, following Mann's discussion, typically provides key infrastructural services such as roads, security, and information, which then enable the operations of other actors, such as individuals and companies. Digital platforms also typically deploy an infrastructural function as they provide various affordances that allow individuals to perform various actions, to complete transactions, to identify themselves in front of other parties. This in turn is supported by different notions of authority and specific forms of infrastructural power. The infrastructural power of the state is concerned with using tools like taxation and identification which in turn stems from notions of citizenship as membership in a corporate organisation. In partly similar though also significantly different ways, the infrastructural power of platforms instead relies on socio-technical affordances such as ID systems, user profiles, databases and algorithms as a means to organise user behavior. In the continuation of the chapter we will develop this discussion further: first by looking at how infrastructural power found traditionally in the state is now mirrored by the infrastructural power of platforms, and then approaching the platformization of the state as an interpolation of the infrastructural logic of both states and platforms.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Table 1 – Parallelism between infrastructural features of the state and features of the digital platform

Aspect	State	Digital Platform
Service Provision	Provides essential infrastructure (e.g., roads, public data) and enables private sector services	Provides digital infrastructure (e.g., APIs, app stores) enabling user-created services and app
Authority over Population & Territory	Exerts authority over physical territory and citizens, setting laws and regulations	Exerts authority over a digital territory and users through terms of service and reprogrammable software
Infrastructural Power	Uses tools like taxation and identification (e.g., passports) to regulate and track citizens	Uses data collection, digital IDs, and algorithms to monitor and influence, redirect user behavior

3. The digital platform's "ambient power"

The rise of digital platforms is by now widely considered as one of the most important trends of socio-economic transformation in contemporary societies. It is a trend associated mainly with the rise of global corporations—often referred to as "GAFAM" (Google, Apple, Facebook, Amazon, Microsoft) and "BATX" (Baidu, Alibaba, Tencent, Xiaomi)—which play a pivotal role in the lives of Western citizens. These platform companies have achieved dominance in specific markets and have leveraged this success to expand into other sectors, creating interactional ecosystems of users and producers of services (Srnicek, 2016; Petit, 2020). The unprecedented dominance of platform companies has not gone unnoticed by scholars. Some have highlighted how these entities now perform roles traditionally associated with public authorities (Pollicino, 2021; Golia, 2023); others have noted that they increasingly resemble administrative bodies, issuing self-enforcing authorizations (Ranchordas, 2023) or even functioning as "autonomous global legal orders" (Bassan, 2021), and as agents implicated in an "infrastructural transformation of the public sphere" (Nosthoff & Maschewski, 2024).

While there are many definitions of platforms across various disciplinary perspectives (Cristofari, 2024), most researchers now agree on a 'minimal definition.' This defines platforms as intermediary organizational forms that connect two or more sides, providing the infrastructure necessary to facilitate interactions between different groups that build their services upon it (Schüler & Petrik, 2021). Classical examples of platform companies are Google's search engines, Uber, and Amazon Marketplace. From a technical perspective, platforms utilize technical standards to centralize control over their infrastructure (Bratton, 2016) and operate through a feedback loop between data collection and infrastructure reprogrammability. In other terms, the platform activity consists in organizing interactions—encompassing both users and service providers—by systematically collecting, processing, monetizing, and circulating data through algorithmic processes (Poell et al., 2019).

The platform can be viewed essentially as a *cybernetic form of government* that combines legal rules (terms of services) with actionable software. Like the modern state needed a grid to make sense of its citizens (Scott, 1998), the platform form of government is based on a certain legibility of users and on intense datafication. This ability of creating a controllable environment, act on users and reprogramming affordances has been variously described as algorithmic governmentality (Rouvroy & Stiegler 2016), governance by infrastructure (Musiani et al. 2016), regulation by design (Hildebrandt, 2013), and technological management (Brownsword 2016). This power relies on technical tools such as Application Program Interfaces (APIs), which determine the conditions under which data is collected from smartphones by apps and related services. APIs also enable bi-directional flows of data between platforms, facilitating the ongoing control and organization of interactions within the platform ecosystem (Maruping & Matook 2020; Lamothe et al 2021). As a consequence, platforms present what could be called an "ambient-making" power: organizing social relationships and determining who is connected or disconnected within specific spatial and temporal contexts. In so doing, platforms create a clear distinction between their "inside" (users and producers connected via devices) and the "outside" (the social and institutional environment in which the platform operates).

This requires continuous efforts to manage and organize its ecosystem, and scholars have theorized this activity into three key components: regulation (establishing standards), moderation (e.g., the process of monitoring, reviewing, and managing user-generated content), and curation (determining the relevance of content by deciding what and how to present it to users) (Poell et al., 2021). As such, the platform's "ambient-making

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

power" lies in its ability to create a structured field of action where a variety of tasks can be executed. In cybernetic terms, the platform performs 'selection of selections', reducing the complexity for other actors.

The implication of such a new organizational form primarily deals with the creation and organization of markets. The platform is indeed *more than a market* in the coordination of people, money and services in space-time. Platform marketplaces create interactional ecosystems that can be, to a certain extent, centrally controlled. These are recursive markets within the 'Market' in which social groups are coopted by turning them into scalable assets (Chicchi et al. 2022; Birch 2017). Attention to the forms of political planning on the 'inside' is essential to understanding the innovation of the platform model. Platform corporations make plans within their own ecosystem of complementors, to the point that ven liberal thinkers have criticized the asymmetrical distribution of knowledge created by platforms, disrupting the Hayekian ideal of an "equal amount of ignorance about the market." Surveillance capitalist platforms, as Zuboff (2019) argues, can "see the invisible hand" of the market and actively manipulate it. In this sense, the platform represents an organizational form that transcends the traditional dichotomy between centralization and decentralization—assuming such a dichotomy ever truly existed. It occupies a space between market and government: centralizing data collection, infrastructural reprogrammability, and political planning, while simultaneously decentralizing decision-making through the widespread distribution of reprogrammable interfaces. As such, the 'platform' should be considered a new organizational or institutional form that represents a historical break from traditional structures like hierarchies, markets, and networks (Cristofari 2024; Bratton, 2016; Van Doorn, 2020; Vallas & Schor 2020).

According to some authors this growing power of digital platforms leads to a weakening of the state. Three pivotal works—Manuel Castells' *The Rise of the Network Society* (2000), Taylor Owen's *Disruptive Power* (2015), and Vili Lehdonvirta's *Cloud Empires* (2022)—each argue that states, once powerful central authorities, are increasingly challenged by the rise of networked structures and global platform corporations. Castells saw a rise of a "network state" that collaborates with and competes against other global actors. In this new model, the state shifts from exercising absolute sovereignty to acting as a flexible node in a multi-layered governance system, constantly negotiating authority with non-state actors (Castells 2000).

Taylor Owen has pointed to examples such as Anonymous, Bitcoin, social media-fueled protests, the rise of Pirate Parties and open-source mapping platforms like Ushahidi to illustrate how digital technologies and networks disrupt the state's traditional monopoly on information and influence (Owen, 2015). He noticed that "collecting data and publishing maps were once the sole privilege of the state" (p. 125). This weakening of the state is the product of the disruptive power he attributes to social media in which the state's "institutionalized structures and norms that lead to lethargy, waste, inefficiency, and a lack of innovation" (p. 8) are easily out-maneuvered by the flexible, mobile and sprawling nature of networks. Thereby, "enabled by digital technology, disruptive innovators are now able to influence the behavior of large numbers of people without many of the societal constraints that have developed around state action" (p.9).

In *Cloud Empires* (2022), Vili Lehdonvirta takes this argument further, positing that tech giants now act as "virtual states" with power comparable to that of traditional governments. Lehdonvirta argues that the CEOs of major tech firms have, in many ways, become more powerful than national leaders, exercising control over vast digital territories without democratic accountability: "the chief executives of leading tech companies are now by many measures more powerful than most countries' heads of state" (p. 3). All in all, in this situation, "the authorities in charge are not nation states but digital platform companies" (p. 6). Our contention is that the situation is more complex. While platforms have *de facto* acquired functions that were typical prerogatives of the state, they have done so with the consent of their state of incorporation as seen most evidently in the US. Further, the current drive towards a platformization of the state as well as the growing efforts by other world regions other than the US, to recuperate some degree of digital sovereignty (Pohle and Thiel, 2020), may well be seen as a pathway to recuperate state capacity by means of digital technology, as we shall expound in the ensuing section.

4. Infrastructural power as the logic of the platform state

Both the state and digital platforms, in their respective domains, establish foundational infrastructures and create conditions that allow various stakeholders—citizens and other institutions in the case of the state, and users and complementors in the case of digital platforms—to engage in productive, value-generating activities. Examining this analogy helps clarify the role of government as a "platform provider," as described by Tim O'Reilly (2011). Both states and platforms create incentives and opportunities for external entities to contribute value. In the case of the state, infrastructure investments in areas like transportation and communication lay the groundwork for private sector growth. Roads enable businesses to operate across regions, and public data sets, like those from the National Weather Service, become critical resources that drive innovation in weather forecasting, logistics, and beyond. Similarly, digital platforms provide APIs, developer tools, and marketplaces that enable entrepreneurs to create apps, content, and products, effectively expanding the platform's value and reach.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

For instance, platforms like Apple's App Store allow developers to create applications that enhance the iPhone's functionality, expanding the ecosystem and, in turn, increasing the device's appeal to users.

Much like roads, power grids, and other state-built infrastructure facilitate economic activity, platforms create indispensable digital infrastructures—cloud computing, app ecosystems, and marketplaces—that shape how businesses and individuals interact and create dependencies that resemble those between citizens and state infrastructure. As Morgan Ricks and colleagues argued in their fundamental treaty on networks, platforms and utilities by quoting Felix Frankfurter (1930), the services provided by platform enterprises are "as truly public services as the traditional governmental functions of police and justice" (Ricks et al, 2022). A second analogy can be drawn by building on the work of the legal scholar Julie Cohen (2019). Global platforms can be seen as international actors in their own rights besides other states not only because of their global reach but also because they have an authority, a population, and a territory with clearly demarcated spaces. The territory produced by digital platforms is of course not a contiguous physical space but that is instead is designed via the software architecture and defined using protocols, data flows, algorithms, and can be reprogrammed. Cohen sees the platform authority as 'network power' as well as the 'power to create networks' that originate from a combination of legal documents such as terms of services (ToS) and the control of the software infrastructure.

Ultimately, it is the platform that enforces the decisions via its infrastructure by reprogramming the code and the interface. Some examples in the realm of social media platforms include accounts suspensions and shadow-banning; in the case of delivery platforms, prioritizing those platform workers that stick to their parameters (Aloisi & De Stefano 2022); in the case of the Amazon marketplace, that of giving relevance to vendors (Khan, 2018). This view of the platform as analogous to the legal order of the state can lead us to approach the platform as an organizational logic which exercises its power over a population and a territory (Sassen 2006; Foucault, 2007). However, if the population of a certain state implies citizenships and humans are considered subjects in the sense that they are subjected to the law of the state, the platform ecosystem is instead constituted by the status of users. The distinction between the two is crucial, because a user is not a juridical entity, but a position within a system, so that the relations of those users are organized and orchestrated cybernetically via standards and protocols.

Here the parallel with the core innovations of the platform model is evident. Today, there are approximately 6.5 billion smartphones worldwide, produced and controlled primarily by two American companies—Apple and Google. These companies not only dominate smartphone production but also hold a monopoly over their respective app stores, levying a 30% tax on every transaction. Like the state, platform marketplaces not only allow direct 'taxation' and capture of value production at source, but they also imply a large visibility of the behavior of users and their choices, and they act to modify that behavior (Zuboff 2019). Moreover, similarly to the postal address, the platform reach extends to the IP address of the users (Bratton 2015).

As for identification practices, nowadays, all the main platforms facilitate digital identification, enabling users to log in seamlessly across services, echoing the state's efforts to extend infrastructural power through efficient, centralized identification. This centralized control over digital identities allows platforms to verify users, track behaviors, and link activities across different services, much as states track citizens' movements, credentials, and records across various domains. With single sign-on systems, platforms establish themselves as identity providers, exerting influence over users' access to the broader digital landscape. The analogy between the infrastructural power of platforms and that of the state reveals how platforms exercise control over digital spaces much like states regulate physical territories. Just as states use taxation, identification, and surveillance to manage and shape society, platforms use data collection, digital identities, and algorithmic oversight to control user behavior and extract value within their ecosystems.

In this light, platforms wield a new form of infrastructural power— pervasive and deeply integrated into users' lives—that resembles the power traditionally exercised by states. This parallel raises questions about accountability, sovereignty, and public welfare, as platforms become quasi-state actors in the digital domain. This point is shared by Kelton and colleagues (2022), who analyzed the reach of the infrastructural power of private digital platforms in the United States. They claimed that digital platforms acquired powers across the virtual territories by exercising aspects of infrastructural power defined previously as the prerogative of the sovereign territorial state. Building on the work of Weiss and Thurbon, they claim that there are two components of infrastructural power. First, 'extractive power' (what we have called taxation of the ecosystem), which is the 'capacity to permeate society, and extract and deploy resources with social consent and legitimacy'. Second, 'transformative power', which is the capacity to initiate, sponsor and harness substantial technological innovation for state benefit. According to the authors, we are witnessing another 'social contract' between users and private platforms that challenges the social contract between citizens and the state.

Kelton and colleagues conceptualize this shift in terms of 'virtual sovereignty'. While we can question whether we should speak of virtual sovereignty or instead of platform sovereignty, as perhaps is more adequate, what is apparent is that what is at stake here indeed is a new form of sovereignty, a new form of control over population and territory. Regardless of the difference in terminology, what matters is that the platformization of the state carries with it itself. Digital platforms have essentially acquired an infrastructural power that was previously typical of the state and a practical exercise of its condition of sovereignty.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

5. Case studies of the platform state: Italy, France and Estonia

Having explored how global digital platforms exhibit a form of infrastructural power traditionally associated with the state, this section focuses on the concept of the platform state. As a historical manifestation of state governance, the platform state is best understood as a theoretical abstraction. However, its characteristics should also be rooted in the tangible platformization processes of public administrations worldwide. To this end, we compare patterns of state platformization across diverse contexts, including Estonia, Italy, France and India. Despite the vast social, political, economic, and cultural differences among these countries, we argue that their efforts to platformize public administration are based on common principles and promise to deliver similar results. In particular, the platform state promises to increase the legibility of citizens, regain infrastructural power and enable the creation of what might be called 'welfare ecosystems'. In this framework, the concept of the platform state serves as a unifying lens to bundle together the multiplicity of terms used to describe the digitization of public administrations, such as e-government (Jaeger, 2002), one-stop government, and open government (Cordella, 2019). In what follows we shall see how some of these tendencies apply to different European countries that have engaged in programmes of digital transformation of their governments.

5.1 The Italian case: connecting public institutions

Over the last ten years, the Italian government has put forward many projects that incarnate the idea of Government as a Platform (Gaap) with the aim of improving the services offered to citizens and businesses by simplifying administrative action. Three main interconnected 'enabling platforms' have been developed to allow individual public administrations bodies to log in into a shared software that enables them to perform foreseen actions. The three platforms are the 'SPID' (*Public Digital Identity Service*) as the national identification system; second, 'PagoPA', an electronic system that allows citizens and businesses to make standardized payments to public bodies; third, the app of public services 'AppIO' as a single access point for public services that allows to make requests, download documents and can that send push notifications to users (for example, when a deadline for payments is approaching of the ID document is expiring) (Esposito, 2024).

In a true platform fashion, this centralized approach is complemented by The Developers Italia (DevIt) and Designers Italia (DesIt) initiatives. These projects aim to standardize and modernize public administration (PA) digital services. DesIt focuses on spreading a design culture in the PA by providing practical tools, including guidelines, templates, and UX/UI kits, to create inclusive, accessible, and citizen-centered digital services. It supports smaller PAs with limited resources by offering standardized website templates and service archetypes aligned with national regulations. DevIt complements this effort by equipping IT developers with open-source software, libraries, and documentation to integrate enabling platforms and reduce development time and risks. Both projects promote collaboration and resource-sharing through platforms like Docs Italia, Forum Italia, and GitHub Italia, advancing a unified and consistent digital transformation framework across the Italian state. (Esposito 2024)

According to Cordella and Paletti, the Italian case of platformization of public administration enhances the efficiency of public services by reducing silos and avoiding duplication of core functionalities. This approach enables services to evolve more seamlessly and facilitates the integration of interdependencies between different service provisions, allowing for improvements and new service offerings. By adopting the GaaP model, public agencies can achieve better coordination, delivering greater value to citizens without requiring additional resources. However, this shift also redefines the operational capabilities of public administration, reshaping its organizational structure and capacity to create and deliver public services, ultimately transforming how public value is generated (Cordella & Paletti, 2019).

5.2 The French case: renovating administrative relationships

In France, the concept of the "platform state" has sparked significant debate following the publication of O'Reilly's article on government as a platform. Nicolas Colin and Henri Verdier introduced this debate in France envisioning a future where digital platforms revolutionize public service delivery:

> Imagine that 100 applications offer taxpayers different interfaces and innovative experiences for declaring their income and paying taxes online. [...] Imagine that 100 applications combine resources from distinct administrations to provide a unified service integrating multiple functions: declaring a birth, enrolling a child in school, scheduling a hospital appointment, or filing a police report. Imagine these same services blending with others unrelated to administration: being able to shop for groceries, share opinions on movies or books, and, within the same application, request housing assistance from the family benefits office (Colin & Verdier, 2018, 250-251).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

France has emerged as a focal point for this discussion due to its distinctive administrative tradition and the active involvement of public authorities. In tracing the development of the debate of the platform state in France, Jeannot (2020) reported that the expression was first used in 2014 within the public administration in relation with the project FranceConnect. It was then discussed in a series of report produced by public institutions such as the *Conseil d'État* (2017) in a report on public power and digital platforms, as well as by public authorities like then-Minister Franck Riester (2011) and the *Cour des Comptes* (2018). Overall, these reports have advocated for an interventionist role for the state in developing public services inspired by the innovations of private platforms. These discussions extend to related topics, such as open data and open government, underscoring the complex transformation of public administration.

Jacques Chevallier (2018) describes the platform state as a strategy for a global transformation of the administration and public services, a paradigm shift from traditional bureaucratic systems to more agile, horizontally integrated platforms, fostering citizen co-production and administrative efficiency. Chevallier emphasizes how digital tools, data sharing, and Application Programming Interfaces (APIs) are central to this transformation. Pauline Turk (2020) examined the platform state through the lens of public law, arguing that its core objective is to pursue a form of voluntaristic politics grounded in pragmatic realism. This approach reflects an ambition to adapt the state's role to the challenges of contemporary governance while maintaining its commitment to delivering efficient, high-quality public services. Central to this vision is the transformation of the state from a direct provider of services to an enabler of service delivery through the development and maintenance of critical infrastructure. The state is operating like a platform insofar as its primary function becomes the facilitation and coordination of various actors—public, private, and civil society—in delivering services. Rather than relying on traditional, hierarchical methods of administration, the state adopts a model of outsourcing that leverages digital tools and technologies to optimize service delivery. According to Turk, this marks a profound mutation in the state's role, signaling a move away from direct intervention toward a platform-oriented governance model that prioritizes flexibility, efficiency, and citizen-centric solutions.

The case of FranceConnect serves as a prominent example of France's platformization. As Alauzen (2019) ethnographic research explains, FranceConnect operates as a decentralized authentication system based on the OpenID Connect protocol, which enables secure and interoperable digital identity management. Its architecture is designed to allow users visiting a government website to choose between using a local account or logging in through FranceConnect, providing a unified, streamlined experience across various public services, simplifying administrative processes for citizens. The system also exemplifies the concept of digital sovereignty, as emphasized by its developers. In interviews, the technical director of the FranceConnect project described it as "like Facebook, but it's the state," highlighting its role as a state-owned alternative to commercial platforms (Alauzen, 2019). A defining feature of FranceConnect is its decentralized design, which ensures that there is no centralized database where all public administration data converges. Instead, data remains distributed across the respective administrative entities, with FranceConnect as a facilitator of secure interactions. This approach underscores the importance of ensuring that French citizens authenticate with public services via a government-controlled system rather than relying on private platforms.

5.4 The Estonian case: a borderless state-based platform

Another prominent case of platform state is that of Estonia. Even if the process of platformization of Estonia was developed before and independently from the 'platform state' concept, its case is widely quoted as the cornerstone example of government as a platform and of a proactive approach to the digitization of the public administration. This transformation is particularly significant given Estonia's historical context: following its independence in 1992, the country transitioned from a centrally planned economy to a market-based system, becoming a model of innovative public administration grounded in principles of openness, simplicity, and citizen participation (Espinosa, 2024).

For our purposes, what matters is that the Estonian government developed a three-tiered platform architecture to support its digital ecosystem. At the core lies X-Road, with registries and a data exchange system that enables seamless data sharing departments and agencies.By 2016, X-Road enabled interoperability across 1,700 services and 900 organizations, processing over 500 million transactions annually and more than 1 million requests per day (Margetts & Naumann, 2017). The second tier is a universal eID system adopted by over 90% of the population aged 15 and above, ensuring secure identification for public and private services. The final tier consists of a service layer, accessible through portals like eesti.ee, which integrates these systems into a cohesive, user-centric interface. These interconnected layers underpin a wide range of digital services utilized by citizens, professionals, and businesses to interact and conduct transactions with both public and private sectors.The basic infrastructure – X-Road, eID and the official state portal eesti.ee - are managed and developed by the Estonian Information Service Authority, a central agency with about 120 personnel.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

Tammpuu et al. (2022) expanded the conversation by explicitly applying the platformization framework to analyze the Estonian case, focusing particularly on its e-Residency program. Drawing on interviews conducted with non-Estonian residents, their work investigates how the concept of platformization, typically associated with private-sector platforms, can be adapted to state functions. The researchers highlight how the Estonian government discursively frames e-Residency as a "platform," "gateway," and "one-stop shop" for accessing public and private e-services, particularly for commercial activities. This framing underscores the state's dual role as a service provider and a transactional platform. Tammpuu et al. 's (2022) reveal how Estonia's e-Residency program supports a novel platform-based relationship between the state and individuals. It is transactionality, a hallmark of digital platforms, that now defines the interaction between e-residents and the state. In this sense, the process of platformization can lead to perceive the state as a "market actor" introducing its digital solutions to the global economy but also as a "membership organization" extending its community beyond territorial borders. Through its digital ID infrastructure, e-Residency program, and vision of a "borderless digital state," Estonia exemplifies the transformative potential of platformization in redefining the role of the state and its relationship with territory in the digital age (Tammpuu et al. 2022).

6. Platforming *et impera*

The cases of France, Italy, and Estonia exemplify a broader trend of state platformization, wherein governments seek to become enablers of digital services rather than remain dependent on private platforms ultimately tied to foreign states. It signals how limited is the dominant narrative of a "weak state" in digital times (Owen, 2015; Lehdonvirta, 2022), and how in fact platformization are unlocking new ways for the state to control its territory and population. To develop this discussion, we have shown how a key strategy in this transformation is the utilization of APIs and public digital identification systems, which facilitate the integration of public institutions, enhance interactions between the state and citizens, and move beyond the siloed approach to administration that has historically fragmented governance structures. By adopting a multi-sided logic, akin to private digital platforms, the platform state reconfigures service delivery, replacing traditional bureaucratic models reliant on physical offices and extensive public employment with reprogrammable digital interfaces that optimize administrative functions. At the core of state platformization is automation and the redistribution of administrative labor. Algorithms increasingly streamline bureaucratic processes, reducing the need for manual oversight by public employees, while platforms shift administrative tasks to citizens themselves—whether for tax payments, permit applications, or welfare access.

We can outline two reasons why the platformization of the state is likely to intensify. First, from an evolutionary perspective, the state cannot ignore the organizational advantages provided by the platform model. This is not simply a matter of delivering more efficient and distributed public services while integrating existing institutions; it is also rooted in the technocratic essence of the platform itself. Second, this shift reflects the broader crisis of governance in an era of global complexity. The platform model allows the state to address its overextended capacity by embracing a distributed, recursive structure. It integrates diverse institutions into a unified framework while preserving their autonomy and facilitating dynamic interactions.. The platformization of the state, therefore, is not only a response to technological advances but also an adaptation to the structural pressures of globalized governance. By internalizing the evolutionary logics of the platform model, the state navigates its inherent limitations and continues to evolve in line with the complexities of modern society. This intensification of platform logic reflects both the constraints and possibilities of governing in an interconnected world.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

Beer, S. (1980). Designing Freedom. In Vickers, G. (1970). Freedom in a Rocking Boat. Allen Lane. The Penguin Press. London.

Bender, B., Heine, M. (2021). Government as a Platform? Constitutive Elements of Public Service Platforms. In: Kö, A., Francesconi, E., Kotsis, G., Tjoa, A.M., Khalil, I. (eds) Electronic Government and the Information Systems Perspective. EGOVIS 2021. Lecture Notes in Computer Science(), vol 12926. Springer, Cham. https://doi.org/10.1007/978-3-030-86611-2_1

Birch, K. (2017). Rethinking Value in the Bio-economy: Finance, Assetization, and the Management of Value. Science, Technology, & Human Values, 42(3), 460-490.

Bratton, B. (2015) *The Stack: On Software and Sovereignty*. MIT Press.

Brownsword, R. (2015). In the year 2061: from law to technological management. Law, Innovation and Technology, 7(1), 1-51.

Burgess, J. (2021) 'Platform studies'. In: Cunningham S and Craig D (eds) Creator Culture: An Introduction to Global Social Media Entrainment. New York University Press, 21–38.

Castells, M. (2000). The Rise of the Network Society. Blackwell.

Chevallier, J. (2018). Vers l'État-plateforme ?, Revue française d'administration publique, vol. 167, n° 3, 2018, p. 627-637, https://doi.org/10.3917/rfap.167.0627

Chicchi F., Marrone, M. and Casilli, A. (2022) Introduction: Digital labor and crisis of the wage system. Sociologia del Lavoro 163: 51–69.

Cingolani, L. (2021) 'The survival of open government platforms: Empirical insights from a global sample'. Government Information Quarterly,. Volume 38, Issue 1, 2021.

Cordella, A., Paletti, A.: Government as a platform, orchestration, and public value creation: the Italian case. Govern. Inf. Q. 36, 101409 (2019)

Cristofari, G. (2022). Bratton and the Double Movement of State Platformization and Platform Institutionalization. La Deleuziana Vol 13, 83 -101.

Cristofari, G. (2024). Understanding the "platform" keyword: An inquiry on the contested use of metaphors in platform studies. *Platforms & Society*, *1*. https://doi.org/10.1177/29768624241285294

Espinosa VI and Pino V (16 Feb 2024): E-Government as a Development Strategy: The Case of Estonia, International Journal of Public Administration, DOI:10.1080/01900692.2024.2316128

Esposito, F. M. (2024). Platforming Public Administration: An Empirical Analysis on the Institutionalization of Digital Technologies. Tecnoscienza – Italian Journal of Science & Technology Studies, 15(1), 39–59. https://doi.org/10.6092/issn.2038-3460/18779

Gerbaudo, P., 2021. 'Are digital parties more democratic than traditional parties? Evaluating Podemos and Movimento 5 Stelle's online decision-making platforms'. *Party Politics*, *27*(4), pp.730-742.

Gerovitch, Slava (2002). From Newspeak to Cyberspeak: A History of Soviet Cybernetics. MIT Press.

Hautamäki, A., Oksanen, K.: Digital platforms for restructuring the public sector. In: Smedlund, A., Lindblom, A., Mitronen, L. (eds.) Collaborative Value Co-creation in the Platform Economy. TSS, vol. 11, pp. 91–108. Springer, Singapore (2018). https://doi.org/10.1007/978-981-10-8956-5_5

Hendrikse, R., Adriaans, I., Klinge, T. J., & Fernandez, R. (2022). The big techification of everything. Science as culture, 31(1), 59-71.

Hildebrandt, M. (2013). Smart technologies and the end(s) of law: Novel entanglements of law and technology. Edward Elgar.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

Iaione, C. (2016). The platform-state. Government as an enabler of civic imagination and collaboration. *The city*.

Kelton, M., Sullivan, M., Rogers, Z., Bienvenue, E., Troath, S. (2022) Virtual sovereignty? Private internet capital, digital platforms and infrastructural power in the United States, *International Affairs*, Volume 98, Issue 6, November 2022, Pages 1977–1999, https://doi.org/10.1093/ia/iiac226

Lamothe, M, Guéhéneuc, Y-G, and Shang W. (2021). A Systematic Review of API Evolution Literature. ACM Comput. Surv. 54, 8, Article 171 (November 2022), 36 pages. https://doi.org/10.1145/3470133

Lehdonvirta, V. (2022). Cloud Empires: How Digital Platforms Are Overtaking the State and How We Can Regain Control. MIT Press.

Mann, M. (1986). *The sources of social power: Volume 1, A history of power from the beginning to AD 1760*. Cambridge University Press.

Mann, M. (2008). Infrastructural Power Revisited. *St Comp Int Dev* **43**, 355–36. https://doi.org/10.1007/s12116-008-9027-7

Margetts, H., Naumann, A.: Government as a platform: What can Estonia show the world. Research paper, University of Oxford (2017)

Maruping, L. M., & Matook, S. (2020). The evolution of software development orchestration: current state and an agenda for future research. *European Journal of Information Systems*, *29*(5), 443–457. https://doi.org/10.1080/0960085X.2020.1831834

Mazet, P. Vers l'État plateforme. La dématérialisation de la relation administrative, La Vie des idées, 2 avril 2019, https://laviedesidees.fr/Vers-l-Etat-plateforme.html

Medina, E. (2011). Cybernetic Revolutionaries: Technology and Politics in Allende's Chile. MIT Press.

Moran, M. (2002). Understanding the regulatory state. *British journal of political science*, *32*(2), 391-413.

Musiani, F. Cogburn D. L. DeNardis L. & Levinson N. S. (2016). *The turn to infrastructure in internet governance*. Springer Link.

Nosthoff, A.-V., & Maschewski, F. (2024). The platform economy's infrastructural transformation of the public sphere: Facebook and Cambridge Analytica revisited. *Philosophy & Social Criticism*, *50*(1), 178-199. https://doi.org/10.1177/01914537231203536

Owen, T. (2015) Disruptive Power. The Crisis of the State in the Digital Age. Oxford.

Passerin d'Entrèves, A. (1967). *The notion of the state: an introduction to political theory*. Oxford U.P.

Peters, B. (2016). How Not to Network a Nation: the Uneasy History of the Soviet Internet. MIT Press.

Petit, N. (2020). Big Tech and the Digital Economy: The Moligopoly Scenario. Oxford University Press.

Piia Tammpuu, Anu Masso, Mergime Ibrahimi, Tam Abaku (2022) ESTONIAN E-RESIDENCY AND CONCEPTIONS OF PLATFORM-BASED STATE-INDIVIDUAL RELATIONSHIP, TRAMES, 26(76/71), 1, 3–21

Pildes, R. H., & Sunstein, C. R. (1995). Reinventing the regulatory state. *The University of Chicago Law Review*, *62*(1), 1-129.

Poell T, Nieborg D and Van Dijck J (2019) Platformisation. Internet Policy Review 8(4).

Poell T, Nieborg DB and Duffy BE (2022) Platforms and Cultural Production. Polity.

Pohle, J., & Thiel, T. (2020). Digital sovereignty. *Pohle, J. & Thiel*.

Pollicino, O (2021) Judicial Protection of Fundamental Rights on the Internet: A Road Towards Digital Constitutionalism? Hart Publishing.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Rouvroy, A. and Stiegler, B. (2016) The digital regime of truth: From the algorithmic governmentality to a new rule of law. La Deleuziana 3.

Schüler, F. and Petrik, D. (2021) Objectives of platform research: A co-citation and systematic literature review analysis. In: Seiter M, Grünert L and Steur A (eds) Management Digitaler Plattformen. ZfbF-Sonderheft, vol 75/20. Springer Gabler.
Soifer, H. (2008). State Infrastructural Power: Approaches to Conceptualization and Measurement. *St Comp Int Dev* **43**, 231–251 (2008). https://doi.org/10.1007/s12116-008-9028-6

Srnicek N (2017) Platform Capitalism. Polity Press.

Steinberg M (2019) The Platform Economy: How Japan Transformed the Consumer Internet. UMP.

Türk, P. (2020) . L'État plateforme numérique. *Revue du droit public,* Septembre(5), 1189-1212. https://droit.cairn.info/revue-revue-du-droit-public-2020-5-page-1189?lang=fr.

Van Dijck, J. Poell, T., & Waal, M. d. (2018). *The platform society : public values in a connective world*. Oxford University Press.

Van Doorn N (2020) A new institution on the block: On platform urbanism and Airbnb citizenship. New Media & Society 22(10): 1808–1826.

Weaver, V. M., & Lerman, A. E. (2010). Political consequences of the carceral state. *American Political Science Review*, *104*(4), 817-833.

Zuboff, S. (2019). The age of surveillance capitalism: The fight for a human future at the new frontier of power. New York: Public Affairs.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 8: Digital Platform Government and Core Public Values

Track Description

The concept of a digital platform government has its origins in initiatives like the UK's GOV.UK and the Obama administration's Open Government Initiative. While no universally accepted definition exists, it is helpful to compare it to related concepts. Unlike e-government, which focuses primarily on digitalizing services, the digital platform government emphasizes process innovation and operates as a public-private partnership service model. It encourages stakeholder participation and leverages intelligent technologies. Both models promote online citizen engagement, but the digital platform government grants citizens a more direct role in decision-making. Its core public values include efficiency, accountability, fairness, participation, collaboration, transparency, reducing the digital divide, and promoting digital equity. The structure of a digital platform government varies based on its objectives and the role of the government. Scholars have proposed various digital platforms aligned with these goals. With this framework in mind, the aim of the track was to gather papers that examine the relationship between digital platform government practices and these core public values.

Track Chairs

J. Lee, University of Nebraska at Omaha, United States of America
W. Sung, Seoul National University of Science and Technology, South Korea

Contents

Citizen's interaction, perceived benefits, and effectiveness of open government data on trust in government 459
H. Astuti and C. Hinnant

Digital Platform Government in the Promotion of Brazilian Audiovisual Content 472
L. Abs, A. Barbosa, V. Pontes, J. Rosa, A. Rego, T. Cordeiro, L. Santa Rita, A. Gomes, L. Távora, and D. Fernandes

Citizen's interaction, perceived benefits, and effectiveness of open government data on trust in government

Hanim Astuti [a*, b], *Charles* Hinnant [c]

[a] School of Information, College of Communication and Information, Florida State University, Tallahassee, United States, hma20i@fsu.edu, 0000-0002-8761-8895.

[b] Information Systems Department, Faculty of Intelligent Electrical and Informatics Technology, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia.

[c] School of Information, College of Communication and Information, Florida State University, Tallahassee, United States, 0000-0002-7425-5685.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. The declining trend of trust in government has received significant attention among scholars in various fields, particularly in efforts to find ways to reverse this decline. This paper investigates the relationship between trust in government and open government data (OGD), through a proposed model that links trust in government and three variables, i.e., citizens' interaction with OGD, citizens perceived benefits of OGD, and perceived effectiveness of OGD. Utilizing the dataset from Pew Research Center's survey on public perceptions of OGD, we test the model using structural equation modeling (SEM). Our findings show that the three variables positively affect trust in government. However, while the three variables are significant, perceived benefits and effectiveness of open government data are more essential determinants of trust than citizens interaction with government data. This study contributes to understanding how open government data initiatives could increase trust in government, by suggesting practical implications. Nevertheless, this study uses 2014 dataset that might not be able to capture changes in society, such political, economic, social, and technological conditions.

Keywords. Open government data, trust in government, structural equation modeling, citizen interaction, perceived benefits, effectiveness

Reseach paper, DOI: https://doi.org/10.59490/dgo.2025.1006

1. Introduction

Citizens' trust in government has received a great deal of attention from scholars in various fields, ranging from political sciences, public administration, information and technology sciences, and social sciences (Meijer et al., 2012). Their concern was mainly due to the declining trend of trust in government. Tolbert and Mossberger (2006) mentioned that this phenomena has been occurred for the past three decades from the 2000s. A quite recent publication issued by Pew Research (2022) confirmed that the highest trust in government was in 1964, with 77% of citizens trusted the U.S. government. Since then, public trust has declined and remained unstable. The average citizen's trust in government has never reached 30% since 2004.

Distrust in government can be seen from three aspects, i.e., distrust in institutional or political systems (Miller,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1974), personal aspects, such as political leaders (Citrin, 1974), and the combination of institutional and personal aspects (Christensen & Lægreid, 2005). No matter what aspects citizens might feel skeptical about the government, the declining trust could be seen as a positive and negative indication in a democratic country (Chanley et al., 2000). However, it could also lead to serious implications, especially when citizens opt out of their decisions and refuse to participate in government's programs. Ultimately, it could obstruct the process of elections (Orren, 1997), policymaking, and policy implementation (Chanley et al., 2000).

Various studies were undertaken to investigate the causes of the declining trend in trust in government. Chanley et al. (2000) mentioned some causal factors that led to the changes in trust in government, i.e., national economic factors (Citrin & Green, 1986; Feldman, 1983; Hetherington, 1998; Mansbridge, 1997; Miller & Borrelli, 1991), socio-cultural factors including problems in society (Mansbridge, 1997), or political factors such as war, political scandals, and corruption (Orren, 1997). Chanley et al. concluded that "declining trust in government is a complex phenomenon with multiple potential causes." (2000, p. 240).

Not only understanding the causes, but a vast amount of literature also discusses various efforts to reverse the decline in trust in government. Norris (2001) argued that an open and transparent government is expected to remedy the loss of faith in government. Government reform is considered indispensable (Osborne & Gaebler, 1992; Peters, 2001), where it requires citizen participation to get involved in the political process (Barber, 2003; Dryzek, 1990). Electronic government was deemed a solution offering myriad opportunities for achieving government reforms. E-government makes it possible for the government to deliver more effective services online (West, 2004), improve citizen-government communication, and increase citizens' political participation (Mossberger et al., 2003; Tolbert & Mossberger, 2006). There are a considerable number of publications that investigate the influence of e-government on trust, such as the work of Horsburgh et al. (2011), Parent et al. (2005), Porumbescu (2016), and Welch et al. (2005), where most of them show a positive association between trust in government and e-government.

As e-government has been widely adopted by federal, state, and local government institutions, there is a trigger for government to be more open and transparent regarding their activities and performances. Open government was coined as the continuation of e-government which enables the creation of massive government data, including the availability of government documents on websites (Abu-Shanab, 2015). Open government is expected to increase the transparency of government activities, improve citizen participation, and strengthen citizen-government cooperation (Susha et al., 2015; Wirtz et al., 2018). One of the open government initiatives is open government data (OGD), which refers to any government-related data generated and owned by various government agencies. The government data such as budget, education, health, population, technology development, geographical data, meteorological data, etcetera, which are available and accessible for public to use are part of OGD (Ubaldi, 2013).

While many scholars have studied the influence of e-government and trust in government, relatively few studies discuss the effect of open government data on trust in government. In addition, to my best knowledge, there is no literature discussing the influence of open data in government and e-government services on trust in government. This paper explores the interconnection between citizens' interaction with government data and citizens' trust in government. The article begins with discussing the current state of research by reviewing some existing studies on trust in government associated with e-government and OGD. Subsequently, we deduce the conceptual model and hypotheses based on theoretical concepts. Later, findings are presented where we test the model using structural equation modeling (SEM). We use data collected by Pew Research Center (2015) on American Trends Panel Wave 9 Dataset. Finally, we end this article with discussions and conclusions regarding the research implications and future work.

2. Literature, hypotheses, and model

2.1 Trust in government

Trust is a concept that has been discussed in various domains, such as management, public administration, marketing, psychology, and sociology. However, Castelfranchi and Falcone (2010) stated that trust has no clear-cut definition. Focusing on public administration, Hinnant (2007) analyzed various definitions of trust and came up with the concept of trust seen from two perspectives, i.e., trust as behavior and trust as a belief and/or attitude. As a behavior, trust requires taking risks because of uncertainty due to limitations in acquiring information. As an attitude, trust is related to belief which allows an individual to commit even without full knowledge (Luhmann, 2000). As a belief, trust consists of two different attitudes, i.e., attitudes towards the person or object and attitudes towards a specific situation.

Thomas (1998) defined trust based on three conceptions, i.e., fiduciary, mutual, and social. Fiduciary trust occurs when there are asymmetric relationships between a trustee and a trustor. It stands on the principal-agent theory where the principal has limited control over the performance of its agents, and therefore, there are chances for malfeasance. An example of fiduciary trust is trust in professionals such as patients and doctors, clients, and

lawyers. Mutual trust arises from repeated interactions between a trustee and a trustor. This type of trust is always interpersonal, for example, between students and their teachers as well as citizens and street-level bureaucracy. Social trust emerges as a result of social factors within social systems such as cultures, regulations, ethics, and norms, which restrain individual choices to calculate some options.

With regard to trust in government, fiduciary relationships have long been perceived as an essential component of citizens' trust in government (Barber, 1983; Kass, 1994; Thomas, 1998). Citizens have limited knowledge and ability about what the government is doing and how to control their performance. Therefore, the citizens-government relationship is considered asymmetric. Taking the concept of trust defined by Hinnant (2007), the asymmetric relationship makes the citizens take risks and believe that the government will perform in their interests.

The declining trend in trust in government has attracted the interest of many scholars. Many studies were conducted to investigate the causes of falling, such as Citrin and Green (1986), Feldman (1983), Hetherington (1998), Mansbridge (1997), and Miller and Borrelli (1991). They argue that the national economic factor is the reason why citizens distrust their government. Socio-cultural factors such as societal problems are another determinant (Mansbridge, 1997; Pew Research Center, 1998). Wars, political scandals, and corruption are considered political factors that could undermine trust in government (Orren, 1997). The declining trend is complex due to many possible factors (Chanley et al., 2000).

2.2 Citizen's interaction with government data

As a new concept implemented by government institutions, there is limited research investigating the link between trust in government and open government data. Among these few studies, most of them focus on understanding citizens' trust in open government data (Purwanto et al., 2020) and the intention of citizens in using open government data (Khurshid et al., 2022; Souza et al., 2022; Wirtz et al., 2019). To our best knowledge, the study conducted by Gonzálvez-Gallego et al. (2020) is the only study that directly explores the link between open government data and trust in government. The association was investigated through a mediation role, i.e., citizens' satisfaction, measured based on satisfaction with the economy, government, education, health services, and democracy.

While limited research is found on OGD and trust in government, many studies investigated the influence of e-government on trust in government. Parent et al. (2005) found that citizens' transactions with government services positively affect trust in government and external political efficacy. Their findings confirm that trust in government was influenced by several factors, including the quality of e-government experiences. They measured experiences based on questions related to respondents' activities with online government services. Welch et al. (2005) investigated the link between citizen satisfaction with electronic government services and trust in government. Their findings also showed a positive association between e-government satisfaction and trust in government. Later, Tolbert and Mossberger (2006) also explored the influence of e-government on trust and confidence in government. Their evidence suggests a link between the use of government websites and trust in government. They concluded that e-government has the force to increase trust through interactions with citizens. Other scholars who concentrated on public administration corroborate that trust in public administration is positively associated with the perceived quality of electronic services (Gracia & Casaló Ariño, 2015). They asked respondents about experiences and perceptions about e-government services based on four dimensions of service quality proposed by Parasuraman et al. (2005).

We conclude that according to these studies, the interactions of citizens with government digital services influence trust in government. The more the citizens interact with government digital services, the more they trust in government. Interactions can be in the form of accessing government websites (Tolbert & Mossberger, 2006) and other experiences using e-government services (Gracia & Casaló Ariño, 2015; Parent et al., 2005).

As open government data is part of digital government services, we argue that interactions of citizens with open government data influence trust in government. There are some forms of interactions; access to data is one of them. When citizens access government data, it facilitates the principle of transparency which "allows the citizen to see what the government is doing, and how it is doing it" (O'Hara, 2012, p. 226). It shapes the citizens' perception that their government is accountable for what they are doing, and as a result, their trust in government increases. Therefore, we propose a hypothesis to relate the interaction of citizens with data and trust in government.

H1: Citizen's interaction with government data positively influences citizen trust in government.

2.3 Perceived benefits

The perception of benefits has been seen as a determinant of trust in prior studies in the information systems-related field. E-government and OGD have triggered government institutions to treat information as an asset that

offers tremendous benefits for the government and stakeholders, including citizens. The benefits of OGD for citizens are mainly clustered based on political and social benefits and economic benefits (Janssen et al., 2012; Mokobombang et al., 2019; Safarov et al., 2017).

In terms of political and social benefits, opening government data to the public enables the government to be more transparent. Linders and Wilson (2011) argued that transparency is an anti-corruption mechanism to ensure decision-makers' accountability. Transparency in government data makes it possible for citizens to have equal access to the data, participate in controlling the functioning of government, and ensure that government is accountable to public. OGD also enables citizen participation at various policy cycle stages (Galster, 2018), forcing the government to be more aware of their decision-making process as citizens can always get informed about the government's workings. OGD is thus expected to result in better decisions by government officials. Another benefit is to increase the quality of public services. In their paper, Safarov et al. (2017) noted some publications that focus on the use of OGD to improve public services, for example, citizens apps that make use of OGD to solve urban-related issues such as public transportation, public safety, and public utilities (Desouza & Bhagwatwar, 2012). OGD also brings impacts on public engagement with the government that can lead to trust in the government.

We argue that the benefits of OGD perceived by citizens influence trust in government. In trust-related research, some scholars associate trust with benefits and values. Yang (2005) mentioned two theoretical approaches in trust research, the economic and ethics approach. The economic approach assumes that trust is defined by four assumptions, one of which is the logic of calculations where people see benefits and costs before they trust an entity (Hardin, 2002; Williamson, 1996). Concerning OGD, understanding its benefits can help citizens have a better logical calculation to trust their government. The second approach, the ethics approach, assumes that trust is defined by three assumptions (Baier, 1995; Uslaner, 2002), one of which is social and moral relations. In terms of OGD, citizens will tend to trust in government whenever OGD's benefits are associated with social and moral values. The power of OGD as an anti-corruption tool fits the social and moral values. Therefore, we claim that the perceived benefits of OGD positively influence citizen trust in government.

H2: Citizen's perceived benefits of government data positively influence trust in government.

2.4 Effectiveness

Effectiveness is related to evaluation and usually linked to efficiency. When efficiency is defined as completing tasks with little waste, effectiveness reflects achieving the desired results, outcomes, or effects (Kjurchiski, 2014). Effectiveness is not only about achieving the objectives but also the desired results, outcomes, or impacts. A government program is called effective when the actual results achieve the objectives and produce the intended effects.

There is no publication focusing on the effectiveness of OGD. However, some publications discuss the effectiveness of e-government and general information systems (IS). Wang and Liao (2008) mentioned the effectiveness of information systems as the success of IS. An information system is called effective whenever it successfully achieves the intended outcomes. They argued that measuring the effectiveness of IS means measuring the success of IS. Therefore, they referred to the Information Systems Success Model (ISSM) developed by DeLone and McLean (1992, 2003) to measure the effectiveness of IS. The model consists of six dimensions that explain the success of IS. One of the dimensions associated with the definition of effective is net system benefits, which means the ability of the system to deliver impact or values to users as well as the organization. This dimension is seen as the intended outcomes of information systems, including e-government.

Based on the ISSM, OGD is called effective when citizens perceive and feel that OGD brings net benefits or values for them—not only for their government. Having access to open government data, citizens can experience values, such as more transparent government, equal access to government data, ability to reuse data for other purposes, ability to control government, etcetera. For the government, there is a wide range of benefits such as better service delivery to citizens, good governance, an increase in images, more innovations in society, and so on. Therefore, citizens may respond positively following the disclosure of government data. They might perceive OGD as effective because they could know better what the government is doing. As a result, their trust in government increases.

H3: Citizen's perceived effectiveness regarding open government data positively influences trust in government.

2.5 Model

This paper investigates whether citizens' interaction with government data, perceived benefits, and perceived effectiveness of government data are essential indicators of citizen trust in government. The formula to solve the aim of the paper is as follows. Trust in government is a function that consists of three variables, i.e., `Citizen Interaction`, `Perceived Benefits`, and `Perceived Effectiveness`.

Trust in Government = ƒ (Citizen Interaction, Perceived Benefits, Perceived Effectiveness)

3. Data and methods

We use data from a national survey conducted by Pew Research Center on public opinion, taken from the American Trends Panel Wave 9 Dataset (Pew Research Center, 2014) that was undertaken between November 17 and December 15, 2014. The survey topic was post-election of 2014 and US citizens' views of open data/open government. The sample consists of 3,212 respondents, where 2,856 of them participated in Web surveys, and the other 356 respondents participated through the mail. To ensure the representativeness of the population, the sample was weighted in several steps (Pew Research Center, 2015). The margin of error for the total sample is ± 2.3%. The survey asked respondents to answer 192 questions, including demographic. The survey questions were categorized based on three sections, i.e., the post-election section, open government and open data section, and religious demography section. This paper uses data in the open government and open data section.

We realized that the data used in this study are old because it is from 2014. There have been changes in political situation, federal initiatives, technology advancements, and so on that might also change the public experiences on open government data. However, there are at least two reasons that justify the relevance of the data even today for understanding public opinions towards open government data and trust in government. First, the comprehensiveness and representativeness of the data. The dataset provided by the Pew Research Center is large, with extensive demographic representativeness (as seen in Table 1) and a rigorous methodology, ensuring the reliability of the findings. Second, there is no recent dataset that captures public opinion's data on OGD and trust in government as comprehensive as the American Trends Panel Wave 9 Dataset. To my knowledge, this dataset is the most comprehensive and publicly available data source, notwithstanding its age. In addition to its large sample size, this dataset remains relevant to comprehend the phenomena as described in our research question.

Regarding the demographics of the respondents as seen in Table 1, more female respondents participated in the survey than males, with the percentages of female and male respondents being 52.1% and 47.9%, respectively. Regarding the age distribution of the respondents, most of them were within the range of 50-64 years old (32.7%), 30-49 years old (27.2%), and more than 65 years old (25.4%). Only 14.2% of the respondents belonged to the 18-29 age group. With regards to education, half of the respondents were college graduates. Concerning their race/ethnicity, 77.8% of them were white non-Hispanic (77.8%). Other minorities, i.e., black non-Hispanic, Hispanic, and other races, were counted for 8%, 7.6%, and 5.7%, respectively. Almost all respondents (97.9%) were US citizens. There were more Democrat/Lean Democrat supporters than Republican/Lean Republicans who participated in this survey. The respondents' income concentrated on a yearly income up to $75,000 and around $30,000-$74,999. Regarding Internet use, the demographic result showed that most respondents were Internet users (92.4%).

Tab. 1 - Respondents' demographics

Categories	Percentage (%)
Age	
18-29	14.2
30-49	27.2
50-64	32.7
65+	25.4
Sex	
Male	47.9
Female	52.1
Education	
College graduate	52.1
Some college	28.7
High school graduate or less	19.1
Do not know/refuse to answer	.1
Race/ethnicity	
White non-Hispanic	77.8
Black non-Hispanic	8.0
Hispanic	7.6
Other	5.7
Do not know/refuse to answer	.9
Citizenship	
US Citizen	97.9
Not US Citizen	2
DK US Citizen	.1
Party	

Republican/Lean Republican	41.9
Democrat/Lean Democrat	50.6
No Lean	7.5
Income	
More than $75,000	35.6
$30,000 - $74,999	35.3
Less than $30,000	23.6
Do not know/refuse to answer	5.4
Household internet status	
Not Internet user	7.6
Internet user	92.4

The dependent variable in the model is `trust in government`. The data are taken from the survey questions about trust in government which consists of three items. This variable is measured by the frequency of trust in federal, state, and local government on a four-point item scale ranging from 1 (just about always) to 4 (none of the time). The independent variables consist of `citizen interaction`, `perceived benefits`, and `perceived effectiveness`. The variable citizen interaction is operationalized as citizens' access to information or data provided by the federal, state, and local governments, as reported in the survey. The operationalization uses a two-point scale (yes and no). The perceived benefits variable is operationalized as the perception of respondents regarding the impacts that open government data has on public. There are five items with a two-point scale (yes and no). The last variable is perceived effectiveness, operationalized as respondents' perception of whether the government is effective in sharing government data with the public. This variable has three items with a four-Likert scale, ranging from 1 (very effectively shares the data it collects) to 4 (not all effectively).

Regarding the methods, we used IBM SPSS Statistics for descriptive analysis and internal consistency. Subsequently, we conducted a study using structural equation modeling (SEM) on IBM SPSS AMOS 27 to find the causal relationships in the hypothesized model. SEM consists of the measurement and structural models (Fan et al., 2016; Kline, 2015). The measurement model determines the relationship between each unobserved or latent variable and its indicators (observed variables), whereas the structural model describes the relationship between the variables or the constructs in the model. The structural model tests the hypothesized model (Kline, 2015).

For the measurement model, whenever the indicators for each unobserved variable are specified based on relevant theories or prior knowledge, confirmatory factor analysis (CFA) is applicable to the use (Brown, 2015; Harrington, 2009; Jöreskog, 1969). Whenever the underlying latent variables are not yet specified because of little knowledge about them, exploratory factor analysis (EFA) is relevant. In this paper, the proposed model has never been introduced before. However, the underlying latent variables are specified based on prior knowledge and models as described in the previous section. Therefore, we use CFA before the structural model to determine whether there is a relationship between the observed variables and their unobserved or latent variables (Child, 1990; Kline, 2015). We use the maximum likelihood (ML) estimation method for the CFA. We continue with the structural model to test the hypothesized model whenever the result is satisfactory.

However, we acknowledge that the operationalization of the constructs used in this study is based on the survey items provided by the Pew Research Center's data rather than purposeful survey instruments built specifically for this study. Both dependent and independent variables are approximated through existing questions in the Pew Research's questionnaires that are closely related to our theoretical foundations. However, even so, the measures provide a meaningful way to investigate the relationships being studied in this paper.

4. Data analysis and findings

4.1 Measurement Model

We use CFA to measure the quality of latent variables by examining the relationship between the latent variables and their indicators or items before we use them in our structural equation model. The first step is to calculate the factor loadings or the correlation coefficient of the indicators that associate with each latent variable to check the convergent validity of our variables or constructs. Figure 1 presents the measurement model, including the standardized factor loadings. As seen in the figure, the values of the factor loadings range from .640 to .930. Most values are above .7, which indicates essential indicators. There are three items with loading factors between .6 to .7. As the cutoff for standardized factor loadings adopted by many scholars is .5 (Fabrigar et al., 1999), these indicators are retained. To sum up, the convergent validity of our variables is good, indicated by high standardized loadings.

Not only checking the convergent validity of the variables and their items, but we also check the discriminant validity by identifying the correlation of each pair of variables in our model. According to Figure 1, there are six

pairs of variables with correlation value lies between .095 and .430. None of them has a correlation value greater than .85—the cutoff used by some researchers to combine two variables due to discriminant validity.

The final step in reviewing the measurement model is checking the goodness of fit statistics to examine whether the model fits with the data. The summary of the fitness indices is presented in Figure 1. When we set the alpha level at .05 with df 71, we get the result that the chi-square is larger than the chi-square of the critical value, and thus, we reject the null hypothesis. It means that the hypothesized model significantly deviates from the observed model. However, chi-square is sensitive to the number of samples. With a large sample size, a researcher tends to get significant results and thus reject the null hypothesis even though the model is good. Therefore, we also use other indices, i.e., RMSEA, CFI, TLI, and SRMR. We follow the cutoff for fitness proposed by Hu and Bentler (Hu & Bentler, 1999). According to Figure 1, the RMSEA (.072) is less than .05, which indicates a good fit. CFI and TLI are .941 and .925, respectively, which both suggest a reasonable fit (.90 to .95). SRMR (.0419) is lower than .08 and therefore considered a good fit. Finally, we conclude that the fitness indices produce satisfactory results, and thus, it is assumed that the hypothesized model is a valid representation of the data or the empirical reality.

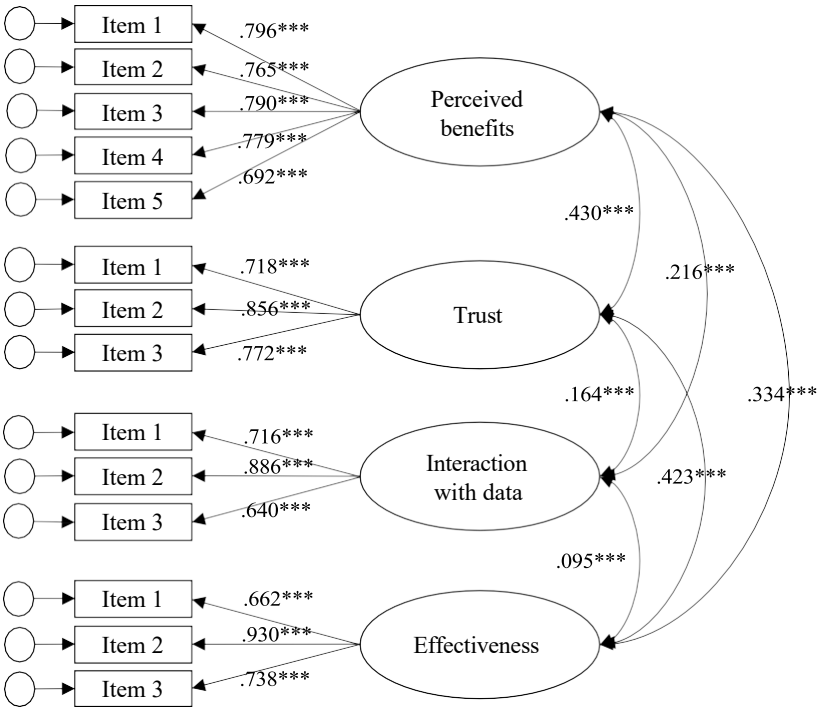


Fig. 1 - The measurement model, including its fit indices

4.2 Structural Model

We summarize the fitness of the model, the path coefficients, and the squared multiple correlations (R^2) in Figure 2 to assess the structural model. The global fit indices indicate a satisfactory fitness of the model because the index meets the cutoff of a good fit. It means the hypothesized model is a good representation of the empirical data.

According to the path coefficients, the three hypotheses are significant; thus, we fail to reject the null hypotheses. The path coefficients confirm the positive and significant impact of perceived benefits, interaction with data, and effectiveness on trust in government. To be more specific, perceived benefits (.312) and effectiveness (.312) appear to be stronger determinants to trust in government, while interaction with data (.067) has relatively lower importance. Altogether, the overall hypothesized model is significant, and the R^2 is .277, which means 27.7% of the variance of trust in government is explained by the three factors, i.e., perceived benefits, interaction with data, and effectiveness.

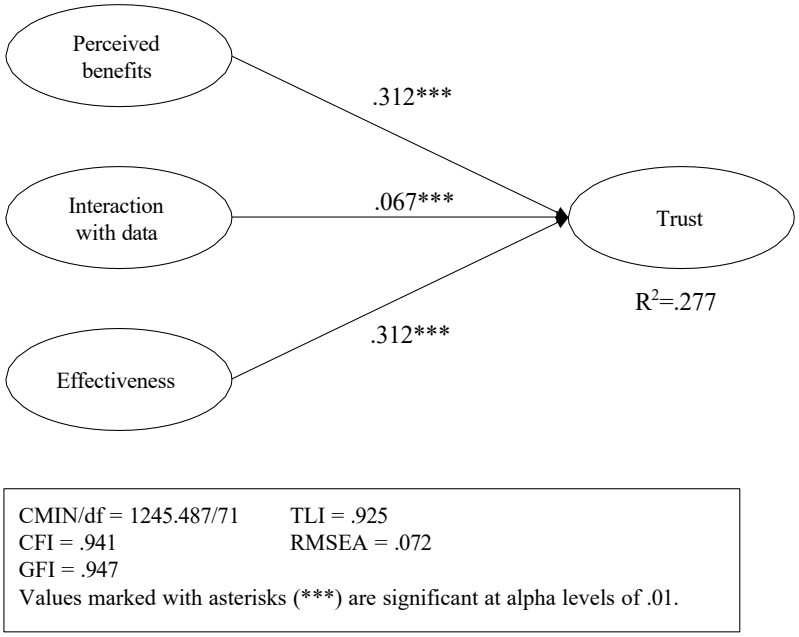


Fig. 2 - The measurement model, including its fit indices

5. Discussion

OGD increases trust in government through citizens' interaction with the data

The findings of this study support previous findings on e-government and trust in government. Our results confirm Parent et al. (2005), Tolbert and Mossberger (2006), and Gracia & Casaló Ariño (2015), who stated that citizens' transactions with government services had a positive association with trust in government. More specifically, they argue that trust in government is influenced by the quality of e-government experiences (Gracia & Casaló Ariño, 2015; Parent et al., 2005) and interaction with government websites (Tolbert & Mossberger, 2006). Our findings validate the importance of these interactions in building trust in government. While prior studies have highlighted the interaction of citizens with e-government, our findings emphasize that open government data can increase trust in government through citizen engagement with the data. Since no prior study investigates interaction with data and trust in government, our study is the first to confirm that citizens' interaction with government data positively influences trust in government.

Moreover, our results also corroborate the literature on the concept of trust. Interaction has long been perceived as a concept that forms trust in public administration. For example, Thomas (1998) states that mutual trust emerges whenever repeated interaction occurs between individuals or entities. Our findings extend the definition of interaction by arguing that even indirect interaction with government data can influence citizens' trust in government.

Perceived benefits of OGD matter for trust in government

Furthermore, perceived benefits play an essential role in improving trust. Our findings support previous studies in information systems literature on the perception of benefits and trust (Catoiu et al., 2014; Park et al., 2019). Focusing on mobile payment, Park et al. (2019) found that the perception of the benefits of using m-payment positively influences the customer's trust in m-payment. Investigating users' trust in online social networks, Catoiu et al. (2014) reported a positive correlation between the user's perceived benefits and trust in online social networks. Our results are consistent with their findings, indicating a positive and significant correlation between perceived usefulness and trust. Although our domains are different, the three findings confirm that the perception of benefits is an essential determinant of trust. Specifically, in the context of trust in government, our findings highlight that perceptions about the benefits of OGD are a significant determinant.

These findings can be explained by the previous trust theory proposed by Yang (2005), who accentuated that individuals are usually triggered by some logical calculations such as benefits and costs before they trust an entity (Hardin, 2002; Williamson, 1996). Our study confirms that this economic logic is relevant in public administration. Before trusting their government, citizens will consider what benefits they can obtain from specific services. Citizens develop perceptions regarding the benefits that they might get. In the context of open government data, where the data can be obtained freely, many benefits of OGD outweigh the costs, and therefore, it brings citizens to trust their government. This argument is also consistent with the statement of Wirtz et al., who states that "… although citizens seem to be blind to external incentives, they strongly take into account the usefulness of open government data, thus suggesting that to some extent their behavior is indeed also guided by "practical rationality,"

and thus underlies instrumental considerations in terms of maximizing their benefit." (Wirtz et al., 2018, p. 315).

Our results also support the assumption that trust is defined by social and moral relations (Baier, 1995; Uslaner, 2002). Based on this assumption, individuals tend to trust other individuals or entities whenever the offered benefits are aligned with their social and moral values. This logic seems plausible in the context of open government data, as its benefits are linked to social values. For example, government data has the power to improve the accountability, transparency, and good decision-making of government, where all of which are associated with responsibility, honesty, integrity, and justice of the government. These values, in turn, inspire citizens to trust their government. As Hinnant (2007) suggests, trust can be seen as an attitude or behavior. We also agree that social values influence citizens' attitudes toward trusting their government, as these values are reflected in the benefits of open government data. Another possible explanation is the asymmetric relationship between citizens and government (Thomas, 1998), where citizens have limited knowledge about what the government is doing. Given this imbalance, it is plausible that after all, citizens rely on social and moral values when deciding to trust their government.

The significance of OGD effectiveness on trust in government

Our findings provide strong evidence that the effectiveness of open government data has a positive correlation with trust in government. Effectiveness is defined as the achievement of the desired results or outcomes (Kjurchiski, 2014). OGD is called effective whenever citizens both perceive and feel that it delivers the results they expect. Our results confirm that trust in government increases whenever citizens recognize that OGD has met their expectations. These expectations are typically related to accountability, transparency, and good decision taken by the government.

Wang and Liao (2008) denoted the effectiveness of information systems as the success of IS. Over the past several years, some studies have been conducted to investigate the success of IS in various domains, including e-government (Rana et al., 2015; Scott et al., 2009) and open government data (Purwanto et al., 2017). However, to date, no study has explicitly looked at the link between the effectiveness of IS or the success of IS and trust in government. Our study bridges the gap, highlighting the connection between research in public administration and information systems.

Practical implications

According to our research findings, we suggest practical implications for public administrators, public managers, and policymakers that could help increase citizens' trust in government through OGD. Considering the importance of perceived benefits, we find it crucial for practitioners to focus on increasing the understanding of the open data benefits for citizens. The objective is not only to inform citizens regarding possible direct benefits when they participate in open government data but also indirect benefits such as transparency, accountability of government, and so on. In the ladder of citizen participation, informing citizens is "the first step toward legitimate citizen participation" (Arnstein, 1969, p. 219).

There are several approaches that the government can do to inform citizens about OGD's benefits. One of which is to improve the relations between government and media, allowing journalists to use government data to report and inform what the government is doing (Papoutsaki, 2008). Citizens favor this indirect benefit, as confirmed in our study, because they believe that OGD enables journalists to cover government actions in greater detail. Another essential approach is to focus on creating informed and engaged citizens. Milner (2002) stated civic literacy is vital to developing informed citizenship. Creating informed citizens can be done through the collaboration between government and community.

Our finding validates the significance of citizens' interaction with open government data. Thus, a practical implication for the government is to increase the availability of government data and information for public to access and utilize the data. This means that data must be free, available, and accessible for citizens in a standardized format, following the principles of open data. Wirtz et al. (2018) also mentioned that government websites and online platforms used to present the open data must align with citizens' needs, stressing the necessity to design the platforms with usability in mind. By focusing on making more government data accessible to citizens and improving the usability of the online platforms, the government can increase the effectiveness of OGD and ultimately, strengthen citizens' trust in government.

6. Conclusion

This paper aims to investigate the connection between trust in government and three factors, i.e., the interaction of citizens with government data, the perception of benefits of government data, and the effectiveness of government data. Our findings show that citizens' interaction with OGD matters in increasing trust in government. Specifically, the more citizens interact with open government data, the greater their trust in the government. This finding aligns with previous studies in the e-government domain, for example, the work of Parent et al. (2005), Tolbert and Mossberger (2006), and Gracia & Casaló Ariño (2015). Our findings also strengthen the concept of

trust proposed by Thomas (1998), who states that repeated interaction between individuals and entities can create trust.

However, our results indicate that perceived benefits and effectiveness of government data are more essential determinants than citizens interaction with government data. When citizens have a better perception of the benefits of open government data, they tend to trust their government. Therefore, we conclude that government needs to focus on informing citizens about the values of open government data, both direct and indirect benefits. Another important determinant is the effectiveness of OGD. The findings also reveal that the effectiveness of open government data has a positive correlation with trust in government, meaning that when citizens both understand the benefits of OGD and also feel that it delivers their desired expectation, they will tend to trust their government.

Our study has some limitations, especially concerning the data and the questionnaire. First, the data used were taken in 2014. Even though the sample size is enormous, there might be cases where there are some changes in society, such as political, economic, social, and technological conditions. These changes could result in different responses and, thus, different results whenever the same study is conducted using more recent data. We recommend conducting a similar study using more recent data to test the consistency of the results. Second, this study uses existing data provided by Pew Research Center (2014). As a result, the number of items asked in the questionnaire cannot be adjusted according to our needs. For example, there are many types of interactions, but this study only considers the first interaction level, i.e., data access. The number of items for each factor is also limited as we used the Pew Research Center's data. Using the same model to test trust in government, we recommend having a more thorough instrument that includes more items. We also recommend testing the same model in the context of OGD outside the United States to know whether trust in government in other countries is positively influenced by perceived benefits, effectiveness, and interaction with open government data. Third, there is a possibility of reverse causality, meaning that there is a chance that high trust in government might lead to more interaction with government data. This phenomenon has not yet explored in this study. Finally, we recognize that the model of trust in government used in study is notably like the constructs used in technology acceptance, especially the Technology Adoption Model (TAM) (Davis, 1989). This overlap could further be explored to investigate the intersection between trust in government and technology acceptance in the context of open government data. This investigation could provide insights into how public acceptance on open government data influences their trust in government. Therefore, future study to extend the model is worth investigating to enrich the literature of both technology acceptance and trust in government.

Acknowledgement

- **Funding or Grant** (if applicable)**:** -
- **Data/Software Access Statement** (if applicable): -
- **Contributor Statement***: Author 1 (Conceptualization, Data Curation, Formal Analysis, Methodology, Writing); Author 3 (Conceptualization, Methodology, Supervision).
- **Use of AI***: During the preparation of this work, the author(s) used ChatGPT in order to assist with the paraphrasing and grammar check. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Abu-Shanab, E. A. (2015). Reengineering the open government concept: An empirical support for a proposed model. *Government Information Quarterly*, *32*(4), 453–463. https://doi.org/10.1016/j.giq.2015.07.002

Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Institute of Planners*, *35*(4), 216–224. https://doi.org/10.1080/01944366908977225

Baier, A. (1995). *Moral prejudices: Essays on ethics*. Harvard University Press.

Barber, B. (1983). *The logic and limits of trust*. Rutgers University Press.

Barber, B. (2003). *Strong democracy: Participatory politics for a new age*. University of California Press.

Brown, T. A. (2015). *Confirmatory Factor Analysis for Applied Research, Second Edition*. Guilford Publications.

Castelfranchi, C., & Falcone, R. (2010). *Trust theory: A socio-cognitive and computational model*. John Wiley & Sons.

Catoiu, I., Orzan, M., Macovei, O.-I., & Iconaru, C. (2014). Modelling users' trust in online social networks. *Amfiteatru Economic Journal*, *16*(35), 289–302.

Chanley, V. A., Rudolph, T. J., & Rahn, W. M. (2000). The origins and consequences of public trust in government. *Public Opinion Quarterly*, *64*(3), 239–256. https://doi.org/10.1086/317987

Child, D. (1990). *The essentials of factor analysis*. Cassell Educational.

Christensen, T., & Lægreid, P. (2005). Trust in government: The relative importance of service satisfaction, political factors, and demography. *Public Performance & Management Review*, *28*(4), 487–511. https://doi.org/10.1080/15309576.2005.11051848

Citrin, J. (1974). Comment: The political relevance of trust in government. *American Political Science Review*, *68*(3), 973–988. https://doi.org/10.2307/1959141
Citrin, J., & Green, D. P. (1986). Presidential leadership and the resurgence of trust in government. *British Journal of Political Science*, *16*(4), 431–453. https://doi.org/10.1017/S0007123400004518
Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319–340. JSTOR. https://doi.org/10.2307/249008
DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, *3*(1), 60–95. https://doi.org/10.1287/isre.3.1.60
DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, *19*(4), 9–30. https://doi.org/10.1080/07421222.2003.11045748
Desouza, K. C., & Bhagwatwar, A. (2012). Citizen apps to solve complex urban problems. *Journal of Urban Technology*, *19*(3), 107–136. https://doi.org/10.1080/10630732.2012.673056
Dryzek, J. S. (1990). *Discursive democracy: Politics, policy, and political science*. Cambridge University Press.
Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., & Strahan, E. J. (1999). Evaluating the use of exploratory factor analysis in psychological research. *Psychological Methods*, *4*(3), 272.
Fan, Y., Chen, J., Shirkey, G., John, R., Wu, S. R., Park, H., & Shao, C. (2016). Applications of structural equation modeling (SEM) in ecological studies: An updated review. *Ecological Processes*, *5*(1), 19. https://doi.org/10.1186/s13717-016-0063-3
Feldman, S. (1983). The measurement and meaning of trust in government. *Political Methodology*, 341–354. https://www.jstor.org/stable/25791197
Galster, A. (2018). Transparency and open government. *Report 35th Session. Council of Europe. Disponível Em: Https://Rm. Coe. Int/Transparency-and-Open-Government-Governance-Committee-Rapporteur-Andre/16808d341c Acesso Em*, *5*.
Gonzálvez-Gallego, N., Nieto-Torrejón, L., & Pérez-Cárceles, M. C. (2020). Is open data an enabler for trust? Exploring the link and the mediating role of citizen satisfaction. *International Journal of Public Administration*, *43*(14), 1218–1227. https://doi.org/10.1080/01900692.2019.1668412
Gracia, D. B., & Casaló Ariño, L. V. (2015). Rebuilding public trust in government administrations through e-government actions. *Revista Española de Investigación de Marketing ESIC*, *19*(1), 1–11. https://doi.org/10.1016/j.reimke.2014.07.001
Hardin, R. (2002). *Trust and trustworthiness*. Russell Sage Foundation.
Harrington, D. (2009). *Confirmatory Factor Analysis*. Oxford University Press, USA.
Hetherington, M. J. (1998). The political relevance of political trust. *American Political Science Review*, *92*(4), 791–808. https://doi.org/10.2307/2586304
Hinnant, L. C. (2007). *The trust experience from the truster's perspective: A theoretical discussion and experiment*. Syracuse University.
Horsburgh, S., Goldfinch, S., & Gauld, R. (2011). Is public trust in government associated with trust in e-government? *Social Science Computer Review*, *29*(2), 232–241. https://doi.org/10.1177/0894439310368130
Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118
Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data and open government. *Information Systems Management*, *29*(4), 258–268. https://doi.org/10.1080/10580530.2012.716740
Jöreskog, K. G. (1969). A general approach to confirmatory maximum likelihood factor analysis. *Psychometrika*, *34*(2), 183–202.
Kass, H. D. (1994). Trust, agency and institution building in contemporary American democracy. *Administrative Theory & Praxis*, 15–30.
Khurshid, M. M., Zakaria, N. H., Arfeen, M. I., Rashid, A., Nasir, S. U., & Shehzad, H. M. F. (2022). Factors influencing citizens' intention to use open government data—A case study of Pakistan. *Big Data and Cognitive Computing*, *6*(1), 31. https://doi.org/10.3390/bdcc6010031
Kjurchiski, N. (2014). Public administration efficiency in resource economies. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2440725
Kline, R. B. (2015). *Principles and practice of structural equation modeling*. Guilford publications.
Linders, D., & Wilson, S. C. (2011). *What is open government? One year after the directive*. 262–271.
Luhmann, N. (2000). Familiarity, confidence, trust: Problems and alternatives. *Trust: Making and Breaking Cooperative Relations*, *6*(1), 94–107.
Mansbridge, J. (1997). Social and cultural causes of dissatisfaction with U.S. government. In J. S. Nye Jr., P. D. Zelikow, & D. C. King (Eds.), *Why people don't trust government*. Harvard University Press.
Meijer, A. J., Curtin, D., & Hillebrandt, M. (2012). Open government: Connecting vision and voice. *International Review of Administrative Sciences*, *78*(1), 10–29. https://doi.org/10.1177/0020852311429533
Miller, A. H. (1974). Political Issues and Trust in Government: 1964–1970. *American Political Science Review*, *68*(3), 951–972. https://doi.org/10.2307/1959140

Miller, A. H., & Borrelli, S. A. (1991). Confidence in government during the 1980s. *American Politics Quarterly*, *19*(2), 147–173. https://doi.org/10.1177/1532673X9101900201
Milner, H. (2002). *Civic literacy: How informed citizens make democracy work*. UPNE.
Mokobombang, N., Gutierrez, J., & Petrova, K. (2019). The benefits of open government data use: A crosscountry comparison. *CONF-IRM 2019 Proceedings*. International Conference on Information Resources Management (CONF-IRM). https://aisel.aisnet.org/confirm2019/21
Mossberger, K., Tolbert, C. J., & Stansbury, M. (2003). *Virtual inequality: Beyond the digital divide*. Georgetown University Press.
Norris, P. (2001). *Digital divide: Civic engagement, information poverty, and the Internet worldwide*. Cambridge University Press.
O'Hara, K. (2012). Transparency, open data and trust in government: Shaping the infosphere. *Proceedings of the 3rd Annual ACM Web Science Conference on - WebSci '12*, 223–232. https://doi.org/10.1145/2380718.2380747
Orren, G. (1997). Fall from grace: The public's loss of faith in government. In *Why people don't trust government* (pp. 77–107). Harvard University Press.
Osborne, D., & Gaebler, T. (1992). *Reinventing government: How the entrepreneurial spirit is transforming the public sector*. Addison-Wesley.
Papoutsaki, E. (2008). *South Pacific Islands communication: Regional perspectives, local issues*. AMIC.
Parasuraman, A., Zeithaml, V. A., & Malhotra, A. (2005). E-S-QUAL: A multiple-item scale for assessing electronic service quality. *Journal of Service Research*, *7*(3), 213–233. https://doi.org/10.1177/1094670504271156
Parent, M., Vandebeek, C. A., & Gemino, A. C. (2005). Building citizen trust through e-government. *Government Information Quarterly*, *22*(4), 720–736. https://doi.org/10.1016/j.giq.2005.10.001
Park, J., Amendah, E., Lee, Y., & Hyun, H. (2019). M-payment service: Interplay of perceived risk, benefit, and trust in service adoption. *Human Factors and Ergonomics in Manufacturing & Service Industries*, *29*(1), 31–43. https://doi.org/10.1002/hfm.20750
Peters, B. G. (2001). *The Future of governing*. University Press of Kansas.
Pew Research Center. (1998, March 10). *How Americans View Government*. Pew Research Center. https://www.pewresearch.org/politics/1998/03/10/how-americans-view-government/
Pew Research Center. (2014). *American Trends Panel Wave 9*. Pew Research Center. https://www.pewresearch.org/internet/dataset/american-trends-panel-wave-9/
Pew Research Center. (2015). *Americans' Views on Open Government Data*. https://www.pewresearch.org/internet/2015/04/21/open-government-data/
Pew Research Center. (2022, June 6). *Public Trust in Government: 1958-2022*. https://www.pewresearch.org/politics/2022/06/06/public-trust-in-government-1958-2022/
Porumbescu, G. A. (2016). Linking public sector social media and e-government website use to trust in government. *Government Information Quarterly*, *33*(2), 291–304. https://doi.org/10.1016/j.giq.2016.04.006
Purwanto, A., Janssen, M., & Zuiderwijk, A. (2017). *Towards an open government data success model: A case study from Indonesia*. 154.
Purwanto, A., Zuiderwijk, A., & Janssen, M. (2020). Citizens' trust in open government data: A quantitative study about the effects of data quality, system quality and service quality. *The 21st Annual International Conference on Digital Government Research*, 310–318. https://doi.org/10.1145/3396956.3396958
Rana, N. P., Dwivedi, Y. K., Williams, M. D., & Weerakkody, V. (2015). Investigating success of an e-government initiative: Validation of an integrated IS success model. *Information Systems Frontiers*, *17*(1), 127–142. https://doi.org/10.1007/s10796-014-9504-7
Safarov, I., Meijer, A., & Grimmelikhuijsen, S. (2017). Utilization of open government data: A systematic literature review of types, conditions, effects and users. *Information Polity*, *22*(1), 1–24. https://doi.org/10.3233/IP-160012
Scott, M., DeLone, W. H., & Golden, W. (2009). Understanding net benefits: A citizen-based perspective on eGovernment success. *ICIS 2009 Proceedings*, 86.
Souza, A. A. C. de, d'Angelo, M. J., & Lima Filho, R. N. (2022). Effects of predictors of citizens' attitudes and intention to use open government data and government 2.0. *Government Information Quarterly*, *39*(2), 101663. https://doi.org/10.1016/j.giq.2021.101663
Susha, I., Zuiderwijk, A., Janssen, M., & Grönlund, Å. (2015). Benchmarks for evaluating the progress of open data adoption: Usage, limitations, and lessons learned. *Social Science Computer Review*, *33*(5), 613–630. https://doi.org/10.1177/0894439314560852
Thomas, C. W. (1998). Maintaining and restoring public trust in government agencies and their employees. *Administration & Society*, *30*(2), 166–193. https://doi.org/10.1177/0095399798302003
Tolbert, C. J., & Mossberger, K. (2006). The effects of e-government on trust and confidence in government. *Public Administration Review*, *66*(3), 354–369. https://doi.org/10.1111/j.1540-6210.2006.00594.x
Ubaldi, B. (2013). *Open Government Data: Towards Empirical Analysis of Open Government Data Initiatives* (OECD Working Papers on Public Governance 22; OECD Working Papers on Public Governance, Vol. 22). https://doi.org/10.1787/5k46bj4f03s7-en

Uslaner, E. M. (2002). *The moral foundations of trust*. Cambridge University Press.
Wang, Y.-S., & Liao, Y.-W. (2008). Assessing eGovernment systems success: A validation of the DeLone and McLean model of information systems success. *Government Information Quarterly*, *25*(4), 717–733. https://doi.org/10.1016/j.giq.2007.06.002Get
Welch, E. W., Hinnant, C. C., & Moon, M. J. (2005). Linking citizen satisfaction with e-government and trust in government. *Journal of Public Administration Research and Theory*, *15*(3), 371–391. https://doi.org/10.1093/jopart/mui021
West, D. M. (2004). E-government and the transformation of service delivery and citizen attitudes. *Public Administration Review*, *64*(1), 15–27.
Williamson, O. E. (1996). *The mechanisms of governance*. Oxford University Press.
Wirtz, B. W., Weyerer, J. C., & Rösch, M. (2018). Citizen and open government: An empirical analysis of antecedents of open government data. *International Journal of Public Administration*, *41*(4), 308–320.
Wirtz, B. W., Weyerer, J. C., & Rösch, M. (2019). Open government and citizen participation: An empirical analysis of citizen expectancy towards open government data. *International Review of Administrative Sciences*, *85*(3), 566–586. https://doi.org/10.1177/0020852317719996
Yang, K. (2005). Public administrators' trust in citizens: A missing link in citizen involvement efforts. *Public Administration Review*, *65*(3), 273–285.

Digital Platform Government in the Promotion of Brazilian Audiovisual Content

Lorena Abs [a*], *Anderson* Barbosa [b], *Vivian* Pontes [c], *Julia* Rosa [d], *Aluísio* Rego [e], *Thiago* Cordeiro [f], *Luciana* Santa Rita [g], *Adriana* Gomes [h], *Lina* Távora [i] *and Daniela* Fernandes [j]

[a] Faculdade de Economia, Administração e Contabilidade, Universidade Federal de Alagoas, Alagoas, Brasil, lorena.franca@nees.ufal.br, https://orcid.org/0009-0001-6064-0005

[b] Instituto de Computação, Universidade Federal de Alagoas, Alagoas, Brasil, anderson.barbosa@nees.ufal.br, https://orcid.org/0009-0006-1227-9346

[c] Bacharelado em Sistemas de Informação, Instituto Federal de Alagoas, Alagoas, Brasil, vivian.pontes@nees.ufal.br, https://orcid.org/0009-0006-2372-138X

[d] Programa de Pós-Graduação em Políticas Públicas, Universidade Federal do Rio Grande do Sul, Rio Grande do Sul, Brasil, julia.rosa@nees.ufal.br, https://orcid.org/0000-0002-4941-8147

[e] Laboratório de Análise de Dados e Inteligência Computacional, Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte, Rio Grande do Norte, Brasil, aluisio.rego@nees.ufal.br

[f] Instituto de Computação, Universidade Federal de Alagoas, Alagoas, Brasil, thiago.cordeiro@nees.ufal.br, https://orcid.org/0000-0003-0976-7040

[g] Faculdade de Economia, Administração e Contabilidade, Universidade Federal de Alagoas, Alagoas, Brasil, luciana.santarita@nees.ufal.br, https://orcid.org/0000-0002-6868-9014

[h] Secretaria do Audiovisual, Ministério da Cultura, Brasília, Brasil, adriana.gomes@cultura.gov.br

[i] Secretaria do Audiovisual, Ministério da Cultura, Brasília, Brasil, lina.tavora@cultura.gov.br

j Secretaria do Audiovisual, Ministério da Cultura, Brasília, Brasil, daniela.fernandes@cultura.gov.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 27 June 2025

Abstract. The paper presents the Brazilian Public Audiovisual Content Platform, an initiative by the Ministry of Culture that aims to democratize access to national audiovisual content, with a focus on cultural inclusion and diversity. The platform complies with Law 13.006/2014, which mandates the screening of national films in schools and adopts the principles of Digital Government as established by Law 14.129/2021, prioritizing citizen-centricity, social participation, interoperability, and integration with other public services. The study employed an exploratory evaluation, supported by a qualitative approach, for collecting and analyzing primary data. The research methodology incorporated document analysis, pilot testing, and representative groups from the platform's user base. Data collection initially involved reviewing official documents, including the Work Plan approved by the Ministry of Culture, compliance reports, public policy documents, and legislation related to Digital Government. The analysis highlights technological challenges such as data security and accessibility, as well as the need to reduce digital exclusion. It concludes that the platform represents progress toward building a more inclusive and transparent digital government, with the potential to inform future public policies in the cultural and digital domains.

Keywords. Digital Platform Government; Brazilian Audiovisual Content; fairness, democratization
Policy paper, DOI: https://doi.org/10.59490/dgo.2025.1050

1. Introduction

Democratizing access to culture is a historic challenge in countries with significant social, cultural, and regional diversity, such as Brazil. Inequality in access to cultural goods is exacerbated by economic, geographical, and technological barriers, limiting the ability of millions of citizens to participate in and enjoy cultural expressions

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

[13]. Cultural democratization policies play a crucial role in expanding the distribution of cultural goods and increasing access to cultural institutions and public spaces [4].

Culture is a crucial structural component for the development of society and its subsequent social transformation [12]. Brazil's Federal Constitution of 1988 establishes that the State must guarantee the whole exercise of cultural rights, facilitate access to sources of national culture, and promote the appreciation and dissemination of cultural expressions [2]. In this sense, cultural policies play a strategic role in ensuring social inclusion and cultural citizenship, promoting diversity of expression, and encouraging access to cultural productions across multiple platforms [12].

In this context, the Brazilian Ministry of Culture (MinC) proposes the development of a Public Platform for Brazilian Audiovisual Content as a strategy to democratize access to national audiovisual production and promote cultural inclusion through diverse audiovisual content, representing different languages, formats, and aesthetics, with special attention to issues of gender, race, and accessibility. The platform is also targeted at schools to comply with Law 13.006/2014, which requires the screening of nationally produced films in elementary and secondary education schools, as well as the use of non-commercial cultural dissemination spaces.

The platform is under development through a partnership between the Secretariat of Audiovisual of the Ministry of Culture (SAV/MinC) and the Center for Excellence in Social Technologies (NEES), linked to the Institute of Computing (IC) of the Federal University of Alagoas (UFAL) through a consultancy hired by the Organization of Ibero-American States (OEI) [10]. This collaboration enabled the development of a digital platform that not only meets the needs of public access to Brazilian audiovisual content but also incorporates the guidelines and principles of the Digital Platform Government.

This article proposes a public platform aligned with the principles of the Digital Platform Government, aiming to promote the democratization of Brazilian audiovisual content. To this end, it seeks to fulfill three specific objectives: (1) examine citizen-centricity and user experience; (2) discuss social participation and collaboration; and (3) identify possibilities for interoperability and integration with other services.

From a theoretical standpoint, it is essential to emphasize that, within the Brazilian context, a significant gap exists regarding unequal access to culture as a historical challenge. In this regard, investigating how digital platforms can foster cultural inclusion contributes to understanding how digital public policies can directly impact the democratization of cultural access, a key issue in theories addressing social justice, equal access, and digital inclusion. In terms of the challenges to be addressed, the platform-based governance model can foster practices of public collaboration, transparency, and social inclusion in a country with continental dimensions and significant social inequalities.

Concerning practical implications, the research proposes a discussion on democratizing access to governmental digital platforms as an effective means to overcome historical challenges related to the unequal distribution of cultural goods. Furthermore, the research could serve as a reference for other digital governance initiatives that seek to promote inclusion and equity in access to culture, particularly in terms of accessibility needs and the integration of cultural content, while also promoting transparency, collaboration, and interoperability in the face of digital fragmentation, as well as challenges related to data security and universal internet access.

The article's structure is as follows: The following section contextualizes the concept of Digital Platform Government, highlighting its main characteristics and fundamental role in cultural democratization and digital inclusion. The following is the research methodology. Next, the results and discussion are presented, focusing on specific objectives. Finally, the platform's contributions to strengthening cultural inclusion and digital governance are discussed, highlighting technological challenges and offering support for improving public policies and future strategies that aim to expand access to culture in the digital environment.

2. Background

Public administration needs a solid structure to guarantee the adequate provision of public services. In an increasingly connected society, it is essential to develop mechanisms that optimize public management and align government action with the emerging demands of the digital world [6]. With the advancement of Information and Communication Technologies (ICTs), governments around the world have adopted digital solutions to improve service delivery and facilitate interaction with their societies.

Just as in the private sector, the modernization of public administration seeks to establish a new paradigm of action, making processes more agile, less bureaucratic, and citizen-oriented. The creation of digital government platforms has been a key driver of this transformation, providing greater accessibility and efficiency in public management. In this context, the concept of Digital Government has emerged, an approach that aims to integrate technological solutions into state administration, promoting the interoperability of systems, the centralization of services, and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

citizen participation [5].

The digitization of public services not only makes it possible to expand access to cultural goods but also to promote more inclusive and transparent management. In the cultural field, the application of these principles has made it possible to create initiatives such as the Public Platform for Brazilian Audiovisual Content, which seeks to facilitate access to national audiovisual production and promote cultural diversity through an accessible and interoperable technological solution. In this way, the adoption of digital platforms in government cultural management represents a significant advance in democratizing culture and ensuring fair access to Brazilian audiovisual content nationwide.

2.1 Digital Platform Government

The Digital Platform Government is an innovative model that cuts red tape in administrative processes and modernizes public services through the intensive use of digital technologies. The model emphasizes process innovation, operates as a public-private partnership, and encourages stakeholder participation. It also leverages innovative technologies and ensures transparency in managing public data [5, 11].

The core values of this model include efficiency, accountability, fairness, participation, collaboration, transparency, reducing the digital divide, and promoting digital equity. Its structure varies according to the government's objectives and role, and it is adaptable to different institutional and technological contexts. The literature already proposes various types of digital platforms and explores and applies them in multiple areas of the public sector [6].

In Brazil, Law No. 14.129/2021 (Digital Government Law) formalizes the digital modification of Public Administration, expanding citizen participation and encouraging innovation in public services. The legislation establishes essential guidelines for building digital platforms that guarantee accessibility, security, transparency, and interoperability between government systems [5].

In this way, the Digital Platform Government shows excellent potential in modernizing and expanding access to cultural goods. By integrating these principles into initiatives like the Public Platform for Brazilian Audiovisual Content, the goal is to ensure the democratization of access to digital culture, allowing citizens not only to consume but also to participate in cultural and audiovisual production actively. To this end, it must maintain as its central axes: (1) the satisfaction of a growing set of demands from society; (2) the openness and transparency of data; (3) the wide distribution of services; (4) the use of clear and accessible language as a way of communicating and getting closer to citizens; (5) the prioritization of public services in digital format; (6) the guarantee of security and privacy of citizens' sensitive data; (7) the promotion of social participation. In short, the Digital Government must act as an open and inclusive platform focused on the country's socioeconomic development and technological advancement, intending to continuously expand and optimize the quality and reach of public services [6].

2.2 Inclusion and Cultural Democracy

Equal access to and participation in cultural life have gained prominence in national and international discussions. Guaranteeing the active involvement of civil society acts as a catalyst for social inclusion [15]. Social inclusion is the active participation of civil society based on respect for cultural plurality and the value of individual diversity [7].

This emphasis on equal access and cultural participation fosters social inclusion and underpins true cultural democracy. In this scenario, the creation and circulation of cultural goods must be accompanied by a guarantee of their accessibility to diverse audiences, ensuring that inclusion becomes a central principle throughout the cultural process [14].

In recent decades, democratic societies have gradually promoted inclusion as a universal right, guaranteeing access for all to various social spaces. In Brazil, this movement gained momentum after the 1988 Federal Constitution, which established legal and regulatory provisions to ensure accessibility, especially in leisure and cultural areas. Although still in the early stages, cinemas, theaters, museums, parks, and other venues have been designed or adapted to meet the needs of people with disabilities, reducing obstacles and promoting their full participation in cultural and social activities [7]. This progress represents a continuous effort to ensure social inclusion and equal access to essential spaces for human and cultural development.

In short, education, culture, and leisure play crucial roles as structured spaces that have a fundamental power to mediate social inclusion, not just for people with disabilities but for all individuals [7]. In this scenario, digital transformation has created new opportunities for cultural inclusion, allowing more people to access cultural goods through digital platforms. However, there are also challenges, such as the risk of digital exclusion, as well as the need for public policies that guarantee connectivity and full accessibility for all [14]. In this context, the development of a Public Platform for Brazilian Audiovisual Content represents a significant step forward in

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

promoting digital equity and cultural inclusion, making access to audiovisual productions more democratic and affordable.

3. Research Methodology

The results from the exploratory evaluation were consolidated with the support of a qualitative approach to collecting and analyzing primary data. The research was conducted using a combination of document analysis, pilot tests, and representative user groups on the platform.

Initially, data collection involved reviewing official documents, such as the Work Plan approved by the Ministry of Culture, as well as compliance reports, public policy documents, and legislation related to Digital Government (Law No. 14,129/2021).
In terms of the specific objectives of the pilot, these were outlined in both technical and political terms, namely: a) To extract data and reference indicators regarding the reception of the target audience and their experience with the use of the social technology, and; b) To technically test the performance, usability, accessibility, communicability, and load support.

The first phase of the pilot involved identifying the sample, creating a target audience list composed of 30 federal government employees selected by the Ministries of Culture, Education, Science and Technology, and Justice, as well as Secretaries linked to these entities. In the second phase, participants were encouraged to explore the platform autonomously, with 15 days of free access to independently experiment with its functionalities. In the final phase, focus groups were used to gather data on the audience's reception and experience with the technology, focusing on usability, accessibility, and other technical aspects such as performance and load support.

4. Results and Discussions

This section presents the results of this work by discussing the general and specific objectives.

4.1 Public Brazilian Audiovisual Content Platform

The platform is characterized by its principle of free and democratic access. It allows any individual, regardless of their location or socioeconomic status, to access a wide range of audiovisual materials, including short films, feature films, documentaries, animations, and video art.

The Public Platform for Brazilian Audiovisual Content aims to develop and launch a platform that will make audiovisual productions from Brazilian producers available. The platform offers an open and accessible digital space where filmmakers, TV and video directors, video artists, producers, students, enthusiasts, and the general public can share, watch, and explore a wide variety of national audiovisual content, such as fiction, nonfiction, information, entertainment, education, science, and the arts [9].

The platform is characterized by its principle of free and democratic access, allowing any individual, regardless of their location or socioeconomic status, to access a wide range of audiovisual materials, including short and feature films, documentaries, animations, and video art. Another fundamental aspect is the promotion of cultural and creative diversity in Brazilian audiovisuals, ensuring the representation of different languages, formats, and aesthetics, as well as the recognition of various social identities, with a focus on issues such as social class, gender, and ethnicity. The platform also seeks, based on equity, to ensure visibility for regional and local productions, offering a space for expression for young, independent creators and filmmakers, and encouraging the discovery of new talents and innovative projects [9].

4.2 Citizen Centricity and User Experience

Citizens' full adherence to Digital Platform Government models requires the creation of an infrastructure that goes beyond simple internet access to devices. Digital inclusion must follow measures that ensure digital literacy, accessibility, and data protection for citizens [6]. Given this, there is a need for detailed regulations that ensure concrete conditions for the realization of fundamental rights in the digital environment, considering the growing digital presence of the population [3]. Furthermore, the construction of a citizen-focused government involves creating an interoperable system for personal data, as recommended by Brazilian Law 14,129/2021 (Digital Government Law), aiming to ensure transparency and effectiveness in the use of government digital platforms [5].

Given this scenario, the Brazilian Public Audiovisual Content Platform adopts the principle of citizen-centricity, promoting an accessible, personalized, and intuitive digital experience. The platform's design prioritizes digital accessibility, providing audiovisual content adapted to different audiences. This platform includes three levels of adaptation: subtitles, descriptive subtitles, and interpretation in Brazilian Sign Language (Libras), ensuring that people with disabilities can fully enjoy the available content.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In addition to accessibility, the platform incorporates user experience personalization tools, allowing each individual to tailor their interaction to their needs and preferences, always in line with the best practices of leading content platforms on the market. Among the features offered are browsing history, personalized playlists, the selection of display preferences, and control over subtitles and audio, allowing users to create a digital environment that best suits their needs [5].

The platform's interface was designed with a focus on usability, ensuring an intuitive and fluid experience. Content organization facilitates navigation and allows users to find desired productions quickly. Responsive design ensures compatibility with different devices, increasing accessibility and convenience for different audiences [6].

Participants highlighted the positive aspects of the platform, commending its attractive and intuitive design, which makes navigation easy. Some points for improvement were identified regarding usability, such as difficulty navigating in full-screen mode and the need to refresh the page when entering an incorrect PIN, which made the initial experience confusing. Issues with filter navigation were also reported, with the suggestion to display the combination of active filters on the screen. Furthermore, the "Continue Watching" feature and "Top 10" options appearing on every page can be confusing, leading to the recommendation that they should be displayed only on the main page. Participants also pointed out challenges, such as difficulty locating films with audio descriptions and the lack of optional subtitles.

The platform undergoes continuous evaluations involving accessibility analyses, a review of functionalities and technical requirements, and pilot tests with representative groups of the target audience. These initiatives ensure that the service meets the population's actual demands and can continually evolve to promote a genuinely inclusive and efficient digital experience.

4.3 Participation and Social Collaboration

The digital governance policy in Brazil is based on principles that aim to enhance the provision of public services and strengthen citizen participation. Among these principles, the following stand out: centrality in societal needs, ensuring that government actions and services effectively meet the population’s demands; transparency and open data, promoting access to information and social oversight; infrastructure and service capacity sharing among different governmental bodies; and process simplification to facilitate public access to government services. Additionally, the policy prioritizes digital service delivery, ensuring the security and privacy of citizens’ data. Social participation is also established as a central pillar, promoting government as an open platform dedicated to technological and socio-economic development, with continuous investments in innovation to improve public administration [8].

To promote social participation and collaboration in developing the Public Platform for Brazilian Audiovisual Content, the Ministry of Culture launched a public call for selecting audiovisual content to be licensed and added to the platform’s catalog. This initiative aims to integrate more than 400 completed audiovisual works, allow for their public exhibition, and expand access to national audiovisual production [1]. It also aims to ensure greater diversity and representation, including productions from different regions of the country and independent filmmakers.

Implementing pilot tests during the platform's development is a crucial aspect of enhancing social participation. These tests evaluate the user experience, identifying challenges and opportunities for improving navigation and content accessibility. Collecting user feedback enables technical adjustments and refinements, promoting digital inclusion and ensuring that the platform is genuinely accessible and responsive to users' needs.

Moreover, the platform aims to encourage civil society engagement through participatory tools, including discussion forums, surveys, and collaborative spaces for suggestions and improvements. These functionalities contribute to creating a dynamic and inclusive environment where users can not only consume content but also actively participate in curating and continuously developing it.

4.4 Interoperability and Integration with Other Services

Government digital platforms offer both structural and operational advantages, making them essential for modernizing public administration. Among these advantages, their modularity, adaptability, and scalability are particularly notable. These aspects allow the services provided to evolve as new social and technological demands emerge. Additionally, interoperability between different government systems is a crucial factor in ensuring efficiency and service centralization in a unified, accessible, and secure environment.

The use of open-source software, open standards, and accessible data facilitates interoperability between platforms. This approach makes information exchange between public entities easier and promotes transparency in the sharing of data. It also enhances digital security by allowing different services to integrate modern

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

technological solutions, such as blockchain, to ensure the authenticity and protection of governmental records and information [11].

Interoperability is a key aspect of the Public Platform for Brazilian Audiovisual Content. In addition to offering public and free audiovisual content streaming functionality, the platform provides a centralized space for promoting the national audiovisual sector. This space aggregates multiple sources of information, including other streaming platforms (both public and private), cinema programming, film criticism, research portals, and initiatives focused on the relationship between cinema and education, offering courses related to national audiovisual production. This integration seeks to connect the various stakeholders in the audiovisual production chain, increasing their visibility and fostering a supportive environment for national culture.

Preliminary analysis indicates that the platform has been designed to integrate with other government digital initiatives, such as citizen identification systems and cultural databases. This interoperability enables the creation of a broader digital ecosystem where audiovisual services can be accessed in an integrated manner with other cultural and educational public policies. For instance, integration with school databases and administrators can provide restricted access to educational institutions for audiovisual content. In this way, the platform's reach is expanded, promoting digital inclusion and encouraging the population's access to Brazilian audiovisual content.

Thus, the interoperability of the Public Platform for Brazilian Audiovisual Content reinforces the commitment to a digital government that is efficient, secure, and accessible. It ensures that citizens can benefit from integrated, personalized services that meet their cultural and educational needs.

5. Final Considerations

The study demonstrates that the Public Platform for Brazilian Audiovisual Content, run by the Ministry of Culture, is an initiative aligned with the principles of the Digital Platform Government, centralizing access to national audiovisual content and promoting inclusion and cultural democratization. The analysis highlights how the platform strengthens citizen participation, data governance, and interoperability with other public policies and government initiatives focused on the creative economy. However, significant challenges remain, such as ensuring universal accessibility, data security and privacy, and financial sustainability, which are essential for its consolidation and effectiveness.

The technological and cultural challenges in implementing the platform encompass multiple dimensions. From a technological perspective, issues such as interoperability between government systems, integration with cultural databases, scalability, accessibility, connectivity, and the ability to process large volumes of data are fundamental aspects to ensure an efficient and secure service. The use of open standards, free software, and secure protocols can enhance the user experience and provide a safe and accessible digital environment for all.

From a cultural perspective, the platform must reflect the diversity of the Brazilian audiovisual landscape, encompassing productions from different regions, genres, contexts, and social groups. This requires policies that encourage national production, content curation that represents diverse identities, and accessibility strategies to ensure that people with disabilities can fully enjoy the provided content. Furthermore, digital exclusion remains a challenge, limiting the access of vulnerable populations due to infrastructural, cognitive, and socioeconomic barriers. Investments in digital literacy and expanding connectivity are crucial to mitigating this problem.

Digital exclusion in Brazil manifests in different ways, including instrumental exclusion, resulting from the lack of technological devices; infrastructural exclusion, due to limited connectivity in remote areas caused by the lack of cabling, signal, or internet transmission; cognitive exclusion, related to difficulties in understanding and using digital technologies; and institutional exclusion, when the lack of access prevents citizens from knowing or exercising their rights.

Finally, the platform's governance requires a transparent and participatory model that balances state regulation with collaboration from civil society and the productive sector, ensuring a democratic space for the dissemination and appreciation of Brazilian audiovisual content. It is crucial to foster a culture of innovation, overcome challenges related to digital exclusion, and implement secure practices for managing citizens' data. These aspects are essential to guarantee accessibility, transparency, and security in the use of digital technologies, promoting a more inclusive and efficient digital governance. Future research could further examine the social and cultural impacts of the platform, evaluating its effectiveness in promoting digital inclusion and fostering cultural democratization.

Based on these results, it is recommended that the Brazilian government implement public policies to ensure accessibility and interoperability between various digital platforms, including those beyond cultural ones. This will enable services such as education, healthcare, and social assistance to be accessed in an integrated manner. Furthermore, it is essential to promote public policies that encourage the production of independent audiovisual content, expand fiscal incentives, and provide subsidies for producers and artists from various regions, while

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

establishing a sustainable financing model for digital cultural platforms. This can be achieved through the creation of public-private partnerships.

This study acknowledges its limitations, as it is based on an initial exploratory study that relies on documentary data. Additionally, the dependence on information from the platform's current development stage may not accurately reflect its final version, so complementary studies may be needed as its implementation progresses. Therefore, this research contributes to the debate on the digitalization of public cultural services, emphasizing the importance of participatory governance models and the strategic use of digital technologies to expand access and diversity in the production and distribution of audiovisual content.

Acknowledgement

- **Contributor Statement***: 1, Conceptualisation, Writing-Original Draft ; 2, Writing – Review & Editing; 3, Conceptualisation, Writing; 4, Review & Editing; 5, Review & Editing; 6, Supervision, Review and Editing; 7, Supervision, Methodology, Review & Editing 8, Conceptualisation; 9, Conceptualisation;10, Conceptualisation.
- **Use of AI***: During the preparation of this work, the authors used ChatGPT and Grammarly to improve the text. After using this tool or service, the authors reviewed, edited, made the content their own, validated the outcome as needed, and took full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

[1] Brasil. Ministério da Cultura. (2024). Edital de Licenciamento de Obras Audiovisuais. https://www.gov.br/cultura/pt-br/assuntos/editais/inscricoes-em-andamento/edital-de-licenciamento-de-obras-audiovisuais/edital-de-concurso-minc-no-1-de-21-de-agosto-de-2024

[2] Brasil. (1988). Constituição da República Federativa do Brasil de 1988 - Art. 215. Jusbrasil. https://www.jusbrasil.com.br/topicos/10648364/artigo-215-da-constituicao-federal-de-1988

[3] Júnior Nogueira, D. A., Valle, V. C. L. L., & Benelli, A. C. (2024). Direitos dos usuários de serviços públicos no ambiente do governo eletrônico e da administração pública digital. Revista de Direito Administrativo, 283(1), Artigo 1. https://doi.org/10.12660/rda.v283.2024.90691

[4] Lacerda, A. P. D. (2010). Democratização da cultura x democracia cultural: Os pontos de cultura enquanto política cultural de formação de público.

[5] Lanzillo, A. S. da S., & Andrade, J. P. do N. R. de. (2024). Compartilhamento de dados pessoais no governo digital: Uma revisão sistemática de literatura. CONTRIBUCIONES A LAS CIENCIAS SOCIALES, 17(6), e7668–e7668. https://doi.org/10.55905/revconv.17n.6-252

[6] Lima, C. M. M., Sousa, T. P. de, & Cristóvam, J. S. da S. (2023). Governo por plataforma e serviços públicos na Lei no 14.129/2021: Considerações para uma transformação digital adequada. A&C - Revista de Direito Administrativo & Constitucional, 23(91), Artigo 91. https://doi.org/10.21056/aec.v23i91.1699

[7] Mazzotta, M. J. da S., & D'Antino, M. E. F. (2011). Inclusão social de pessoas com deficiências e necessidades especiais: Cultura, educação e lazer. Saúde e Sociedade, 20, 377–389. https://doi.org/10.1590/S0104-12902011000200010

[8] Moura, M. A. (2016). Política de Governança Digital Brasileira: Em pauta a participação social e a transparência ativa. Revista Brasileira de Governança Digital, 1(1).

[9] Núcleo de Excelência em Tecnologias Sociais (NEES). (2024a). Relatório de Cumprimento de Objeto TED 30882120230034: Plataforma de Streaming Público (p. 124) [Relatório de Cumprimento de Objeto TED].

[10]Núcleo de Excelência em Tecnologias Sociais (NEES). (2024b, setembro 18). NEES e UFAL participam do desenvolvimento de plataforma pública de streaming para difusão de filmes nacionais. https://www.nees.ufal.br/nees-e-ufal-participam-do-desenvolvimento-de-plataforma-publica-de-streaming-para-difusao-de-filmes-nacionais/

[11] Repette, P. F. R., Sell, D., & Bastos, L. C. (2020, novembro 18). GOVERNO COMO PLATAFORMA: FATORES CRÍTICOS DE SUCESSO. Congresso Internacional de Conhecimento e Inovação (ciKi). https://doi.org/10.48090/ciki.v1i1.891

[12] Rhoden, V. (2015). Política cultural e democratização do acesso à cultura: A experiência do Vale-Cultura. Revista de Humanidades, 30(2), 347–361. https://dialnet.unirioja.es/servlet/articulo?codigo=6168726

[13] Santos, G. B. dos. (2020). Direitos humanos e o acesso à cultura na favela: Estudo de caso de uma biblioteca na Maré [Trabalho de Conclusão de Curso, Universidade Federal do Rio de Janeiro]. http://pantheon.ufrj.br/handle/11422/14430

[14] Santos, F. O. (2011). Democracia, democracia cultural e o Revelando os Brasis.

[15]UNESCO. (2025). Cultura | UNESCO. https://www.unesco.org/pt/g20/culture

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 9: Digital Transformation in Subnational Governments

Track Description

Digital transformation is an essential component of government strategies at both national and subnational levels, with an emphasis on secure citizen identification systems, data privacy, and digital inclusion. This track focused on the challenges subnational governments (states, regions, provinces, municipalities) face in implementing digital transformation. It seeks to highlight real-world cases, discuss the difficulties of integrating digital initiatives across different levels of government, and provide actionable recommendations for researchers, developers, and digital government practitioners. The track also aimed to (i) address collaborative governance, citizen participation, and federative or national-subnational relations in digital transformation; and (ii) foster discussions on overcoming the digital divide, enhancing cooperation between national and subnational levels, and developing more effective digital governance systems.

Track Chairs

B. B. B. Lanza, IDB, Brazil
J. R. Gil-Garcia, CTG SUNY Albany, United States of America
M. A. Cunha, Fundação Getúlio Vargas, Brazil
T. J. T. Ávila, Fundação Getulio Vargas, Brazil

Contents

Application of Design Thinking in Digital Transformation in Human Resources in the Public Sector 481
I. Monte, M. Marinho, G. Valença, R. Medeiros, and U. Cardoso

Brazilian Federal Institutions as Intermediaries: Driving Digital Transformation Through Open Innovation 491
J. Lima-Júnior, K. Gama, and J. Correia-Neto

Developing a BI Solution for Public Process Monitoring 505
R. J. Moura, M. G. Nascimento, G. Valença, K. Brito, G. Fraga, S. Peixoto, and E. Andrade

Digital Transformation, Technology, and Innovation: Analysis of Mayoral Candidates' Proposals in the 2024 Brazilian Municipal Elections 518
D. S. Valotto, B. B. B. Lanza, and T. J. T. Ávila

Government Data Science Teams: A Framework for Implementing Strategic Monitoring Solutions 531
H. A. V. Medeiros, A. L. Wanderley, D. de C. Bezerra, C. A. G. de Amorim Filho, R. Z. da Nóbrega, and F. G. de M. Ferreira

How can E-Government respond to the Digital Divide? Two Case Studies from Brazil 544
B. A. de Figueiredo and M. C. da C. Cruz

Integrating an Online Management System into Technical Schools: A Step Toward Digital Transformation 556
S. Lages, P. C. da Silva Neto, E. B. de Faria, J. M. de Figueiredo, and A. O. O. Confessor

The implementation of an integrated education data system at national level: the case of the Sistema Gestão Presente 568
F. Peres, C. da Silva, and A. B. Fernandes

What drives local governments' digital transformation in Brazil? 580
L. Lui, R. B. de Aguiar, L. N. dos S. ten Cate, and S. de M. Barbosa

Wind of Change or Just Another Digitalization Breeze? Lessons from Municipal Digital Change Agent Initiatives 594
I. Jäger, A. Hein, and H. Krcmar

Application of Design Thinking in Digital Transformation in Human Resources in the Public Sector

Iury Monte[a*], Marcelo Marinho[a], George Valença[a], Robson Medeiros[a], Uilca Cardoso[b]

[a]Universidade Federal Rural de Pernambuco (UFRPE), Recife, PE – Brasil.
Email: {iury.tavares, marcelo.marinho, robson.medeiros, george.valenca}@ufrpe.br

[b]Tribunal de Contas do Estado de Pernambuco (TCE-PE), Recife, PE – Brasil.
Email: {uilca}@tcepe.tc.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. The digital transformation of public sector organizations is often hindered by bureaucratic rigidity, inefficient processes, and resistance to change. This study explores how Design Thinking can drive innovation in the Department of People Management at the Court of Auditors, addressing these challenges through a user-centered approach. Using a mixed-methods methodology, the research combines qualitative interviews with people management leaders and quantitative surveys with employees to identify inefficiencies and co-develop solutions. Key pain points include complex leave request workflows, lack of integration with digital tools, and communication gaps. To tackle these issues, Design Thinking was applied iteratively, facilitating collaborative workshops, prototyping, and continuous stakeholder engagement to develop a more efficient, automated leave management system. This solution improved transparency, accessibility, and decision-making, reducing administrative burden and enhancing regulatory clarity. The findings indicate that Design Thinking fosters problem-solving, streamlines people management processes, and promotes adaptability within bureaucratic institutions. By embedding empathy, co-creation, and iterative problem-solving into digital transformation efforts, this approach enables sustainable innovation in public sector organizations. The study contributes to the broader field of digital government by presenting a replicable framework for modernizing people management practices. Future research could assess the long-term impact of these interventions and explore their applicability to other domains of public administration, ensuring continuous improvements in efficiency, service delivery, and user experience.

Keywords. Digital Transformation, Design Thinking, People Management, Public Sector Innovation
Research paper, DOI: https://doi.org/10.59490/dgo.2025.963

1. Introduction

A public sector consists of government entities and state-controlled institutions responsible for governmental functions, regulation, and provision of public services Lane, 1993. Identifying the needs of this sector is crucial to formulating and improving effective public policies, allowing for the appropriate allocation of resources and efforts to efficiently and targetedly meet society's demands Nigro, 1984. However, the bureaucracy inherent to these sectors can make internal processes slow, compromising their effectiveness Cardoso Jr, 2011. To overcome this challenge, the introduction of technology has proven to be relevant, providing greater agility to processes de Oliveira et al., 2012; Haug et al., 2024.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

When we understand that the concept of "public sector innovation" goes beyond the Schumpeterian vision, centered on a manufacturing logic Schumpeter, 1982, and begins to incorporate a perspective focused on services Jæger, 2013, we realize that the value to be delivered must be co-created with users Trischler and Scott, 2016. The capacity for co-creation becomes an indispensable factor for the development of innovations in public services that truly meet the demands of citizens Voorberg et al., 2015. Voorberg, Bekkers and Tummers Voorberg et al., 2015 highlight that co-creation involves everything from the engagement of citizens in the formulation of the service (as co-initiators) to their participation in the design and delivery of content (as co-developers).

The growing need to consider users as co-creators of value in public services poses a series of challenges to public management, which needs to transform itself into a more open and collaborative system. As a result, new methodologies become essential to allow users to co-create the experience they want to have Hanelt et al., 2021; Trischler and Scott, 2016.

To address these issues more effectively, the application of design thinking emerges as an innovative approach. By incorporating empathy, collaboration and creativity into the process of identifying requirements, design thinking provides a more holistic and user-centered way to solve these challenges Melo and Abelheira, 2015. At the heart of this approach is the concept of design thinking, a mindset that transcends the mere literal interpretation of a designer, implying the use of methods adapted to individual needs and making use of available technologies to create value for the user Silva et al., 2012. Furthermore, the application of design thinking results in effective problem-solving, differentiating itself from other approaches that often limit themselves to formulating the problem without achieving a concrete solution Martin, 2009.

In this context, the Court of Auditors of the State of Pernambuco (TCE-PE), the institution responsible for monitoring and auditing public resources in the state, has chosen to make significant investments in technological innovation. The goal is to speed up and improve its internal processes, aiming at a more efficient and transparent management of public resources. However, the court's employees often face challenges in explaining and articulating complex everyday issues, which can result in inadequate and ineffective solutions. The study focuses on using the Design Thinking approach to guide innovation in the Human Resources Department of the Court of Auditors of Pernambuco, aiming to reduce the rigidity intrinsic to institutional bureaucracy. Through this approach, we seek to develop an efficient, intuitive solution adapted to the needs of employees and, as a consequence, disseminate the technique and promote improved deliveries to society, in addition to improving people management processes, automating tasks, integrating information, facilitating data analysis and promoting greater agility and effectiveness in related activities.

2. Related Works

The rapid changes taking place in the contemporary world and the recognition of the limitations of the dominant model of public policy implementation (policymaking) point to the need to discuss the possibilities that open up for public administration, based on the incorporation of design thinking principles and their contributions both to a better understanding of public problems and to the construction of more effective government solutions. However, we still lack structured knowledge about this co-creation approach, especially how it fits into current policymaking practices and public organizations Cavalcante et al., 2019.

Based on this, governments around the world have sought support from this framework to implement co-creation processes (Ansell and Torfing, 2014). In Brazil, Santos and Hoffmann Santos and Hoffmann, 2016 conducted research with the aim of proposing a methodology for the design and implementation of more effective public services, applied in the context of a project in the city of Florianópolis, based on the concepts of Service Design and Project Management. In addition, Cavalcante Cavalcante et al., 2019 organized a collection that enriched the debate on the culture of innovation in Brazil, by presenting and discussing cases that implement innovative methods and approaches to management and public policies in different sectors and levels of government.

On the other hand, Voorberg et al. Voorberg et al., 2015 highlight the lack of empirical knowledge on co-creation, in addition to the scarcity of evidence that positions it as a significant strategy. These authors also raise important questions, such as the objectives of co-creation with citizens, the factors that influence the process and the expected results.

Trischler and Scott Trischler and Scott, 2016 add to these questions the lack of studies on user engagement methods in service design in different contexts of the public sector. Similarly, Cavalcante Cavalcante et al., 2019 highlights that, despite the progress in Brazil in the development of materials and in the training of civil servants to disseminate design thinking in government, it is necessary to understand its principles in greater depth in order to promote and incorporate this approach effectively. For Cavalcante Cavalcante et al., 2019, there is still a lack of structured knowledge on how this approach fits into the current practices of public organizations.

3. Methodology

Improving people management processes is a fundamental objective for organizations seeking efficiency, productivity and innovation. In the context of the Court of Auditors of Pernambuco, this improvement becomes even more crucial, given the strategic role played by this body. To achieve this objective, this study adopts a rigorous and comprehensive approach, centered on the application of a mixed research methodology. The core of this approach lies in the combination of quantitative and qualitative methods, allowing for a complete and multifaceted understanding of the challenges and opportunities faced in the area of people management. This article outlines the steps and procedures adopted to conduct this research, highlighting the importance of each phase and the synergy between them to achieve the proposed objectives.

Through in-depth interviews and questionnaires, we sought not only to identify gaps and areas for improvement in existing processes, but also to understand the perceptions and experiences of the managers and professionals involved. This in-depth understanding serves as a basis for proposing effective and sustainable solutions, aligned with the specific needs and realities of the Court of Auditors of Pernambuco.

By adopting an exploratory-sequential approach, starting with a qualitative investigation and expanding to a quantitative analysis, we hope to obtain valuable and informed insights into the challenges and opportunities in people management in this context.

3.1. Objective of the Study

By exploring the steps, this article aims to understand the application of design thinking in the redesign of public products and services, and as a consequence, disseminate the technique and promote the improvement of deliveries to society.

The ultimate goal of this study is to show how innovative co-creation solutions can be adopted in public environments to automate tasks, integrate information, facilitate data analysis and promote greater agility and effectiveness in the services provided to society.

3.2. Study Type

This is a mixed-methods study, combining quantitative and qualitative methods to obtain a comprehensive understanding of people management processes. The study adopted an exploratory-sequential design, where the qualitative phase precedes the quantitative phase. First, interviews were conducted to explore in depth the perceptions of people managers, since the researchers were unaware of the current problems in the court of auditors. The main objective was to identify what the main problems were and their order of priority given the needs of the managers. The interviews with the managers took place every two weeks and a questionnaire was carried out with the employees in order to obtain a diversity of perspectives in the sector.

3.3. Sample

The sample was composed of two distinct groups:

- **Interviews:** 7 people managers were intentionally selected to participate in the interviews. The selection was based on their experience and knowledge about the people management processes in their respective organizations. It was also considered that it would carry out the management process of authorizing vacation requests.
- **Questionnaires:** 48 professionals in the area of human resources management responded to the questionnaire. In order to map the main problems that vacation requesters had.

3.4. Data Collection

The data was collected in two distinct phases:

- **Qualitative Phase:** Semi-structured interviews were conducted with the 7 human resources managers between March and October 2023. Each interview lasted an average of one hour and was recorded and transcribed for later analysis.
- **Quantitative Phase:** A structured questionnaire was distributed to 48 human resources management professionals during June 2023. The questionnaire included closed-ended questions and Likert scales to measure perceptions about the effectiveness of human resources management processes and the use of automated technologies.

3.5. Research Instruments

- **Recording and Transcription of Interviews:** The interviews were recorded via Google Meet with the consent of the participants and later transcribed for analysis.
- **Analysis and Synthesis of the Questionnaires:** The questionnaires were analyzed quantitatively to create empathy and persona maps.

3.6. Procedures

- **Interview Preparation:** The interviews were conducted in person or via videoconference, depending on the availability of the participants.
- **Questionnaire Development:** The questionnaire questions were developed based on the results of the interviews with the managers, since they also requested vacations from the court.
- **Qualitative Data Analysis:** The interview transcripts were analyzed to map problems in the processes, identify solutions, and define new rules for requesting vacations.
- **Quantitative Data Analysis:** The questionnaire data were analyzed and inferential analyses were performed to identify significant correlations and differences in the participants' perceptions.

4. Application of Design Thinking to Promote Digital Transformation

To achieve the objectives proposed in this study, an approach based on design thinking will be adopted, a human-centered methodology that promotes innovation through multidisciplinary collaboration, empathy and iterative experimentation Brown, 2009. Design thinking is composed of a series of interconnected steps, which will be followed in this project to guide innovation in the Human Resources Department of the Court of Auditors of Pernambuco. Figure 2 illustrates the application of Design Thinking to promote digital transformation.

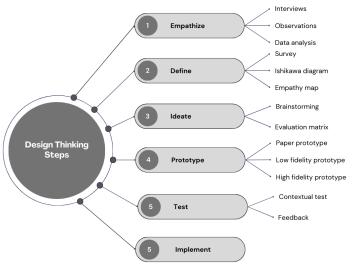


Fig. 1 – Stages in the Development of Design Thinking.

4.1. Empathic Understanding.

4.1.1. Preparatory phase:

Relevant information about the organization was gathered to understand the activities provided, the organizational structure, the organization of workflows, and the management maturity of the agency. The research

team conducted an initial survey with the main stakeholders in order to understand the organizational problems and the context of the work of the employees, as well as the suggested units. From this meeting, it was possible to identify a scope of the main problems faced by the DGP management, as well as to prioritize them.

4.1.2. Kick off:

After defining the scope, together with the confirmation of the research schedule, the data collection activities were formally initiated through meetings that would occur biweekly a priori, and could be scheduled weekly when necessary. This meeting will be attended by the project coordinators from UFRPE, the agency to be dimensioned TCE-PE and the units involved and will be held from March to August 2024. During these meetings, in addition to presenting the objectives and the expected schedule for data collection, the teams from the agency and UFRPE will ask the managers of the selected organizational units to appoint a supporter to their teams. This supporter will streamline contacts during the data collection process and will serve as a collaborator formally appointed by the manager to assist in subsequent tasks.

In order to ensure the efficiency of the meetings, the team from the organizational unit that will be present at the interviews may be composed only of the manager and the designated supporter. Alternatively, other people from the unit may participate, as long as they are appointed by the manager and there is an explicit justification for the need for their support. The presence of these individuals will be conditioned on the justification presented by the manager.

During the closing of the inaugural meeting, the manager of the organizational unit will be asked to fill out a document, with or without the support of members of his/her team, within the deadline agreed upon during the meeting, not exceeding seven days. This document aims to collect preliminary information about the processes and deliverables carried out by the organizational unit. This information will be analyzed by the researchers to optimize the next meetings and guide the next steps of the research process.

This stage consisted of 4 meetings and the table 1 illustrates the main issues faced in the process were identified.

Issue	Description
Process Complexity	The existence of many steps and signatures in the leave request and authorization process can make the workflow bureaucratic and time-consuming, leading to dissatisfaction and delays for employees.
Lack of Integration with Work Calendar	The absence of a functionality that allows the leave system to integrate with the employees' work calendar can result in incorrect calculations of the leave period to be paid, causing rework and manual adjustments.
Difficulties in Leave Accounting	The system's difficulty in correctly accounting for employees' return dates from leave can lead to incorrect payments and inconsistencies in records, causing financial and administrative impacts.
Accumulation of Employee Leave	The occurrence of leave accumulation by employees, even though it is prohibited, can generate future issues related to labor liabilities and negatively impact the organization's leave management.
Inadequate Communication	The lack of clear and transparent communication about the rules and procedures of the Leave Schedule System can create doubts and misunderstandings among employees, making it difficult to comply with established policies.

Tab. 1 – Issues in the Leave Management System

4.2. Problem Definition.

From the empathy phase, we moved on to problem definition, where the main objective of this stage was to clearly and objectively establish the scope of the problem to be solved, ensuring alignment among all those

involved in the process. An in-depth understanding of the problem is essential for us to be able to develop effective solutions that are in line with the reality of the users.

To structure the analysis of the problem, we used the Ishikawa Diagram, also known as the cause and effect or fishbone diagram. This tool allowed us to map the possible causes of the problem in a visual and organized way, identifying factors such as processes, people, tools, methods and environment that directly impacted the situation under study. This artifact made it possible to prioritize the most relevant causes and helped in formulating initial hypotheses for the next stage.

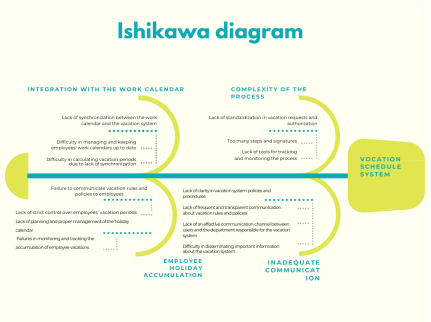


Fig. 2 – Ishikawa Diagram

In addition, we turned our attention to a more in-depth understanding of the users impacted by the process under study. The focus was to consolidate the information collected and validate whether the initial perception of the problem corresponded to the reality of all those involved.

We began this process with users from the DGP (Human Resources Management Department), where we created an Empathy Map and a Persona to represent this group. These two artifacts were essential to understanding their pain points, needs, expectations and behaviors in relation to the problem.

To validate this understanding, we created a form with pertinent questions, seeking to understand whether the DGP's perceptions were shared by others involved in the vacation request and management process. The form was widely distributed among employees and managers, and its analysis generated two new Empathy Maps and two new Personas, expanding our view of the problem and ensuring that the proposed solutions were based on different perspectives.

User Type	Stakeholders Summary
HR Personnel (DGP)	Maya hears that due to the low effectiveness of the current system, vacation days are accumulating. She feels frustrated with the rigid process and wants improvements. She constantly reviews requests and deals with heavy rework. She sees that technology in other areas is effective. Maya, 27, works in HR. She manages vacation requests and needs to integrate them with payroll. She ensures compliance with regulations and avoids excessive vacation accumulation. She is tech-savvy and aims to make the tool more user-friendly.
Employee	Lisa desires system integration and a mobile app for vacation tracking. She values flexibility and clear rules but struggles with the current complex system. She seeks an intuitive interface and shared calendars. Lisa, 27. She wants a simpler vacation request process, mobile access, and notifications. She struggles with process complexity and unclear information but sees opportunities in system improvements.
Manager	Carla hears employee concerns about work-life balance. She wants better internal communication about vacation policies. She feels pressure to manage requests fairly and is frustrated by the lack of clear visibility on vacation balances. Carla, 42, is a team manager. She needs detailed reports on vacation balances, efficient request coordination, and compliance with labor laws. She values technology solutions to automate notifications and decision-making.

Tab. 2 – Stakeholders Summary

These artifacts were essential to deepen our understanding of the problem and ensure that the proposed digital transformation was truly user-centric, meeting their needs and resolving the identified pain points.

4.3. Ideation.

In this step, a collaborative brainstorming session was conducted to generate a wide variety of creative ideas to solve the identified problem. All ideas were welcome and will be explored without initial criticism, encouraging innovation and creativity. This phase focused on generating ideas and solutions to the identified problems. Initially, we conducted a group brainstorming session, where we discussed various measures that could be implemented to solve the challenges faced. During this session, we explored different approaches and considered different perspectives to ensure a wide variety of ideas.

To evaluate the generated ideas, we constructed a solution matrix(see tab. 3). In this matrix, the Y-axis represented the expectations gathered from customers and stakeholders, while the X-axis represented the overall proposals developed by the team. Each idea was evaluated and scored according to its feasibility and alignment with the expectations of those involved. Based on the selected ideas, we moved forward to creating a prototype. The prototype served as a tangible representation of the proposed solution, allowing for a better visualization and understanding of how the solution would work in practice. This artifact was fundamental in directing the subsequent development of the solution, ensuring that it met the needs and expectations of end users.

	Current system	BPMN	Application
Feasibility	x	o	o
Usability	x	x	o
Maintainability	x	o	o
Monitoring	x	x	o

Tab. 3 – Evaluation Matrix

4.4. Testing and Evaluation.

In the testing and validation phase, the developed prototype underwent a series of rigorous evaluations to ensure its effectiveness and usability. These tests were conducted with users representative of the target audience, allowing the identification of possible flaws and areas that needed improvement. In addition, the prototypes were evaluated in a simulated or pilot environment with the collaboration of the Human Resources Department. User feedback was carefully collected and analyzed to measure the effectiveness and usability of the proposed solutions. Based on the results obtained, the prototypes were adjusted and refined as necessary until the final version of the product was reached.

4.5. Implementation and Iteration.

After the successful validation of the prototype, the project was forwarded to the software factory for the development of the final solution. This stage marked the transition from the design and prototyping stage to the practical implementation of the solution, where developers would work to transform the prototype into a functional and robust application. The involvement of the software factory at this stage would ensure that the prototype specifications and requirements are properly translated into code, culminating in the delivery of a final solution aligned with the expectations and needs of the end users and stakeholders involved in the project. Finally, the validated solutions will be implemented in the HR department's work environment. During this phase, special attention will be given to employee training and the integration of new practices into the existing workflow. In addition, a continuous monitoring and evaluation plan has been established to identify opportunities for improvement and iterate on solutions as needed.

5. Discussion

The results of this study demonstrate the effectiveness of applying the design thinking methodology to innovate people management processes at the Court of Auditors of Pernambuco. The approach allowed for a deep understanding of the needs and challenges faced by the department, promoting user-centered solutions that aim to increase the efficiency and effectiveness of the activities carried out.

5.1. Empathetic Understanding

The empathetic understanding phase was crucial to identify the particularities of the Court of Auditors of Pernambuco. The initial research and interviews allowed for a detailed diagnosis of the organization, facilitating the classification of the agency and the definition of the units and services to be dimensioned. This initial diagnosis guided all subsequent steps, ensuring that the solutions developed were appropriate to the specific context of the organization.

5.2. Problem Definition

The problem definition stage was essential to synthesize the information collected and identify the main challenges to be addressed. The collective interviews and the analysis of the documents submitted by the managers of the organizational units provided a clear overview of the internal activities and processes. This detailed understanding allowed the formulation of well-defined problems, which served as a basis for the ideation of innovative solutions.

5.3. Ideation

The collaborative brainstorming session generated a wide variety of creative ideas to solve the identified problems. The use of a solution matrix allowed the evaluation and prioritization of the ideas based on feasibility and alignment with the expectations of the stakeholders. This process ensured that the selected solutions were not only innovative, but also practical and aligned with the needs of the end users.

5.4. Prototyping

The low and high fidelity prototypes developed during the prototyping phase were essential to test and refine the generated ideas. The use of mood boards and the incorporation of elements from existing tools, such as Google Calendar, ensured that the prototypes were intuitive and familiar to the users. This iterative approach allowed the prototypes to evolve based on employee feedback, resulting in solutions that were well-tuned to the real needs of the organization.

5.5. Testing and Evaluation

The testing and evaluation phase validated the effectiveness and usability of the developed prototypes. Testing conducted with representative users and in simulated environments allowed identifying areas for improvement and adjusting the prototypes as needed. This rigorous validation process ensured that the final solution was robust and aligned with the expectations of users and stakeholders.

5.6. Implementation and Iteration

The implementation of the validated solutions in the HR Department's work environment marked the transition to practice. Employee training and integration of the new practices into the existing workflow were essential to ensure successful adoption of the developed solutions. The established continuous monitoring and evaluation plan will allow identifying opportunities for improvement and iterating on the solutions as needed, ensuring the sustainability and effectiveness of the implemented innovations.

5.7. Practical Implications

The results of this study have significant practical implications for HR management in the public sector. The human-centered approach and iterative design thinking methodology have proven to be effective in solving complex problems and fostering significant innovations. The application of this methodology can be extended to other areas and organizations, contributing to the continuous improvement of public processes and services.

5.8. Lessons Learned

Throughout the collaboration between TCE-PE and UFRPE to improve people management processes, several crucial lessons were learned:

1. **Stakeholder Engagement:** Actively involving leaders and employees from the beginning was essential to align initiatives with strategic objectives. Engaging stakeholders not only ensured their support, but also fostered a sense of ownership and commitment to the success of the project. Their contributions provided valuable insights into the organization's priorities and helped shape solutions to meet specific needs.

2. **Comprehensive Data Collection:** Employing diverse data collection methods, focus groups, surveys, and online forms, enabled a holistic understanding of employee needs. By bringing together data from multiple sources and perspectives, including quantitative and qualitative data, a comprehensive view of the challenges and opportunities within the organization was obtained.
3. **Rigorous Data Analysis:** Applying rigorous qualitative analysis techniques, such as Thematic Synthesis, facilitated the accurate identification of key patterns and issues. By closely examining the collected data, themes and trends emerged, enabling a deeper understanding of the causes of problems and guiding the development of targeted solutions.
4. **Interdisciplinary Collaboration:** Working with a multidisciplinary team enriched problem-solving with diverse perspectives. Bringing together experts from different disciplines, including HR, IT, psychology, and business management, encourages innovative thinking and creative approaches to problem-solving. This interdisciplinary approach ensured that solutions were robust and addressed the multifaceted nature of organizational challenges.
5. **Stakeholder Validation and Feedback:** Incorporating stakeholder feedback increased the relevance and acceptance of proposed solutions. By soliciting input from those directly impacted by the changes, solutions were tailored to meet their specific needs and preferences. Stakeholder validation also fostered a sense of inclusion and transparency throughout the project.
6. **Prioritization:** Setting clear priorities based on the severity of issues allowed for effective resource allocation. By identifying and prioritizing the most pressing issues, resources could be directed to areas with the greatest potential for impact. This strategic approach ensured that efforts were focused on addressing the organization's most critical needs.
7. **User-Centered Solutions:** Prioritizing user experience promoted greater engagement and adoption of implemented solutions. By designing solutions with end-users in mind, usability and accessibility were prioritized, leading to higher levels of acceptance and satisfaction among employees. User-centered design also encourages ongoing feedback and iteration to constantly improve the user experience.
8. **Commitment to Continuous Improvement:** Maintaining a mindset of continuous improvement ensured that solutions remained relevant to evolving needs. Recognizing that organizational needs and priorities change over time, a commitment to continuous evaluation and refinement was essential. This iterative approach allowed solutions to be adapted and optimized to meet emerging circumstances and challenges.

These lessons underscore the importance of a collaborative, data-driven, and user-centered approach to improving people management processes at TCE-PE.

6. Conclusion

This study explored the application of the design thinking methodology to improve people management processes at the Court of Auditors of Pernambuco. Through a human-centered approach that involved empathy, multidisciplinary collaboration, and iterative experimentation, it was possible to develop innovative and effective solutions to the challenges faced by the Human Resources Department.

The empathetic understanding phase allowed a detailed diagnosis of the organization, identifying specific needs and challenges. The clear definition of the problems, based on interviews and document analysis, provided a solid basis for the generation of innovative ideas during the ideation phase. Iterative prototyping, with continuous feedback from users, ensured that the solutions developed were well-adjusted to the real needs of the organization.

Rigorous testing and evaluation of the prototypes validated the effectiveness and usability of the solutions, while practical implementation and employee training ensured successful adoption of the new practices. The established continuous monitoring plan will allow constant adjustments and improvements, ensuring the sustainability of the innovations.

The results of this study indicate that the design thinking methodology is an effective approach to solving complex problems in people management in the public sector. The adoption of this methodology can promote greater agility, efficiency and employee satisfaction, contributing to the continuous improvement of organizational processes.

However, it is important to recognize the limitations of this study, such as the relatively small sample size and the need for long-term follow-up to assess the full impact of the solutions implemented. Future studies can expand the application of design thinking to other areas and sectors, as well as explore different organizational contexts, to validate and expand the findings of this work.

In short, this study demonstrated that human-centered innovation, promoted by design thinking, can significantly transform people management, providing practical solutions that are adaptable to the specific needs of each organization.

References

Brown, T. (2009). *Change by design: How design thinking transforms organizations and inspires innovation*. HarperCollins. https://books.google.com.br/books?id=x7PjWyVUoVAC

Cardoso Jr, J. C. P. O. (2011). Burocracia e ocupação no setor público brasileiro.

Cavalcante, P. L. C., Mendonça, L. K., & Brandalise, I. (2019). Políticas públicas e design thinking: Interações para enfrentar desafios contemporâneos.

de Oliveira, S. B., da Motta, R. A. S. M., & de Oliveira, A. S. (2012). Gestão de processos e tecnologia de informação: Em busca da agilidade em serviço. *Gestão. org*, *10*(1), 172–194.

Hanelt, A., Bohnsack, R., Marz, D., & Antunes Marante, C. (2021). A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change. *Journal of Management Studies*, *58*(5), 1159–1197. DOI: https://doi.org/https://doi.org/10.1111/joms.12639.

Haug, N., Dan, S., & and, I. M. (2024). Digitally-induced change in the public sector: A systematic review and research agenda. *Public Management Review*, *26*(7), 1963–1987. DOI: https://doi.org/10.1080/14719037.2023.2234917.

Jæger, B. (2013). User involvement in public services innovation. In *Handbook of innovation in public services* (pp. 432–444). Edward Elgar Publishing.

Lane, J. (1993). *The public sector: Concepts, models and approaches*. Sage. https://books.google.com.br/books?id=-kmGAAAAMAAJ

Martin, R. L. (2009). *The design of business: Why design thinking is the next competitive advantage*. Harvard Business Press.

Melo, A., & Abelheira, R. (2015). *Design thinking & thinking design: Metodologia, ferramentas e uma reflexão sobre o tema*. Novatec Editora.

Nigro, L. G. (1984). Decision making in the public sector. edited by lloyd g. nigro. (new york: Marcel dekker, 1984. pp. 336. $35.00.) *American Political Science Review*, *78*(4), 1209–1209. DOI: https://doi.org/10.2307/1955980.

Santos, G. F. Z., & Hoffmann, M. G. (2016). Em busca da efetividade na administração pública: Proposição de uma metodologia para design e implementação de serviços públicos no município de florianópolis. *NAVUS-Revista de Gestão e Tecnologia*, *6*(1), 88–105.

Schumpeter, J. (1982). Teoria do desenvolvimento econômico. *São Paulo: Abril*.

Silva, M., VIANNA, Y., KRUMHOLZ, I., FIGUEIREDO, B., & Russo, B. (2012). Design thinking. *Inovação em*.

Trischler, J., & Scott, D. R. (2016). Designing public services: The usefulness of three service design methods for identifying user experiences. *Public Management Review*, *18*(5), 718–739.

Voorberg, W. H., Bekkers, V. J., & Tummers, L. G. (2015). A systematic review of co-creation and co-production: Embarking on the social innovation journey. *Public management review*, *17*(9), 1333–1357.

Brazilian Federal Institutions as Intermediaries: Driving Digital Transformation Through Open Innovation

Joel Lima-Júnior[a*], *Kiev* Gama[b], *Jorge* Correia-Neto[c].

[a]Federal University of Pernambuco, Informatics Center, Recife, Brazil, jalj@cin.ufpe.br, https://orcid.org/0000-0002-0738-6351.

[b]Federal University of Pernambuco, Informatics Center, Recife, Brazil, kiev@cin.ufpe.br, https://orcid.org/0000-0003-1508-6196.

[c]Federal Rural University of Pernambuco, Distance Education Unit, Recife, Brazil, https://orcid.org/0000-0001-9977-1267.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. The integration of Open Innovation (OI) and Digital Transformation (DT) is relevant in the public sector, particularly in developing countries where resource constraints demand innovative approaches. OI fosters collaboration between governments, businesses, academia, and civil society, enabling the co-creation of digital solutions that enhance public service efficiency and transparency. In this context, intermediaries play a fundamental role in bridging technical capabilities and institutional needs, facilitating policy implementation, and overcoming cultural and financial barriers. However, while OI and DT have been studied independently, little research has examined how intermediary-driven OI influences the digital transition in government settings. This study investigates the role of federal public institutions as intermediaries in Brazil's OI-driven DT efforts, analyzing how they facilitate innovation adoption at the state and municipal levels. Through a case study of two federal-level institutions, the research identifies key mechanisms by which intermediaries promote digital integration and examines the challenges they face, including budget limitations and resistance to change. The findings identify the strategic role of these institutions in mitigating administrative and legal barriers and in fostering cross-sector collaboration.

Keywords. Intermediaries, Open Innovation, Digital Transformation, Case study
Research paper, DOI: https://doi.org/10.59490/dgo.2025.964

1. Introduction

The pursuit of efficiency and innovation is driving the public sector globally towards strategic approaches integrating technology and collaboration. In many developing countries, DT has become essential for modernizing processes, improving service delivery, and meeting contemporary societal expectations (de Lima-Junior et al., 2024; Escobar et al., 2023). DT involves enhancing organizational performance by incorporating information, computing, communication, and connectivity technologies (Vial, 2019), a process that was once confined to the private sector.

Complementarily, OI has emerged as a valuable strategy promoting external collaboration and idea exchange to foster development and innovation (Brockman et al., 2018). Initially a the private sector concept (Biscotti et al., 2018; Bogers et al., 2016), OI is now gaining traction in the public sector due to its potential for citizen engagement in public affairs and participatory governance, enhancing collective intelligence and co-creation to address complex societal challenges (Androutsopoulou et al., 2017; Criado and Guevara-Gómez, 2021; Ferraris et al., 2020; Gascó, 2017; Mergel et al., 2019).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Although OI initiatives—especially those focusing on open government and open data—have fostered greater transparency and citizen participation in public management (Gasco-Hernandez et al., 2017; Mergel et al., 2019), most research to date has centered on citizen inclusion, with limited involvement from businesses, academia, and other public organizations (Figenschou et al., 2024).

OI has an interplay with DT where OI promotes the development of new technologies that support DT (Robertsone and Lapiņa, 2023). More recently, the integration of OI into DT efforts has gained prominence, particularly in developing countries where resource constraints and unique needs drive innovative approaches (Debeljak and Dečman, 2022; Gong et al., 2020; Mu and Wang, 2022). In this context, intermediaries play a key role by facilitating knowledge sharing and policy implementation in increasingly digital and networked environments (Mu and Wang, 2022; Palumbo et al., 2023). These intermediaries—ranging from specialized consulting firms and technology companies to nonprofit organizations—bridge the gap between technical capabilities and institutional needs, mitigating cultural, financial, and technological barriers. Recent studies have emphasized their role in supporting collaboration, reducing uncertainty, and enabling value co-creation among diverse stakeholders in innovation ecosystems (Figenschou et al., 2024; Pinto et al., 2024).

Despite these advancements, significant research gaps remain. Although DT is widely recognized as key to improving public service delivery and operational efficiency, there is a notable lack of empirical studies that explore the strategies employed –especially those involving intermediary agents in OI projects – to drive DT effectively (de Lima-Junior et al., 2024; Gong et al., 2020). Furthermore, while numerous studies have examined the success of OI in various contexts, little attention has been paid to the intersection of OI and DT in the public sector, particularly regarding how intermediary-driven OI can either facilitate or hinder the digital transition (Criado and Guevara-Gómez, 2021).

In Brazil, federal public institutions have emerged as central intermediaries in the OI process. These institutions connect diverse actors, promote the integration of digital technologies, and help overcome structural and procurement barriers (Pinto et al., 2024). This intermediation not only enhances the capacity of public agencies to adapt to technological changes but also fosters a collaborative culture among government, academia, the private sector, and civil society.

This article aims to deepen our understanding of the role of intermediaries in OI for DT within the public sector. Through a case study of two federal-level institutions acting as OI intermediaries with Brazilian states and municipalities, this research seeks to answer the following central question: *How do Brazilian federal institutions, acting as OI intermediaries, drive DT in the public sector, and what factors influence the outcomes of this process?*

This case study highlights federal intermediaries as key facilitators of technological solutions and stakeholder collaboration. Despite their role in overcoming administrative barriers, budget constraints and resistance to change remain major challenges to fully realizing DT through OI.

2. Background and Related Work

2.1. Digital Transformation in Government

DT has become fundamental for modernizing the public sector, aiming for greater efficiency and improved service delivery to citizens (Gong et al., 2020; Vial, 2019). In the governmental context, DT involves the incorporation of digital technologies to optimize administration and increase transparency (Verhoef et al., 2021). DT entails structural changes that improve operations and redefine government–society relations (Hanelt et al., 2021; Vial, 2019). This becomes particularly relevant amid growing demands for more accessible, inclusive, and personalized public services (Kraus et al., 2021).

In contrast to the private sector, public organizations face specific challenges in digitalizing their services, such as bureaucratic rigidity, limited financial resources, and cultural resistance to change (Hanelt et al., 2021; Tiach and Abdellatif, 2023). Advances in artificial intelligence, big data, and blockchain offer significant opportunities to overcome DT challenges in the public sector, enabling the automation of processes, the protection of data, and making digital services more effective (Escobar et al., 2023; Verhoef et al., 2021).

DT in public administration extends beyond internal improvements, serving as a catalyst for transparency, civic engagement, and collaborative governance (Figenschou et al., 2024). By enabling citizen participation through digital platforms, DT fosters public trust and democratic legitimacy (Edelmann et al., 2023; Palumbo et al., 2023). Central to this process is the creation of digital ecosystems that engage diverse stakeholders in co-developing solutions for key public challenges such as mobility, health, and education (Ferraris et al., 2020; Robertsone and Lapiņa, 2023).

DT requires long-term strategies that tackle institutional and cultural barriers (Gong et al., 2020; Mu and Wang, 2022). This includes investing in digital competencies for public servants, designing adaptive regulatory frameworks, and cultivating an innovation-oriented organizational culture (Edelmann et al., 2023; Tiach and Abdellatif, 2023). Recent empirical studies suggest that governments adopting strategic, participatory, and multi-stakeholder approaches to DT are more likely to improve not only operational efficiency but also public legitimacy and citizen satisfaction (Figenschou et al., 2024; Tiach and Abdellatif, 2023).

2.2. Open Innovation

OI has gained increasing importance in the public sector as a strategy to develop innovative solutions in collaboration with external actors. This model allows for combining internal resources with external knowledge to address complex challenges and improve service delivery (Bogers et al., 2018; Figenschou et al., 2024; Mu and Wang, 2022; Palumbo et al., 2023). In contemporary public and private contexts, OI enables the creation of dynamic networks that accelerate innovation and improve responsiveness to complex societal demands (Goulart et al., 2023; Pinto et al., 2024).

The knowledge exchange intrinsic to OI unfolds in both inbound and outbound flows. Inbound flows allow external contributions—such as ideas, data, and prototypes—to improve internal processes, while outbound flows disseminate innovations via partnerships, licensing, and public–private collaborations (Gasco-Hernandez et al., 2017; Mu and Wang, 2022). Particularly in the public sector, these flows are facilitated by intermediary actors and digital platforms, which expand the scope of participation and collaboration (Figenschou et al., 2024; Smith and Akram, 2017).

OI increasingly relies on active user participation, from identifying problems to co-developing solutions (Edelmann et al., 2023; Ferraris et al., 2020). This participatory logic—known as user-driven innovation, co-creation, or citizen-sourcing—enhances the legitimacy, diversity, and impact of innovation outcomes (L. and D., 2018; Palumbo et al., 2023). By embedding user engagement across multiple stages of innovation, organizations can align their outputs more closely with societal needs and expectations, especially in complex domains such as healthcare, mobility, and digital government services (Figenschou et al., 2024; Mu and Wang, 2022).

Collaborative innovation models are especially pertinent in the public sector, as they enhance both the effectiveness and legitimacy of policies and services (Criado and Guevara-Gómez, 2021; Figenschou et al., 2024). This reflects a broader transformation in digital governance, where trust, transparency, and inclusiveness are central to the creation of public value (Palumbo et al., 2023; Tiach and Abdellatif, 2023).

2.3. OI in the Public Sector

Public institutions are increasingly adopting OI to address complex challenges, inspired by its success in the private sector (Biscotti et al., 2018; Bogers et al., 2016; Gascó, 2017). OI initiatives in the public sector have expanded, driven by goals such as participatory governance, data-informed policymaking, and digital transformation (Figenschou et al., 2024; Mu and Wang, 2022; Palumbo et al., 2023). This approach enhances citizen engagement, leverages collective intelligence, and supports the development of innovative and context-sensitive solutions (Brabham, 2013; Ferraris et al., 2020). By integrating diverse actors into decision-making, OI fosters transparency, legitimacy, and efficiency, while helping to overcome bureaucratic barriers through more collaborative and responsive structures (Figenschou et al., 2024; Mu and Wang, 2022; Palumbo et al., 2023).

However, OI reveals marked differences between the private and public sectors, reflecting their distinct goals. While the private sector emphasizes product development and competitive advantage to drive economic performance (Kivleniece and Quélin, 2011), the public sector prioritizes service quality and the creation of public

value through inclusive and effective responses to social demands (Palumbo et al., 2023). Moreover, public sector OI typically involves broader stakeholder engagement—such as citizens, NGOs, and academia—highlighting its participatory and collaborative character.

2.4. Intermediaries

Public Open Innovation (POI) intermediaries are crucial strategic actors for driving collaborative innovation and DT in the public sector. They connect governments, businesses, universities, and citizens, facilitating the implementation of innovative solutions (Al Maazmi et al., 2024; Figenschou et al., 2024). In public sector contexts, their role is particularly crucial for overcoming institutional inertia and cultural resistance, enabling more inclusive, transparent, and participatory governance arrangements (Mu and Wang, 2022; Palumbo et al., 2023). By bridging gaps between stakeholders and orchestrating multi-actor efforts, intermediaries not only reduce transaction and coordination costs but also enhance the scale and impact of OI initiatives in governmental settings (Pinto et al., 2024; Smith and Akram, 2017).

One of the primary challenges faced by intermediaries in the public sector is navigating bureaucratic rigidity and inflexible organizational structures, which often hinder the implementation of collaborative innovation processes (Mu and Wang, 2022; Palumbo et al., 2023). Additionally, these organizations must operate under budgetary constraints and within highly regulated environments, conditions that can limit experimentation and adaptive governance (Figenschou et al., 2024). To overcome these barriers, intermediaries adopt strategies such as digital platforms, hackathons, and public-private partnerships, all of which support agile collaboration across sectors (Gasco-Hernandez et al., 2017; Smith and Akram, 2017).

POI intermediaries play a strategic role in fostering innovation-oriented cultures in government by developing digital and collaborative competencies among public servants (Mittal, 2020). They also enhance the resilience of public innovation ecosystems by promoting access to emerging technologies and strengthening engagement with civil society. Empirical evidence highlights a strong correlation between well-structured intermediaries and the success of digital transformation initiatives in the public sector (Al Maazmi et al., 2024; Mittal, 2020).

Recent studies have significantly expanded this understanding by incorporating dimensions such as data intermediation, digital capacity-building, and regulatory orchestration (Al Maazmi et al., 2024; Mu and Wang, 2022; Palumbo et al., 2023). These contemporary perspectives are essential to frame federal public institutions as dynamic actors within multilevel innovation ecosystems.

3. Method

3.1. Case Study

Case studies explore ongoing events by integrating evidence from various sources (Yin, 2014). Moreover, a single case may be analyzed using multiple units of analysis (Runeson, 2012). For this case study focusing on federal-level institutions acting as OI intermediaries, two units of analysis were selected. The objective is to explore how OI is driving DT in terms of activities, procedures, and interactions through intermediaries, analyzing the process from the perspective of key individuals responsible for operationalizing intermediation.

Given the exploratory nature of understanding the mechanisms by which federal institutions act as OI intermediaries to drive DT, and the need to analyze real-world practices within their specific contexts, a case study approach is particularly well-suited (Yin, 2014) using qualitative guidelines (Merriam and Tisdell, 2015).

3.2. Units of analysis

We selected the two units of analysis (Enap Challenges Platform and Serpro Ventures) through purposive sampling. Such approach allows researchers to intentionally select cases that offer rich, relevant insights into the phenomenon under study, making it ideal for qualitative research (Patton, 2014).

1. Enap Challenges Platform, led by National School of Public Administration (ENAP) through GNova, connects government and civil society to address public challenges via OI. The platform enables public

managers to launch challenges, inviting citizens, startups, and academics to propose solutions. It supports managers with toolkits, mentorships, and personalized assistance for challenge formulation and management.
2. Serpro Ventures, led by Federal Data Processing Service (SERPRO), drives DT and inclusion in federal agencies through OI. It fosters partnerships with academia, startups, research centers, and companies to develop intelligent solutions. As a federally owned company, Federal Data Processing Service (SERPRO) manages and implements IT policies for the Brazilian government.

The chosen institutions have emerged as key federal intermediaries of OI in Brazil. Enap Challenges Platform represents a model focused on broad engagement with diverse external stakeholders through open challenges, while Serpro Ventures embodies a more structured approach leveraging partnerships with specific innovation actors within the federal IT landscape. Through the Desafios Platform, ENAP has facilitated over 60 public challenges across various levels of government, fostering co-creation with startups, universities, and other actors within the innovation ecosystem. In parallel, SERPRO, through the Serpro Ventures program, has implemented approximately 200 initiatives aimed at driving DT in the public sector, combining hackathons, partnerships with ICTs, and formal co-creation models with private market actors.

The selection was informed by three main criteria: (i) the existence of structured OI mechanisms, (ii) recognition in regional or national DT agendas, and (iii) feasibility of access to relevant data and key informants. These criteria ensured the suitability of the cases for investigating the role of public intermediaries in driving DT. Their distinct yet complementary approaches enable a comparative analysis of different models and their impact on government innovation.

3.3. Data collection and analysis

For this study, documents and interviews were carefully selected to ensure data triangulation and validity (Eisenhardt, 1989; Yin, 2014). Official documents (ordinances, laws, public notices) provided information about legal frameworks, while initiative websites clarified guidelines and key actors.

Semi-structured interviews with leaders and technical staff ensured core perspectives, given the small project teams. In parallel, a systematic literature review (de Lima Júnior et al., 2024) identified four analytical dimensions—innovation approaches, stakeholders, influencing factors, and the role of technology—which informed the interview protocol and guided the processes of triangulation and thematic coding, thereby strengthening the qualitative analysis.

The interview protocol aimed to explore institutional OI practices, involved stakeholders, enabling and hindering factors, and the role of technology in DT efforts. Interviews were conducted remotely via Google Meet, with prior informed consent and subsequent transcription assisted by AI and manually refined. Participants were briefed on analytical dimensions to clarify the study's scope. A thematic analysis was performed following Braun and Clarke's approach (Braun and Clarke, 2006), combining deductive coding from predefined constructs with inductive identification of emerging themes. Initially based on four analytical dimensions, the framework evolved into five core themes: practices, stakeholders, enablers, barriers, and technologies.

3.4. Participant selection

Participants were selected based on a thorough analysis of the profiles of the key organizers of each initiative, according to information available on institutional websites. After the initial contact with the organizations and the presentation of the research objectives, the interviewees promptly expressed their interest in contributing. Consequently, two key individuals per initiative were selected, following the criterion that they should hold strategic positions in the planning, coordination, and execution of the full OI cycle. A detailed description of the interviewees' profiles can be found in Table 1.

4. Results

4.1. Enap Challenges Platform

Enap Challenges Platform connects public agencies with startups, universities, and citizens to solve public challenges via the Desafios platform. ENAP, a Federal Public School, acts as an innovation intermediary, of-

Tab. 1 – Profile of interviewed participants.

Part.	Initiative	Position
I1	Enap Challenges Platform	General Coordinator of Open Innovation
I2	Enap Challenges Platform	Project Manager
I3	Serpro Ventures	Superintendent of Corporate Architecture, Platforms and Cloud
I4	Serpro Ventures	Superintendent of Business Strategy, Pricing and Innovation

fering support, training, and infrastructure to structure these challenges, fostering tech-driven solutions for government efficiency. For this OI process, ENAP has developed a toolkit consisting of seven steps, organized into three main phases.

1. **Pre-Challenge Launch**: *1) Problem Identification:* The process begins with an analysis to understand the complexity of the problem and its feasibility for OI; *2) Market Interviews:* Before launching a challenge, existing solutions are explored and potential contributions from the private sector are assessed; *3) Challenge Planning:* Defining the format, rules, evaluation criteria, and legal framework.
2. **Challenge Launch:** *4) Dissemination and Participant Mobilization:* The platform is used to publicize challenges to startups, companies, universities, and citizens interested in contributing; *5) Interaction and Co-Creation:* Workshops, hackathons, and other methodologies are employed to foster collaboration between the government and participants.
3. **Post-Challenge:** *6) Solution Development and Validation:* The public agency evaluates the submitted solutions and may contract or incubate the best proposal; *7) Scaling and Implementation:* If the solution is successful, it can be expanded to other areas of government.

4.2. Serpro Ventures

The second unit of analysis, known as Serpro Ventures is a structured innovation program led by SERPRO, a publicly owned private-law company. It fosters collaboration with innovation hubs, universities, and ICTs, engaging public servants, researchers, startups, and society in co-creating technological solutions for public agencies. To implement OI, SERPRO applies various strategic approaches.

1. Web Platform: Registers opportunities and partnerships;
2. Hackathons: Explore new ideas and foster creativity;
3. Prototyping and Design Thinking Sessions: Shape innovative solutions;
4. Public Calls: Ensure transparency and create opportunities for diverse participants;
5. Incentive Programs: Provides vouchers for startups to test SERPRO's APIs.

4.3. Dimensions

In this section, we present the main findings of the thematic analysis, organizing them into five core dimensions (i.e., themes): 1) **practices** – a set of efforts, resources, and strategies applied to enable OI processes; 2) **stakeholders** – internal and external participants who play essential roles in the initiative; 3) **enablers** – internal and external elements that can drive project implementation; 4) **barriers** – obstacles that hinder project execution; and 5) **technology** – the role of technological tools in the development and implementation of the initiative.

These dimensions were defined based on a systematic literature review on OI in the public sector (de Lima Júnior et al., 2024), previously conducted to identify conceptual patterns and theoretical gaps in recent scholarly work. The adoption of these categories provided a robust theoretical framework for the empirical analysis, guiding data coding and case triangulation. To further illustrate the findings, we adapted the C1 (Enap Challenges Platform) and C2 (Serpro Ventures) taxonomy, offering a more structured interpretation of the collected data.

4.3.1. Practices

The "practices" theme in this study comprises 41 characteristics (Table 2), with 36 identified through field research and 5 from a systematic literature review (de Lima Júnior et al., 2024). To organize them, 8 overarching

sub-themes were created. Both Enap Challenges Platform and Serpro Ventures relied on structured methodologies, such as stage gate and toolkits, along with specific tools to streamline the innovation process (I1, I2, I3, I4). Legal frameworks played a crucial role in establishing a favorable environment for innovation, supported by NDAs, licenses, contracts, and patents to ensure protection and compliance (I1, I2, I3). Capacity-building was a key investment in both initiatives, incorporating mentorships, workshops, webinars, training, and interactive sessions to promote continuous learning (I1, I2, I3, I4). Table 3 presents the general characteristics of the approach dimension for both initiatives.

Tab. 2 – Practices being employed in both initiatives

#	Practices	C1	C2	#	Practices	C1	C2
1	**Governance and Strategy**			**2**	**Engagement and Collaboration**		
1	Align Expectations	X	X	12	Bring Stakeholders Closer	X	X
2	Innovation Strategy	X	X	13	Involve External Actors	X	X
3	Strategic Planning	X	X	14	Involve Internal Bodies	X	X
4	Administrative Structure	X	X	15	Capture Ecosystem	X	X
5	Institutional Initiatives	X	X	16	Collaboration	X	X
6	Internal Regulations	X	X	17	Mediation	X	X
7	Risk Mitigation	X	X	18	Partnerships	X	X
8	Cultural Change	X	X	19	Participate in Events	X	X
9	Foster Entrepreneurship	X	X	20	Experience Exchange	X	X
10	Product Innovation		X	21	Communication	X	X
				22	Dissemination	X	X
3	**Knowledge and Tools**			**4**	**Management and Operational Processes**		
23	Innovation Tools	X	X	28	Innovation Management and Processes	X	X
24	Prototyping Sessions	X		29	Problem Management and Resolution	X	X
25	Train the Participants	X	X	30	Assign a Dedicated Team	X	X
				31	Remote Process	X	X
5	**Legal Aspects**			**6**	**Incentives**		
32	Legal Support	X	X	36	Financial Resources	X	X
33	Legal Steps	X	X	37	Sponsorship	X	
34	Legal Instruments	X	X	38	Awards	X	X
35	Contract Formatting	X					
7	**Events**			**8**	**Digital and Technological Enablement**		
39	Competitions	X	X	42	Open Data	X	X
40	Community Challenges	X	X	43	Web Platform	X	X
41	Hackathons	X	X				

Tab. 3 – Characteristics of the "Approaches" dimension

Feature	Sample quotes	Interviewee
Legal Instruments	"(...) having regulations and laws that made this easier (...) is important from the government's perspective."	I4
Innovation Management and Processes	"(...) within the toolkit, it is a very important step"	I2
Intermediation	"(...) ENAP is an intermediary (...) for the government."	I1
Train the Participants	"We initially selected a small group (...) these individuals received extensive training"	I4
Legal Support	"(...) we invested in a consulting firm to structure the regulations for our process, ensuring security."	I4
Engaging External Stakeholders	"(...) we always seek partners that can reach different regions of Brazil, ensuring national participation."	I1

4.3.2. Stakeholders

The data analysis reveals that, for this study, the "stakeholders" dimension consists of 22 main types of stakeholders. Among these, 8 emerged from direct engagement with participants (3, 8, 9, 10, 15, 16, 17, and 18), while the remaining 14 (1, 2, 4-7, 11-14, and 19-21) were identified through a systematic literature review (de Lima Júnior et al., 2024). The data are presented in Table 4.

Startups played a central role in Enap Challenges Platform, while Serpro Ventures, though focused on established companies, also engaged with promising startups to stimulate innovation (I1–I4). Both initiatives maintain connections with universities, with Serpro Ventures aiming to deepen research collaborations (I3, I4). Senior management engagement proved critical for decision-making and resource allocation across both cases (I1–I4). Additionally, Serpro Ventures distinguished itself through strong ties with Innovation Hubs, promot-

Tab. 4 – List of Identified Stakeholders

#	Stakeholders	C1	C2	#	Stakeholders	C1	C2
1	Citizens	X	X	12	Intermediaries	X	X
2	Project Council	X	X	13	Joint Venture	X	X
3	Consultant	X	X	14	R&D Laboratory	X	X
4	Companies	X	X	15	Leadership (Senior Management)	X	X
5	Nonprofit Organizations	X	X	16	Internal Agencies	X	X
6	Internal Employees	X	X	17	CSOs	X	X
7	Government	X	X	18	Technology Park	X	X
8	GovTechs	X	X	19	Researchers	X	X
9	Innovation Hub		X	20	Civil Society	X	
10	ICTs		X	21	Startups	X	X
11	Innovators	X	X	22	Universities	X	X

ing knowledge exchange and dynamic collaboration (I3, I4). Table 5 presents the key stakeholders involved in the OI cycles.

Tab. 5 – Sample quotes of the main stakeholders involved

Stakeholder	Sample quotes	Interviewee
Startups	"(...) open innovation is strongly associated with startups, especially in the tech sector."	I2
Private Companies	"(...) some challenges were open to everyone, while others were restricted to companies."	I1
Government	"(...) in our case, the government has primarily acted as a client, the one requesting the challenge."	I1
Leadership (Senior Management)	"(...) senior management must truly believe in this."	I4
CSOs (Civil Society Organizations)	"(...) we work closely with CSOs and have even signed a cooperation agreement with them, including the Impact Hub."	I2
Universities	"(...) we are entering a new phase where we aim to bring certain stakeholders, especially universities, closer to our ecosystem."	I3
Citizens	"(...) any individual or team can register and submit their solution or proposal."	I1

4.3.3. Enablers

The case study identified key enablers and barriers that influenced the initiatives. A total of 20 enablers were classified, with 10 derived from the systematic literature review (1, 2, 5, 8, 11, 13, 15, 17, 19, 20) and 10 from interview insights (3, 4, 6, 7, 9, 10, 12, 14, 16, 18), reflecting practical experiences. The complete list is presented in Table 6.

Tab. 6 – List of identified enablers

#	Enablers	C1	C2	#	Enablers	C1	C2
1	Open Data	X	X	11	Challenge Promotion	X	X
2	Relaxed Environment	X		12	Innovation Ecosystem	X	
3	Administrative Support	X		13	Empowerment of People	X	X
4	Support from Senior Management	X	X	14	Stakeholder Engagement	X	X
5	External Stakeholders	X		15	Ease of Hiring (Initial Stages)	X	X
6	Training for Participants	X	X	16	Infrastructure		X
7	Success Cases	X	X	17	Relevant Legislation	X	X
8	Collaboration	X	X	18	Financial Resources	X	X
9	Communication	X		19	Technology	X	X
10	Organizational Culture	X	X	20	Transparency	X	X

Relevant legislation provided the legal foundation for OI, ensuring compliance and security (I1, I4). Senior management support was crucial for institutional backing, resource allocation, and strategic alignment (I3). Training enhanced innovation capacity, while successful case studies helped reduce resistance and inspire new approaches (I1, I2, I3, I4). Challenge promotion played a key role in engaging startups, companies, and universities. Strengthening ecosystem connections, including partnerships with innovation hubs and research centers, fostered collaboration and a dynamic innovation environment (I1, I2).

Tab. 7 – Sample quotes of the main enablers

Enablers	Sample quotes	Interviewee
Relevant Legislation	"(...) the legal framework already incorporates approaches such as solution acceleration, institutional arrangements, and the use of the startup legal framework for contracting solution testing."	I1
Financial Resources	"(...) more than 20% of the company's revenue now comes from the products we have launched in recent years."	I4
Successful Case Studies	"(...) our main reference, in fact, is challenge.gov."	I1
Senior Management Support	"(...) having leadership invested in making things happen was very important."	I1
Ease of Contracting	"(...) any contracting process is now easier than it used to be, and open innovation-related contracts are relatively straightforward."	I2

4.3.4. Barriers

The analysis identified 18 barriers affecting the initiatives during the operational phase. Among them, 5 emerged from the systematic literature review (3, 5, 13, 14, 17), while 13 were identified through interviews (1, 2, 4, 6-12, 15, 16, 18). Table 8 presents the main obstacles that had to be overcome for successful implementation.

Tab. 8 – List of identified barriers

#	Barriers	C1	C2	#	Barriers	C1	C2
1	Cultural Aspects	X	X	10	Lack of Time	X	
2	Barriers to Engagement	X		11	Limitations	X	X
3	Legal Barriers	X	X	12	Financial Constraint		X
4	Organizational Barriers	X	X	13	Political Mandate	X	X
5	Bureaucracy	X	X	14	Personal Data Privacy		X
6	Conflicts		X	15	Lengthy Process	X	X
7	Engaging External Agencies	X	X	16	Resistance	X	X
8	Lack of Capacity	X	X	17	Technical Restrictions	X	X
9	Lack of Engagement	X		18	Risk	X	X

A key risk in public sector innovation is the fear of accountability among public servants for procedural failures (I1, I2, I3, I4). While bureaucracy ensures transparency, it often hinders innovation (I1, I2, I3, I4). Additionally, cultural resistance, rooted in hierarchical and traditional structures, further challenges change (I1, I2, I3, 11). Table 7 summarizes the main barriers faced during implementation.

Tab. 9 – Sample quotes of the main barriers

Barriers	Sample quotes	Interviewee
Risk	"(...) the public sector has a strong aversion to risk, including fear of making mistakes and then being penalized for them."	I1
Bureaucracy	"(...) open innovation challenges take a long time to materialize because they must go through all these phases."	I1
Political Mandate	"(...) every political transition requires a significant amount of time for realignment—adjusting priorities and refocusing innovation efforts."	I4
Resistance	"(...) when the public call needs to be launched by the institution itself, that's when we encounter resistance to innovation."	I1
Lack of Capacity	"(...) we often work with teams that have never done this before, or perhaps have minimal experience—which is why they seek us out—but they are not experts in open innovation."	I1

4.3.5. Technology

Technology played a fundamental role in driving these initiatives forward. Regarding its influence on these actions, 16 relevant aspects were identified. Among them, 7 were highlighted during the interviews (5, 6, 8,

11, 12, 14, and 15), while the remaining 9 were extracted from the systematic review analysis (1-4, 7, 9, 10, 13, and 16). Table 10 presents the roles played by technology in these initiatives.

Tab. 10 – List of identified Technology Roles

#	Roles	C1	C2	#	Roles	C1	C2
1	Open Data Provisioning	X	X	9	Intermediating the Innovation Process	X	
2	Development of New Technologies	X		10	Social Media Monitoring	X	X
3	API Provisioning	X	X	11	Process Optimization	X	X
4	Provision of Online Services	X	X	12	Enables Transparency	X	
5	Dissemination	X	X	13	Facilitates Communication	X	
6	Documentation	X	X	14	Remote Process	X	X
7	Process Facilitation	X	X	15	Online Meetings		X
8	Innovation Support Tools	X	X	16	Support for Collaborative Activities	X	X

Table 11 highlights key technology roles in OI. Technological tools enabled continuous collaboration among stakeholders (I2, I4). Dissemination expanded initiative reach and engagement (I1, I3). Technology also improved transparency, ensuring all process stages were documented and accessible (I2, I3).

5. Discussion

5.1. Units of analysis comparison

Based on the five themes of this study, the following similarities can be highlighted in both approaches:

- **Practices:** Both Enap Challenges Platform and Serpro Ventures have institutionalized OI in the public sector through legal frameworks and tailored methodologies (I2, I3, I4), reflecting distinct intermediation logics—open dissemination in the case of ENAP, with online-accessible toolkits, and restricted collaboration in Serpro Ventures, based on stage-gated processes with confidential partners (I3, I4). The nationwide reach of both initiatives reinforces their role as federal intermediaries, aligning with discussions on multilevel innovation governance (Figenschou et al., 2024; Mu and Wang, 2022; Palumbo et al., 2023; Pinto et al., 2024). The emphasis on capacity-building—through training in ENAP and professional development in Serpro Ventures —contributes to the sustainability of innovation (Al Maazmi et al., 2024; Edelmann et al., 2023).
- **Stakeholders:** Both initiatives position public agencies as their primary beneficiaries (I1, I2, I3, I4), reinforcing their intermediary role in public sector-oriented innovation networks (Bakici et al., 2013). Active support from senior management (I1, I3, I4) underscores the importance of institutional leadership as a key enabler of DT (Mergel et al., 2019). While academic partnerships are still in the process of consolidation (I1, I3, I4), they reflect an effort to bridge science and public policy design (Ferraris et al., 2020; Palumbo et al., 2023). In parallel, engagement with CSOs (I2, I3) strengthens participatory models of governance (Figenschou et al., 2024).
- **Influencing Factors:** Access to financial resources is critical for investments in platforms, licenses, and experimental initiatives (I1, I2, I3, I4), as highlighted in studies on the sustainability of public innovation (Al Maazmi et al., 2024; Georghiou et al., 2014). Participation in innovation events and forums (I1, I2, I4) serves as a strategy for stakeholder engagement and institutional legitimation (Bogers et al., 2018). Nevertheless, structural barriers such as bureaucratic rigidity and risk aversion continue to hinder collaboration with startups and technology firms (I1, I2, I3, I4).

Tab. 11 – Sample quotes of the main technology roles

Roles	Sample quotes	Interviewee
Open Data	"When data is already open, that is the ideal scenario."	I2
Innovation Support Tools	"(...) using Discord to maintain communication with registered teams, networks—every one of our challenges has a technological component."	I1
API Availability	"(...) we have already used APIs and platforms to support technology development."	I1
Supporting Collaborative Activities	"(...) we rely heavily on technology, using Miro for virtual events that require intense collaboration."	I3

- **Role of Technology:** Technology plays a central role by enabling interoperability between systems through APIs (I1, I3) and facilitating synchronous and asynchronous interactions via platforms such as Discord, Zoom, YouTube, and WhatsApp (I3, I4). These tools enhance collaboration and transparency, contributing to more open digital ecosystems (Gong et al., 2020; Verhoef et al., 2021). The dual role of technology—as both technical infrastructure and a sociotechnical mediation mechanism—aligns with contemporary perspectives on DT in the public sector (Tiach and Abdellatif, 2023; Vial, 2019).

Digital Transformation, driven by OI, enhances engagement, collaboration, and strategic partnerships. For its effective implementation, it is essential to address aspects such as bureaucracy, infrastructure, organizational culture, resource allocation, and capacity building, ensuring sustainable and impactful progress.

5.2. Related work

In this section we position our results compared to a summary of findings from two recent literature reviews on public OI: Mu and Wang, 2022 focused on barriers for OI while Palumbo et al., 2023 brings a broader perspective that cover similar themes as we had.

Some of the barriers we identified to OI align with the barriers identified by Mu and Wang, 2022. These similarities illustrate how traditional barriers to OI persist across digital and administrative domains. E.g., **Technical Restrictions** pose a significant hurdle, closely mirroring the broader challenge of Technical Difficulties, which includes issues related to system service quality, infrastructure, and professional expertise. Similarly, **Lack of Capacity**, **Organizational Barriers**, and **Bureaucracy** reflect the problem of Limited Organizational and Political Capacities, where rigid structures and insufficient resources hinder the adoption and implementation of OI.

Many of the OI practices we identified align with those found in the literature (Palumbo et al., 2023). For instance, **Governance and Strategy**, which includes **Align Expectations**, **Innovation Strategy**, and **Strategic Planning**, corresponds to Public-Private Partnerships (PPPs) and Public-Private-People Partnerships (PPPPs), as both emphasize structured collaboration frameworks between government entities, private organizations, and civil society to drive innovation. **Institutional Initiatives** and **Internal Regulations** also support Open Government Data Initiatives, as they establish the regulatory frameworks necessary for data-driven transparency and innovation. Similarly, **Engagement and Collaboration**, which includes **Bring Stakeholders Closer**, **Collaboration**, and **Partnerships**, aligns with Co-Creation Models, where multiple actors actively participate in the design and implementation of innovative solutions.

The key **stakeholders** of POI mapped by Palumbo et al., 2023 include government entities and public administrations, private sector companies, academia and research institutions, non-governmental organizations (NGOs) and third-sector organizations, and citizens and civil society. These are are also similar to what we mapped.

Similarly, our identified POI enablers align with those from Palumbo et al., 2023 as well. For example, **Open Data** corresponds to technological infrastructures, such as open data platforms and digital collaboration tools, as both emphasize the role of accessible and interoperable data in fostering innovation. Similarly, **Support from Senior Management** and **Administrative Support** align with financial and relational support from public sector entities, highlighting the importance of leadership and institutional commitment in sustaining innovation efforts. The role of **Stakeholder Engagement**, **Collaboration**, and **External Stakeholders** corresponds to trust-building mechanisms to enhance stakeholder engagement, as both recognize the necessity of fostering meaningful relationships and cooperation across sectors. Likewise, **Training for Participants** and **Empowerment of People** align with knowledge-sharing networks to support cross-sector partnerships, ensuring that stakeholders have the necessary skills and opportunities to contribute effectively.

Our findings highlight the critical role of technology in enabling **Open Data provisioning**, which aligns with Palumbo's (Palumbo et al., 2023) concept of Data-Driven Innovation, ensuring that stakeholders can access government-held information to drive new solutions. The **Development of New Technologies** and **API Provisioning** directly contribute to Facilitating Knowledge Flows, fostering continuous inflows and outflows of knowledge that enhance cross-sectoral collaboration. Additionally, **Provision of Online Services** and **Dissemination** are key in Transparency and Open Governance, ensuring accessibility to innovation-driven ini-

tiatives. The **Intermediating the Innovation Process** and **Innovation Support Tools** closely match Orchestrating Multi-Actor Innovation, as they enable coordination among diverse stakeholders within a structured ecosystem.

Only one comparable study focuses on the municipal level (de Lima-Junior et al., 2024), revealing several shared findings. Both highlight the **importance of legal and methodological frameworks**, the need for **stakeholder engagement** and high-level administrative support, and the relevance of **university partnerships** and **collaboration with civil society** in fostering innovation. They also identify **funding** as essential for sustaining initiatives. Common barriers include **bureaucracy and risk aversion**, which hinder participation. Finally, both studies recognize **technology as a facilitator** of OI, particularly through APIs, digital platforms, and open data.

This study contributes to the field of digital government by deepening the understanding of the role of federal public institutions as intermediaries in OI ecosystems—a topic still underexplored in the specialized literature. Its originality lies in the comparative analysis of cases operating under different institutional configurations but sharing the strategic function of articulating multiple actors, fostering interorganizational collaboration, and enabling distributed DT. The relevance of the phenomenon under study is underscored by the growing challenges faced by governments in contexts marked by resource scarcity, complex demands, and the need for agile and collaborative solutions. The research offers theoretical and empirical insights to rethink governance models, expand institutional capacities, and strengthen data-driven and participatory public policies.

5.3. Limitations

This study has some limitations. First, analyzing only two cases may limit the generalizability of the findings, as they may not fully capture the diversity of experiences in similar contexts. Second, the thematic analysis was primarily conducted by a single researcher, introducing potential bias despite later discussions with two others to enhance rigor. Future research could expand the number of cases and involve more analysts to enhance the reliability of findings and reduce subjectivity. Moreover, it is important to investigate the role of other federal institutions that adopt different models of intermediation, as well as to analyze the impact of such initiatives at subnational levels of government, contributing to a more comprehensive understanding of open innovation in the public sector.

6. Conclusions

The empirical investigation conducted in this case (Enap Challenges Platform and Serpro Ventures) highlights innovative pathways and promising strategies for DT in federal agencies. The incorporation of OI has driven significant changes in organizational culture, resulting in substantial improvements in the quality of public services provided to citizens.

The analysis of data obtained from both initiatives reveals strategic actions aimed at improving public services and strengthening the relationship between government and society through OI. The study emphasizes the active participation of various stakeholders in public administration, highlighting the essential role of citizens. As key drivers of DT, citizens exert a direct influence on the adoption of innovative practices by government agencies. In this regard, positioning citizens at the center of the public debate is fundamental to understanding their expectations and needs concerning urban development. This approach reinforces a strategic direction focused on creating innovative solutions through collaboration, ensuring that public demands are met more effectively.

Acknowledgement

The first author acknowledges the support from CAPES (Coordination for the Improvement of Higher Education Personnel), under grant number 88887.491241/2020-00.

References

Al Maazmi, A., Piya, S., & Araci, Z. C. (2024). Exploring the critical success factors influencing the outcome of digital transformation initiatives in government organizations. *Systems*, *12*(12). DOI: https://doi.org/10.3390/systems12120524.

Androutsopoulou, A., Karacapilidis, N., Loukis, E., & Charalabidis, Y. (2017). Towards an integrated and inclusive platform for open innovation in the public sector. *Communications in Computer and Information Science*, *792*, 228–243.

Bakici, T., Almirall, E., & Wareham, J. (2013). The role of public open innovation intermediaries in local government and the public sector. *Technology Analysis & Strategic Management*, *25*(3), 311–327.

Biscotti, A. M., Mafrolla, E., Giudice, M. D., & D'Amico, E. (2018). Ceo turnover and the new leader propensity to open innovation. *Management Decision*, *56*(6), 1348–1364.

Bogers, M., Chesbrough, H., & Moedas, C. (2018). Open innovation: Research, practices, and policies. *California management review*, *60*(2), 5–16.

Bogers, M., Zobel, A.-K., Afuah, A., Almirall, E., Brunswicker, S., Dahlander, L., Frederiksen, L., Gawer, A., Gruber, M., Haefliger, S., Hagedoorn, J., Hilgers, D., Laursen, K., Magnusson, M., Majchrzak, A., McCarthy, I., Moeslein, K., Nambisan, S., Piller, F., & Ter Wal, A. (2016). The open innovation research landscape: Established perspectives and emerging themes across different levels of analysis. *Industry and Innovation*, *24*, 1–33.

Brabham, D. C. (2013). *Crowdsourcing*. MIT Press, Cambridge, MA.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77–101.

Brockman, P., Khurana, I. K., & Zhong, R. ((2018). Societal trust and open innovation. *Research Policy*, *47*(10), 2048–2065. DOI: https://doi.org/https://doi.org/10.1016/j.respol.2018.07.010.

Criado, J. I., & Guevara-Gómez, A. (2021). Public sector, open innovation, and collaborative governance in lockdown times: A research of spanish cases during the covid-19 crisis. *Transforming Government: People, Process and Policy*, *15*(4), 612–626. DOI: https://doi.org/10.1108/TG-08-2020-0242.

Debeljak, A., & Dečman, M. (2022). Digital transformation of slovenian urban municipalities: A quantitative report on the impact of municipality population size on digital maturity. *Network of Institutes and Schools of Public Administration in Central and Eastern Europe. The NISPAcee Journal of Public Administration and Policy*, *15*(2), 25–51.

de Lima Júnior, J. A., Gama, K., & da Silva Correia Neto, J. (2024). The use of the open innovation paradigm in the public sector: A systematic review of published studies. https://arxiv.org/abs/2404.01552

de Lima-Junior, J., Gama, K., & Correia-Neto, J. (2024). Open innovation for digital transformation: Opportunities and challenges at the municipal level. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 494–506. DOI: https://doi.org/10.1145/3657054.3657113.

Edelmann, N., Mergel, I., & Lampoltshammer, T. (2023). Competences that foster digital transformation of public administrations: An austrian case study. *Administrative Sciences*, *13*(2). DOI: https://doi.org/10.3390/admsci13020044.

Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review*, *14*(4), 532–550. Retrieved January 31, 2024, from http://www.jstor.org/stable/258557

Escobar, F., Almeida, W. H., & Varajão, J. (2023). Digital transformation success in the public sector: A systematic literature review of cases, processes, and success factors. *28*(1), 61–81. DOI: https://doi.org/10.3233/IP-211518.

Ferraris, A., Belyaeva, Z., & Bresciani, S. (2020). The role of universities in the smart city innovation: Multistakeholder integration and engagement perspectives. *Journal of Business Research*, *119*, 163–171.

Figenschou, T., Li-Ying, J., Tanner, A., & Bogers, M. (2024). Open innovation in the public sector: A literature review on actors and boundaries. *Technovation*, *131*, 102940.

Gascó, M. (2017). Living labs: Implementing open innovation in the public sector [Open Innovation in the Public Sector]. *Government Information Quarterly*, *34*(1), 90–98.

Gasco-Hernandez, M., Sandoval-Almazan, R., & Gil-Garcia, J. R. (2017). Open innovation and co-creation in the public sector: Understanding the role of intermediaries. *International Conference on Electronic Participation*, 140–148.

Georghiou, L., Edler, J., Uyarra, E., & Yeow, J. (2014). Policy instruments for public procurement of innovation: Choice, design and assessment. *Technological Forecasting and Social Change*, *86*, 1–12.

Gong, Y., Yang, J., & Shi, X. (2020). Towards a comprehensive understanding of digital transformation in government: Analysis of flexibility and enterprise architecture. *Government Information Quarterly*, *37*(3), 101487.

Goulart, D., Carvalho, R., & De Castro, J. (2023). A inovação aberta como catalisadora para a transformação digital: Proposta de um framework integrativo autoria diocélio dornela goulart - diocelio@bluestars.com.br programa de pós-graduação em administração -ppga / puc minas - pontifícia universidade católica de minas gerais paex / fdc -fundação dom cabral.

Hanelt, A., Bohnsack, R., Marz, D., & Antunes Marante, C. (2021). A systematic review of the literature on digital transformation: Insights and implications for strategy and organizational change. *Journal of Management Studies*, *58*(5), 1159–1197.

Kivleniece, I., & Quélin, B. (2011). Creating and capturing value in public-private ties: A private actor's perspective. *Academy of Management Review*, *37*. DOI: https://doi.org/10.5465/amr.2011.0004.

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital transformation: An overview of the current state of the art of research. *Sage Open*, *11*(3), 21582440211047576.

L., S., & D., H. (2018). Unleashing innovation beyond organizational boundaries: Exploring citizensourcing projects. *International Journal of Public Administration*, *41*(4), 268–283.

Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. *Government Information Quarterly*, *36*(4), 101385. DOI: https://doi.org/https://doi.org/10.1016/j.giq.2019.06.002.

Merriam, S. B., & Tisdell, E. J. (2015, August). *Qualitative research: A guide to design and implementation* (first). Jossey-Bass; 4th Revised.

Mittal, P. (2020). Impact of digital capabilities and technology skills on effectiveness of government in public services. *2020 International Conference on Data Analytics for Business and Industry: Way Towards a Sustainable Economy (ICDABI)*, 1–5. DOI: https://doi.org/10.1109/ICDABI51230.2020.9325647.

Mu, R., & Wang, H. (2022). A systematic literature review of open innovation in the public sector: Comparing barriers and governance strategies of digital and non-digital open innovation. *Public Management Review*, *24*(4), 489–511.

Palumbo, R., Casprini, E., & Manesh, M. F. (2023). Unleashing open innovation in the public sector: A bibliometric and interpretive literature review. *Management Decision*, *61*(13), 103–171.

Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage publications.

Pinto, H., Laranja, M., & Uyarra, E. (2024). Smart specialization, public authorities, and innovation intermediaries in developing regions. *Regional Sustainability*, *5*(4), 100175. DOI: https://doi.org/https://doi.org/10.1016/j.regsus.2024.100175.

Robertsone, G., & Lapiņa, I. (2023). Digital transformation as a catalyst for sustainability and open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *9*(1), 100017.

Runeson, P. (2012). *Case study research in software engineering guidelines and examples*. Wiley.

Smith, G., & Akram, A. (2017). Outbound open innovation in the public sector: The roles of intermediaries. *Proceedings of the 4th Annual World Open Innovation Conference*, 1–10.

Tiach, M., & Abdellatif, M. (2023). Digital transformation in public administration: A systematic literature review. *International Journal of Professional Business Review*, *8*, e02372. DOI: https://doi.org/10.26668/businessreview/2023.v8i10.2372.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of business research*, *122*, 889–901.

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2), 118–144.

Yin, R. K. (2014). *Case study research: Design and methods (applied social research methods)*. Sage publications Thousand Oaks, CA.

Developing a BI Solution for Public Process Monitoring.

Rafael José Moura[a*], *Maria Gizele* Nascimento[a*], *George* Valença[a], *Kellyton* Brito[a], *Glória* Fraga[b], *Sérgio* Peixoto[b], *Ermeson* Andrade[a*].

[a]Federal Rural University of Pernambuco, Recife, Brazil. [{rafael.mourasilva, gizele.alves, george.valenca, kellyton.brito, ermeson.andrade}@ufrpe.br], ORCID: 0000-0002-7836-8898, 0009-0007-7048-8565, 0000-0001-9375-5354, 0000-0002-6883-8657, 0000-0002-9614-4492.

[b]Court of Auditors of the State of Pernambuco, Recife, Brazil. [{glorinha, sergiopeixoto}@tce.pe.gov.br], ORCID: 0009-0006-0791-2768, 0009-0009-0589-1037.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. The development of Business Intelligence (BI) tools is essential for improving the efficiency and quality of services in public and private organizations. However, public institutions, especially at the subnational level, often face challenges due to legacy systems that complicate effective data utilization. This study focuses on a subnational public institution, the Court of Auditors of the State of Pernambuco (TCE-PE), which previously relied on a dashboard with several limitations, including usability issues, data inconsistencies, and maintenance complexities due to its dependence on multiple SQL Server database views. This study presents the development of a new dashboard, designed using an agile methodology, to centralize data transformations within the BI tool. The proposed solution focuses on the Accountability process, aiming to enhance data consistency and improve performance monitoring. The development process was structured into four key phases: Problem Identification, Planning and Requirements Collection, Design and Development, and Validation and Testing, ensuring a systematic and iterative approach to address the institution's needs. The new system utilizes Qlik Sense, eliminating dependency on SQL Server views and allowing real-time analysis through interactive dashboards. The solution overcomes prior limitations, providing faster, more accurate, and reliable analyses aligned with the institution's strategic objectives. By improving flexibility, usability, and data reliability, this initiative not only serves as a reference for other subnational institutions in Brazil but can also be adapted as a model for organizations operating in diverse contexts worldwide.

Keywords. Business Intelligence, Process Monitoring, Public Sector, Data Visualization.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.966

1. Introduction

Over time, the volume of information has grown exponentially, particularly in the public sector, which deals with data essential for decision-making and activity monitoring. This growth has made the public sector increasingly aware of the potential value that can be derived from the data it generates (Munné, 2016). In this context, there is a rising demand for Business Intelligence (BI) tools, which stand out as fundamental strategies for organizing and structuring data, facilitating information management, and supporting data-driven decision-making (Negash, 2004).

The use of dashboards in the public sector has proven to be an effective strategy in the context of governmental digital transformation (Andrade et al., 2023), especially in the face of growing challenges in managing large volumes of data and the pursuit of greater transparency and operational efficiency. For instance, serves a

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

variety of purposes, from performance monitoring to policy formulation and public engagement (Matheus et al., 2020). These dashboards provide flexibility by offering both broad overviews and specific insights, promoting transparency and detailed analysis of critical events. However, for these dashboards to reach their full potential, it is essential to ensure the quality of the data used, considering aspects such as granularity, timeliness, and accuracy. Inadequate use or lack of optimization of dashboards can compromise the efficiency of monitoring critical processes and hinder strategic decision-making based on reliable data (Matheus et al., 2020).

Within this context, the Court of Auditors of the State of Pernambuco (TCE-PE) has adopted BI tools to monitor and analyze data related to its activities, with a particular focus on the Process Monitoring Dashboard. However, the dashboard faced limitations that compromised both its usability and the consistency of the information presented. These challenges were primarily associated with the integration of multiple views used to extract and transform data, which reduced the dashboard's efficiency and made its maintenance more difficult. Additionally, the sharing of these views across departments, which applied different data treatments, led to the emergence of conflicting information. As a result, there were obstacles to the accurate visualization of key indicators essential for tracking and improving organizational processes.

The limitations of the previous system resulted in significant impacts, such as delays in indicator analysis and difficulties in implementing essential improvements for monitoring critical processes. These issues were primarily caused by information fragmentation, challenges in adopting new technologies, and difficulties related to data integration and quality. To ensure the effectiveness of BI dashboards, it is essential to overcome these limitations, focusing on proper design and data quality, which are critical factors for promoting transparency and accountability (Matheus et al., 2020). Furthermore, the implementation of BI systems requires a transformation in technological infrastructures, overcoming the barriers of legacy systems and meeting the demand for dynamic and timely information (Mix, 2016).

This study aims to present the development process of a new dashboard for process monitoring, focusing on the "Accountability" modality at TCE-PE. The study highlights the benefits and limitations of the proposed solution, which was developed in Qlik Sense to address issues in the previous system, such as usability problems, data inconsistencies, and reliance on SQL Server views. By enhancing the consistency, efficiency, and reliability of analyses through interactive and real-time visualizations, the solution contributes to optimizing the institution's internal processes and aligning with its strategic goals. Additionally, this study serves as a reference for subnational public organizations, promoting best practices in the use of BI tools to improve efficiency, transparency, and decision-making support within the broader context of digital government and the specific challenges of digital transformation in the public sector.

This article is structured as follows. Section 2 presents related works. Section 3 discusses the theoretical foundation on process management and monitoring in the public sector, as well as the tools and technologies employed. Section 4 details the methodology adopted in the development of the new dashboard. Section 5 describes the main implementations of the dashboard. Section 6 presents the analysis and interpretation of the results obtained. Finally, Section 7 discusses the conclusions and future perspectives of this study.

2. Literature Review

In both public and private organizations, numerous studies explore the use of BI tools for data monitoring and analysis to support decision-making. In the private sector, Widjaja and Mauritsius (2019) addressed the implementation of a BI system at *Indomobil*, one of the leading automotive companies in Indonesia. The study aimed to develop a performance dashboard using the Power BI tool to facilitate the analysis of operational data at the strategic management level. The implementation followed four stages: analysis, design, planning, implementation, and control. The results indicated that the dashboard implementation provided a better understanding of the company's operations, enabling efficient monitoring and identification of areas requiring improvement.

The study by Sanabia-Lizarraga et al. (2024) was conducted at the Agro-logistics Observatory of the Sonora Institute of Technology (ITSON), aiming to support the analysis of Mexico's agricultural foreign trade. The objective was to develop an interactive Power BI dashboard for analyzing Mexican agricultural exports, enabling the visualization and comparison of export and import data to support decision-making for commercial and academic purposes. To achieve this, the Cross-Industry Standard Process for Data Mining (CRISP-DM)

methodology was adopted, involving the collection and cleaning of data from various sources and a modeling process that integrates geospatial data and economic classifications. The developed dashboard provided a detailed visualization of the Mexican agricultural trade scenario and was well-received by its stakeholders for its usefulness in strategic decision-making for the agricultural sector.

In the public sector, Samad and Setyabudhi (2023) identified the need for software to improve and facilitate police services at the Integrated Police Service Center (SPKT). The data used were still processed, according to information needs, using Microsoft Office applications (Word and Excel), which had limitations. Thus, the authors designed a public service administration application to assist in managing this data. The application includes a dashboard that presents important information, combined and organized on a single screen, allowing for quick visualization. The results of developing the public service administration dashboard using the waterfall model involved nine tables to support the application and enabled easier data retrieval. Among the limitations of the work, the authors highlight that the solution is restricted to administration and employee pages and does not support online services for email. Additionally, they emphasize the need to increase human resources to support the new system.

Given the recent increase in the number of refugees due to the war in Ukraine, Sprenkamp et al. (2023) proposed a tool for the Swiss government to manage refugee needs. The authors aimed to demonstrate how modern Natural Language Processing (NLP) techniques can be applied to identify refugee needs from large volumes of textual data. To achieve this, they used the Design Science Research approach, which involved semi-structured interviews with stakeholders to define design requirements and develop the "Refugees to Government" (R2G) application, based on topic modeling applied to Telegram data. This application analyzes public Telegram messages, making them available on a dashboard where users can navigate the data and view the main refugee needs in an organized manner. The results show that the system is effective in identifying refugee needs and can be used to complement public policies. However, the study raises ethical challenges related to refugee privacy and risks of misuse of the tool.

Also in the public sector, Vila et al. (2018) highlight the use of information visualization tools to enhance governmental decision-making. The authors proposed the design of a dashboard that integrates visualizations built from open data provided by the Municipality of Bahía Blanca, Argentina. This dashboard was divided into six areas and aims to provide an overview of the most relevant information about the city, facilitating high-level data analysis for the mayor and other authorities. The proposed dashboard is capable of providing a broad overview of the city, presenting information on the most important areas related to policy. However, the authors argue that dashboards are unable to portray cities as they are in real life due to their reliance on open data, which must be made available by government agencies.

The development of the BI dashboard for the TCE-PE differs from previous studies due to its focus on oversight and transparency in public administration. While works such as (Sanabia-Lizarraga et al., 2024; Widjaja & Mauritsius, 2019) address performance optimization in the private sector, and others like (Samad & Setyabudhi, 2023) deal with specific public services, this study aims to enhance the control of administrative processes and accountability, ensuring greater reliability and efficiency in data management. Despite advancements in BI tools, several challenges persist, including data fragmentation due to reliance on multiple sources (Samad & Setyabudhi, 2023; Sanabia-Lizarraga et al., 2024), limited applicability of solutions without a broader governance approach (Samad & Setyabudhi, 2023; Vila et al., 2018), and concerns regarding transparency and data reliability in decision-making (Sprenkamp et al., 2023; Vila et al., 2018). To address these issues, the proposed dashboard uses Qlik Sense technology, contrasting with the predominant use of Power BI, to integrate and centralize information, reducing fragmentation caused by multiple SQL Server views. This approach strengthens public governance by providing a unified and accessible view of data, serving as a reference for other institutions seeking to improve their management through BI solutions focused on transparency and efficient oversight.

3. Background

3.1. Process Management and Monitoring in the Public Sector

All organizations, whether public, private, or non-profit, need to manage a series of processes (Dumas et al., 2018). Thus, it is necessary to adopt an effective strategy for managing their business processes. A business

process can be defined as a set of interrelated events, activities, and decisions involving various actors and objects, aimed at delivering a valuable outcome to at least one customer (Dumas et al., 2018). In the context of the public sector, business processes are adapted to address the complexity of government regulations and the diversity of stakeholders involved. Effective management of these processes is crucial for improving organizational effectiveness and efficiency, especially when based on cross-functional processes (Gulledge Jr & Sommer, 2002).

However, the degree of implementation and maturity of business process management in public institutions remains relatively low, and the willingness to share knowledge on the topic is limited (Ahrend, 2014). The effective adoption of BPM is often hindered by the lack of integration of its principles into the organizational culture, resulting from both the absence of competitive pressure for rapid changes and the inherent bureaucracy in decision-making processes (Dumas et al., 2018). Additionally, public organizations also face challenges related to multiple stakeholders and cross-cutting portfolio objectives, as they deal with a broader and more complex variety of clients compared to private organizations (Tregear & Jenkins, 2007).

To improve the quality of services offered, proper monitoring of business processes is necessary (Fioretto & Masciari, 2024). Process monitoring reflects the actual performance of planned activities and is essential for good governance, facilitating accountability and transparency (Mohamed & Kulmie, 2023). Through the data collected, it is possible to identify bottlenecks, recurring errors, or deviations from the expected behavior of processes, enabling the adoption of corrective actions (Dumas et al., 2018).

Like other public institutions, the TCE-PE also requires constant monitoring of its business processes. Playing a key role in overseeing public administration, the TCE-PE is responsible for analyzing documentation provided by public institutions, conducting audits, evaluating the legality of managers' actions, and verifying the cost-effectiveness of expenditures and their compliance with government guidelines and programs (TCE-PE, 2025a). In this context, the use of monitoring tools to assess the efficiency of TCE-PE's business processes is crucial for transparency in the analysis of public accounts. In this regard, the prototype of the process dashboard was developed focusing solely on the "Accountability" procedural modality. This modality was chosen due to its importance to the institution and the large volume of available data on it.

3.2. Monitoring Technologies and Tools

Monitoring technologies and tools are used to track, analyze, and evaluate the performance of data related to processes or activities within an institution. In the public sector, monitoring plays a significant role in enhancing activities, contributing to increased effectiveness and efficiency of services provided to society. These tools enable the identification of deficiencies, the evaluation of trends, and the implementation of best practices. Additionally, they allow for the extension and improvement of processes and services, using appropriate instruments to accelerate continuous performance improvement (Dascalu et al., 2016). This provides public managers with more accurate information for decision-making, directly contributing to greater administrative efficiency and better accountability to society.

One of the standout tools in the field of data monitoring and analysis is Qlik Sense (Qlik, 2025), a modern BI platform widely recognized for its advanced capabilities and versatility (Ceccato, 2023). Its functionalities range from data collection and integration to the creation of interactive visualizations and predictive analytics, making it a powerful solution for both public and private institutions. Among its key features are:

- **Customizable and Interactive Dashboards:** Allows the creation of dynamic dashboards with visualizations tailored to the needs of different audiences and purposes, promoting detailed analysis and informed decision-making.
- **Integration with Multiple Data Sources:** Supports data from various sources, such as spreadsheets, SQL databases, XML files, and cloud systems, centralizing information for efficient analysis.
- **Scalability and Flexibility:** Serves small teams to large organizations, allowing adaptations for specific scenarios and ensuring relevance in different organizational contexts.
- **Advanced and Predictive Analytics:** Provides tools for scenario simulations and pattern identification, aiding in anticipating trends and defining more assertive strategies.

Figure 1 illustrates these characteristics in a simplified manner. Data can be extracted from various sources, transformed, and loaded to be presented in dashboard format, in a process known as Extraction-Transformation-Loading (ETL). ETL plays an essential role in data integration and transformation, ensuring

the quality, consistency, and reliability of the analyzed information (Venkateswarlu & Vasista, 2023). Furthermore, the implementation of robust internal controls during each phase of ETL is crucial to prevent errors and ensure data integrity, allowing analyses and decisions to be based on reliable and up-to-date information (Dingre, 2023).

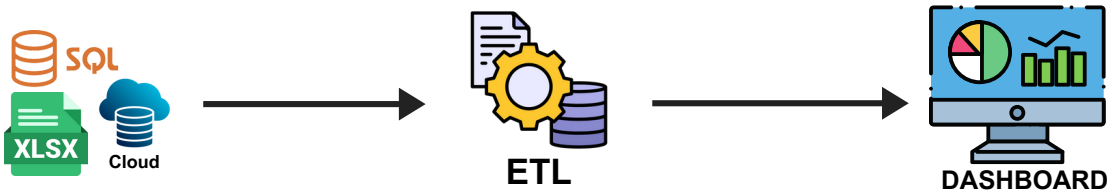


Fig. 1 – Representation of the ETL Process in the context of data integration.

4. Research Method

The development of the new dashboard was carried out collaboratively, using concepts derived from agile methodologies, as described by (Al-Saqqa et al., 2020). These concepts aim to ensure the delivery of a high-quality product within reduced timelines and with optimized resources, aligning with the dynamic needs of the project and promoting continuous adaptability. In this context, the development cycle was adjusted to implement an incremental process with continuous deliveries and feedback. Each increment was subjected to testing and validation, fostering efficient communication among stakeholders and ensuring continuous validation of the product as new functionalities were added. The activities followed a pre-established schedule, structured into four main stages, as shown in Figure 2: Problem Identification, Planning and Requirements Gathering, Design and Development, and Validation and Testing. These stages are detailed below.

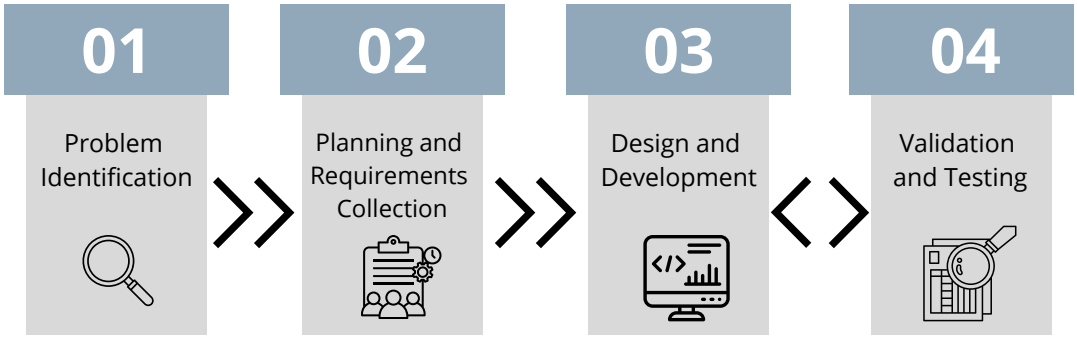


Fig. 2 – Adopted methodology.

4.1. Problem Identification

In this phase, an analysis was conducted to identify the problem to be addressed and the organization's needs. This process involved identifying causes and effects, understanding the nature of the problem, and considering potential constraints. The analysis was primarily based on the previous dashboard and existing requirement documents to understand its deficiencies and limitations. The goal of this stage was to ensure that the proposed solutions not only meet the identified needs but are also effective, feasible, and aligned with the organization's strategic objectives.

Although functional, the process dashboard previously used by the Process Office of TCE-PE had issues that compromised its usability and the consistency of the information presented. Additionally, the dashboard included indicators that were no longer relevant to the sector, while essential indicators were not addressed. The data feeding this dashboard were processed and filtered externally, through the extraction, treatment, and filtering of multiple views from various SQL Server databases.

As a consequence of this chain of views, the dashboard's efficiency was reduced, and data consistency was compromised. Furthermore, these views were shared across various departments, which applied different

types of data treatments, making maintenance difficult and facilitating the emergence of conflicting information. These issues hindered the accurate visualization of the indicators necessary for monitoring and improving the organization's processes. Thus, it became necessary to develop a tool to mitigate these problems.

4.2. Planning and Requirements Collection

After identifying the problems, the next step involved planning and requirements collection, including the establishment of a schedule to be followed and the definition of activities for each phase of the development process. This schedule considered the potential constraints identified in the previous stage and the limitations of resources and time that could impact the feasibility of the proposed solutions. The planning was structured based on the schedule, which was divided into three main stages: Requirements Gathering, Process Dashboard Development, and Testing and Validation.

In the Requirements Gathering stage, activities such as identifying indicators for the Overview, Time, and Inventory tabs, defining filters and views, and reviewing and finalizing the requirements document were carried out. Next, in the Process Dashboard Development phase, data treatment, implementation of the Overview, Time, and Inventory tabs, as well as the implementation of filters and views, took place. Finally, in the Testing and Validation stage, specific tests were conducted for each tab, along with performance and usability tests to ensure the system's effectiveness.

The development of the dashboard was estimated to take 371 calendar days, considering the overlap of some stages, which occur simultaneously. This timeline was distributed among the project activities according to their complexity. The Requirements Gathering stage was planned for a total of 225 days, with 60 days allocated to identifying indicators for the dashboard tabs, 30 days for defining filters and views, and 15 days for finalizing the requirements document. The Process Dashboard Development began immediately after the completion of the general tab's requirements gathering, with an estimated duration of 270 days. Data treatment and the implementation of filters and views also occurred during this period, while the implementation of the tabs was divided into 90-day cycles for each one. Testing was conducted immediately after the implementation of each tab, totaling 65 days, with 15 days for individual tests and 20 days for performance and usability evaluation. With the schedule defined and approved by management, the project execution began.

As defined in the schedule, the project started with requirements gathering, which were recorded in a document containing all the necessary information for the dashboard's development, including technical and functional aspects aligned with organizational objectives. The document was developed through weekly meetings between the TCE-PE team, which defined the indicators to be implemented, as well as the filters and dynamic columns needed to improve information visualization.

The document began with a brief introduction, followed by descriptions of the elements that make up the dashboard: dimensions, measure groups (tabs), related views, and filters. Each tab has its own set of measures; however, the filters and the dynamic table are common to all tabs. Thus, the measures for the Overview tab were defined first, followed by the general and complementary filters and the dynamic table. Finally, the requirements for the Time and Inventory tabs were defined, respectively. After defining the requirements for each tab, the document was submitted to management for approval before being forwarded for development.

4.3. Design and Development

The team involved in the development process included internal public servants and outsourced professionals, working collaboratively throughout the process. This stage consisted of two main phases: design, which involves the processes of data extraction, transformation, and structuring, and development, which refers to the creation of the dashboard, ensuring that the requirements established in the documents are met. During the design phase, the preparation and organization of the data required for the system take place, while the development phase involves the construction of functionalities, charts, columns, and visual structures of the dashboard.

The development of the dashboard included a detailed analysis of the previous dashboard, applying reverse engineering to map the origin and sequence of the *views*, identifying the essential source tables. With this information, it was possible to create a code that extracts data directly from the source, eliminating the dependency on *views* in the new system and ensuring greater control over data consistency and quality. After

mapping the data sources, the direct extraction of information from the databases began, eliminating the need for *views*.

With the data properly structured, the development of the dashboard commenced, following an incremental model using the BI tool Qlik Sense *QLIK Sense* (Qlik, 2025). The dashboard was organized into three main tabs: Overview, Time, and Inventory, each designed to meet specific analysis and monitoring needs. The Overview tab provides a general view of the processes, including information on the number of processes that have completed certain procedural stages. The Time tab displays data related to the duration of process stages (current position), while the Inventory tab presents all formalized processes that have not yet completed the execution phase. The implementation of new tabs was planned for future updates, allowing for the continuous growth of the dashboard.

4.4. Validation and Testing

The validation and testing phase was conducted as each tab was implemented, with the goal of verifying whether the developed solution meets organizational needs. For this purpose, a dashboard validation spreadsheet was used, with access shared between the development team and the testing team, which was composed of the same members responsible for the requirements gathering. The spreadsheet facilitates communication between the two teams and speeds up the resolution of potential inconsistencies during the dashboard implementation phase.

When an inconsistency is identified in the dashboard under development, it is recorded in the validation spreadsheet, which contains specific fields to document a detailed description of the issue, include illustrative images, and provide the step-by-step process that led to the error. With this information, the development team can reproduce the issue and implement the necessary correction. Simultaneously, the testing team monitors the resolution status through a field in the spreadsheet that presents the options: Not Implemented, In Progress, Implemented, Discarded, and In Backlog. The spreadsheet also includes a field for observations, used to record important information about the progress of corrections or to justify the discarding of certain issues.

5. Dashboard Development

The system architecture was developed using Qlik Sense, which integrated both the front-end and back-end of the application. This tool was adopted because it is already used institutionally by TCE-PE. Data were extracted from the Electronic Process System (TCE-PE, 2025b), an electronic process platform of TCE-PE, which facilitates the handling of processes, communication of acts, and transmission of procedural documents virtually. The processes are available for public consultation (TCE-PE, 2025c). It is worth noting that the developed dashboard is exclusively for internal use by TCE-PE, as it contains sensitive and restricted information. According to Article 46 of Resolution No. 22/2015 of TCE-PE, only procedural documents of a public nature will be made available for public consultation, except in cases involving confidentiality to protect privacy or public interest (TCE-PE, 2015). Thus, the Electronic Process System seeks to balance public transparency with the security and confidentiality of its internal data.

The data used in the dashboard were extracted from two main databases, which play complementary roles in the system. The first is the **Reading Database**, which contains essential information about the cases, such as nature, session, judgment, deliberation, and redistribution. The second is the **Complementary Database**, which stores additional data such as information about reporters, municipalities, types of modalities, jurisdictional units (UJ), and staff members. Based on these data, the new dashboard was developed with an initial focus on the "Processes" dimension, aligned with organizational goals, in contrast to the previous dashboard, which included the dimensions: Processes, Activities, and Communications. This dimension encompasses data related to electronic processes, which make up the accounting process modality of TCE-PE providing information such as case quantities, duration, deadlines, and more. The dimension was divided into three tabs: Panorama Geral, Tempo, and Estoque.

The Panorama Geral tab aims to provide an overview of the accounting process and allow monitoring of its phases, showing the quantity of cases that have completed a certain procedural phase. The Tempo tab presents data related to the duration of specific steps in the process, and by default, when accessed, it shows data for the

current date. Finally, the Estoque tab consists of all formalized cases that have not yet completed the execution phase, i.e., all ongoing cases on the selected date. Additionally, the developed dashboard offers several key functionalities for process analysis and monitoring at TCE-PE, enabling interactive visualization and real-time data tracking. Some of the implemented features include views, general filters, complementary filters, and a table with dynamic columns.

Each tab of the dashboard presents a unique set of related views. Views are graphical representations of the measures related to a specific perspective, such as the number of cases by year or month. Thus, views refer to how the data will be graphically displayed to the user. Unlike the previous dashboard, the new Process Dashboard presents views more aligned with organizational goals. Specifically, in the Panorama Geral tab, as illustrated in Figure 3, the user can choose from various options to view the data in different ways. It is important to note that some information in the dashboard has been hidden in the figures due to the sensitive nature of the data.

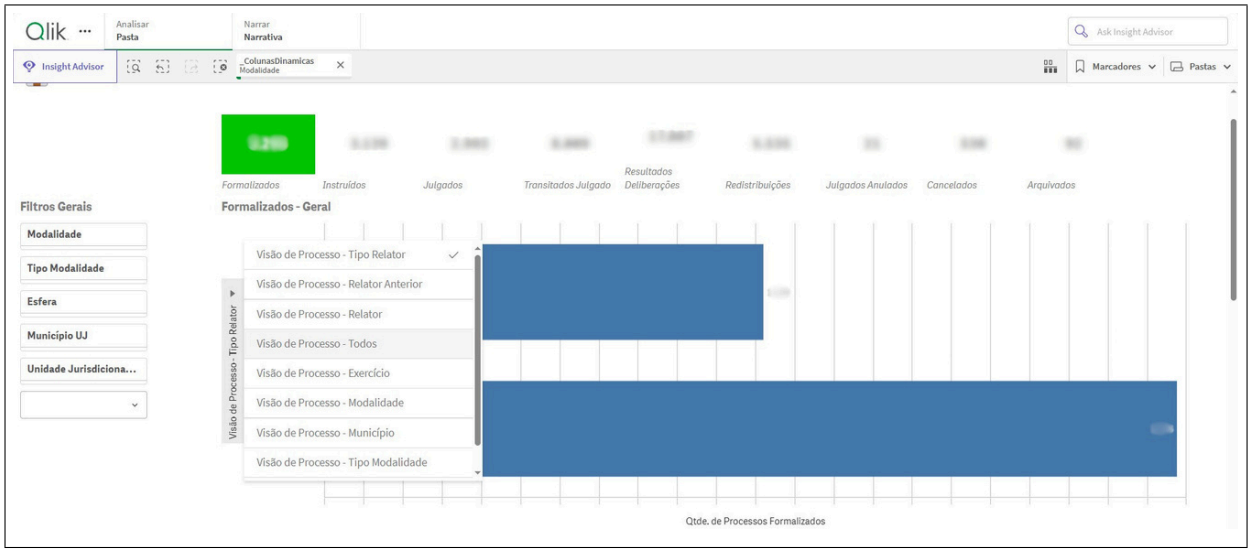


Fig. 3 – Views of the Panorama Geral tab.

The three tabs of the dashboard share a set of interactive filters. These filters apply the criteria selected by the user, adjusting the information displayed in the views. Two types of filters were defined: general and complementary. The general filters include common criteria such as modality, type of modality, sphere, municipality, jurisdictional unit (UJ), exercise, reporter, and process status. The complementary filters offer additional options to further refine the analysis. Figure 4 presents some of these filters.

In addition to the filters, all tabs include a dynamic table. This table presents a representation of the process data that make up the views presented. The table allows the user to add or remove columns dynamically based on their analysis needs. By default, the table displays the following columns: Process Number, Process Link, and Modality, with additional columns that can be added as needed. Figure 5 shows an example of the dynamic table. It is worth noting that the process numbers have been hidden to maintain their confidentiality.

The dashboard was developed to optimize process analysis, offering an intuitive interface and advanced filtering and visualization features. The customization of the dynamic table provides greater flexibility in data visualization, meeting the diverse needs of users. Moreover, the organization of the tabs and filters enhances navigation and allows users to quickly access the most relevant information. With flexibility for future adjustments and expansions, the tool enables continuous monitoring of organizational processes, allowing for greater control and efficiency in operations.

6. Results

The implementation of the new dashboard brought significant improvements to the analysis and monitoring of processes at TCE-PE. To evaluate its effectiveness, tests were conducted with simulated scenarios, demonstrating its ability to provide information more quickly and intuitively. The dashboard allowed managers to

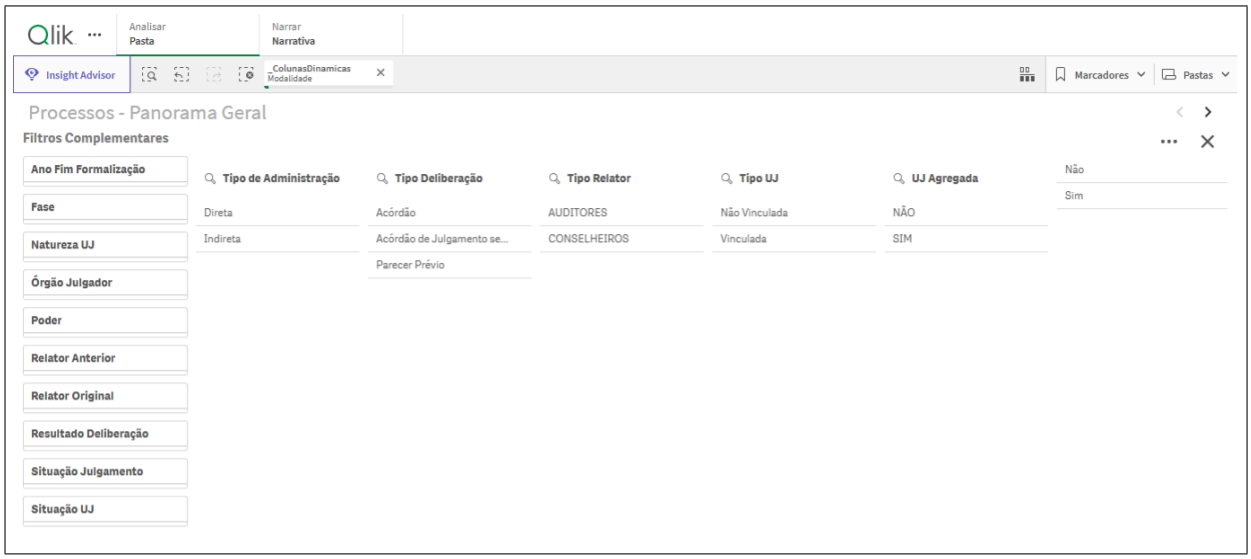


Fig. 4 – List of complementary filters.

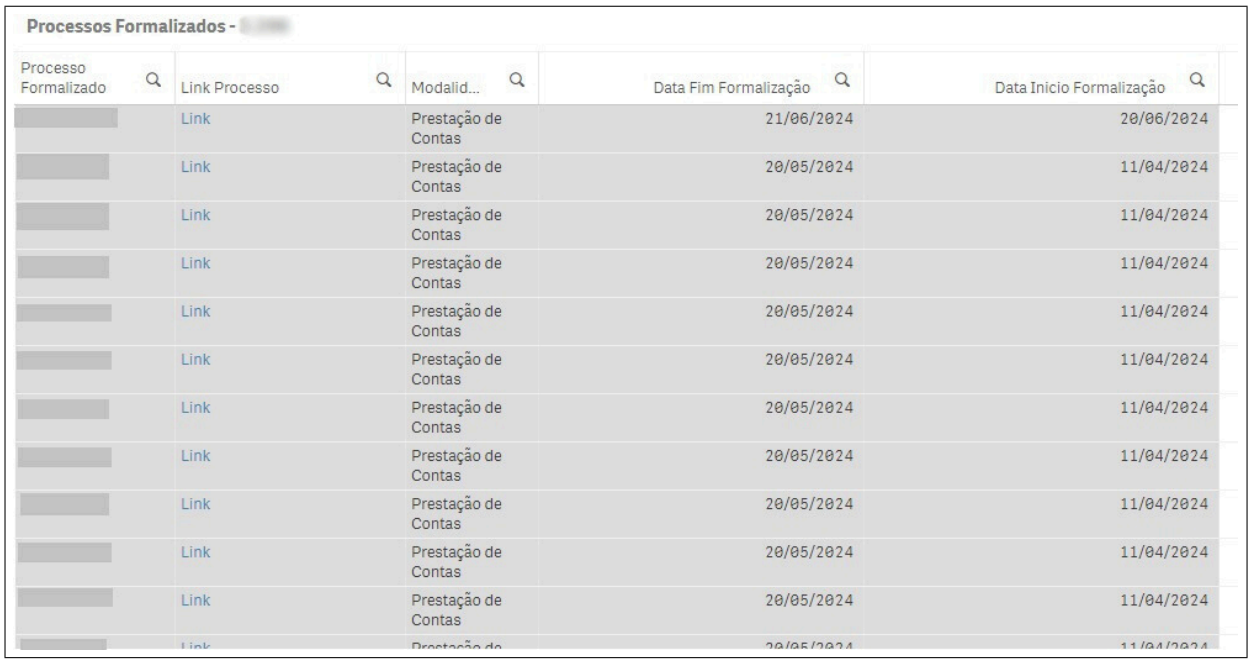


Fig. 5 – Example of a dynamic table.

quickly access essential data, such as the evolution of processes, average processing times, and identified bottlenecks, facilitating strategic decision-making.

Figure 6 presents an example of the Time tab, highlighting the number of processes adjudicated in 2018. In this tab, it is possible to clearly visualize how many processes were completed within and outside the deadline, as well as the timeliness index and the average time, in days, from formalization to adjudication. Additionally, the visualization allows for the identification of the distribution of adjudicated processes over the months of the selected year, providing a more detailed analysis of the processing over time.

Figures 7 and 8 present an example of the Overview tab, filtering the number of formalized processes in the Municipal Sphere with the nature of City Council. In Figure 7, the processes are classified into two modality types: Management and Government. In Figure 8, it is possible to visualize the distribution of processes by year and month of formalization. Figure 9 presents another form of analysis, filtering the Deliberations stage within the Municipal Sphere, considering only processes with the nature of Municipal Prefecture for the year

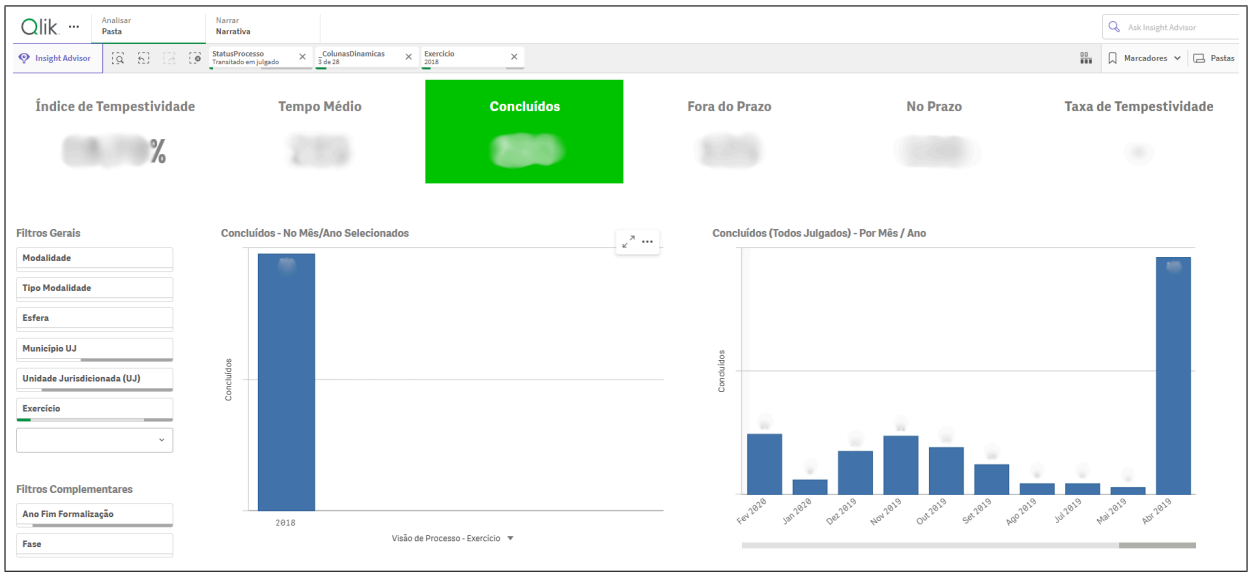


Fig. 6 – Simulation of Adjudicated Processes in the Time Tab.

2024. This visualization allows for the observation of both the total deliberations conducted throughout the year and their monthly distribution.

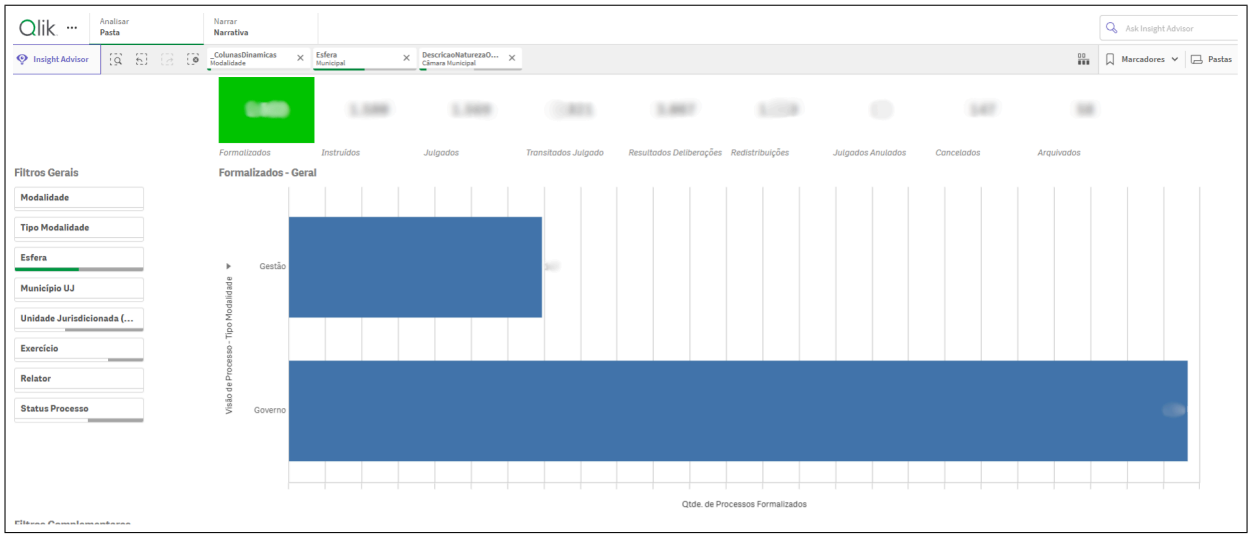


Fig. 7 – Simulation of Formalizations in the Overview Tab, Categorized by Modality.

The implementation of a new, more efficient dashboard aligned with organizational objectives brought significant benefits to the TCE-PE. Among the main benefits achieved are:

- **Greater Efficiency:** The direct extraction of source tables and the optimization of the data flow ensured greater reliability and system performance. The elimination of the use of *views* provided more control over the data, increasing the accuracy of the information presented. Additionally, the centralization of transformations in the Qlik Sense tool reduced processing complexity, making analyses faster and more reliable.
- **Simplified Maintenance:** The entire development and data transformation process was centralized in the Qlik Sense tool, facilitating the identification and correction of errors, the application of improvements, and the understanding of implemented rules.
- **Improved Visualization and Analysis:** The new dashboard presents data interactively and visually clearly, facilitating decision-making and enabling more detailed and intuitive analyses. Additionally, the new filter and view options allow information to be displayed in a customized manner according to user needs.

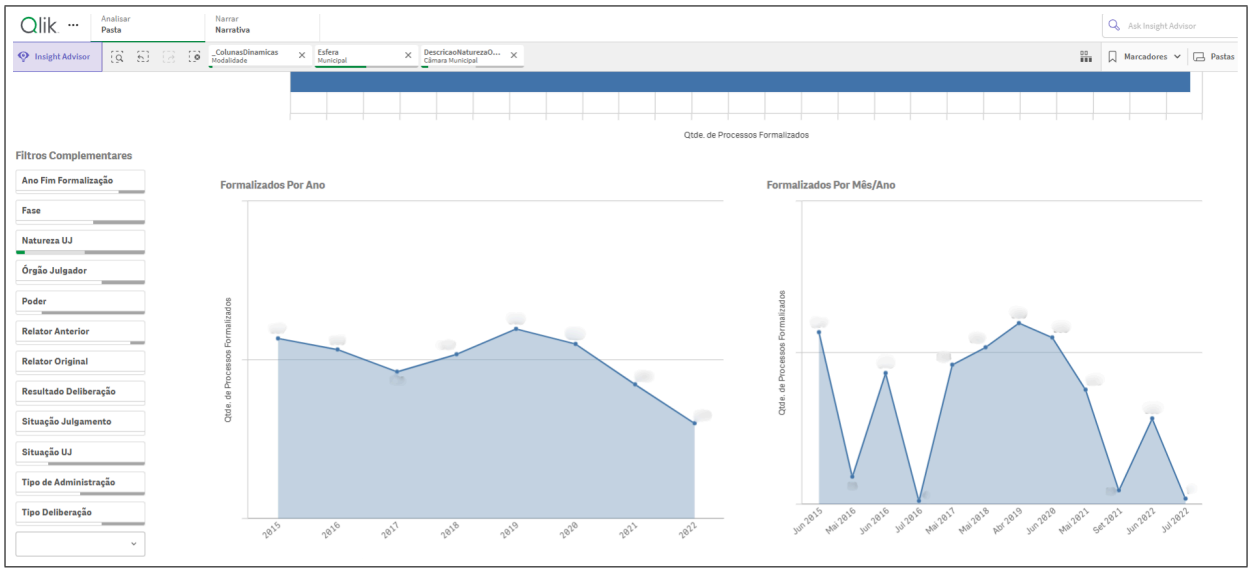


Fig. 8 – Simulation of Formalizations in the Overview Tab, Distributed by Year and Month of Formalization.

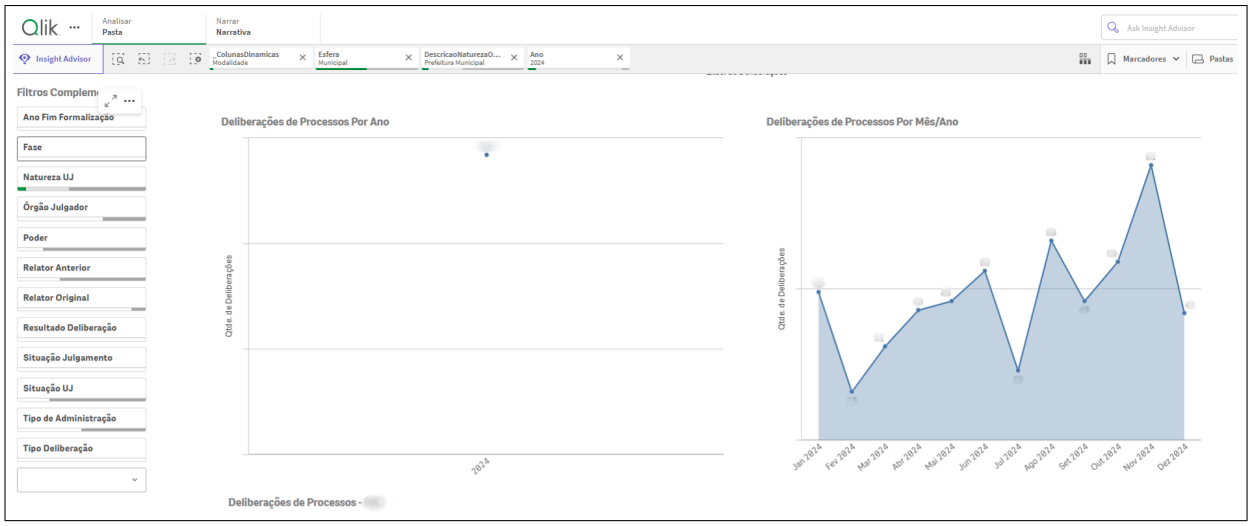


Fig. 9 – Simulation of Deliberations in the Overview Tab, Filtered by Modality and Distributed Throughout 2024.

- **Governance and Accountability:** The dashboard increases transparency in internal processes and strengthens accountability, facilitating the analysis and monitoring of processes by the institution's employees, while ensuring more efficient governance.
- **Scalability and Flexibility:** The developed dashboard has a scalable architecture, allowing flexibility for future adjustments and updates, with the possibility of system expansions as new requirements arise.

Despite the advancements achieved, the new process dashboard at TCE-PE presented some limitations:

- **Limited Implementation Scope:** The dashboard exclusively covers the Accountability modality, one of the main business processes of TCE-PE. However, other procedural modalities could benefit from the dashboard to enhance the analysis and monitoring of their flows. This limitation is due to the prototype having a reduced scope, aiming to ensure agile development and effective implementation.
- **Access and Transparency Restrictions:** The dashboard was designed for internal use at TCE-PE, meeting the needs of the sectors responsible for monitoring and oversight. However, due to the sensitive nature of procedural information, access is restricted to authorized employees, limiting its potential to promote greater public transparency.

- **Absence of Advanced Analytical Features:** The dashboard did not incorporate techniques such as machine learning or predictive models, which could add value to monitoring by estimating deadlines or identifying risks of delays. Artificial intelligence approaches could also detect anomalies and generate automatic alerts for situations requiring managerial attention.

Despite these limitations, the benefits of the developed solution outweighed the challenges, consolidating the dashboard as an essential tool for improving the management and monitoring of processes at TCE-PE. The centralization of data transformations in Qlik Sense mitigated the identified issues, simplifying maintenance and increasing system reliability, ensuring more accurate and trustworthy information. Thus, the developed dashboard was approved by its stakeholders, contributing to greater governance, accountability, and efficiency of the institution.

7. Conclusion and Future Steps

For the public sector, monitoring business processes is essential to ensure good governance, accountability, and transparency. However, maintaining the consistency of the data used is of utmost importance. In this context, this study presented the development of a new BI dashboard for monitoring the Accountability modality processes at TCE-PE, aiming to address the limitations of the previous dashboard, which had usability issues, data inconsistencies, and maintenance difficulties, primarily due to the chaining of multiple views in SQL Server.

The proposed solution centralizes data transformation in the Qlik Sense tool, eliminating the dependency on multiple views and providing greater reliability and efficiency in information analysis. The new dashboard was designed to optimize the analysis and monitoring of processes at TCE-PE, offering an intuitive interface and advanced visualization and filtering functionalities. The segmentation into tabs, the flexibility of dynamic tables, and the diversity of views allow for more precise and efficient tracking of information. With a modular and interactive structure, the tool facilitates data exploration and enables adjustments according to institutional needs. Additionally, its scalable architecture ensures flexibility for future expansions, consolidating the dashboard as an essential resource for strategic management and data-driven decision-making. Furthermore, the new dashboard has also strengthened management by providing more reliable and up-to-date data to support faster and safer strategic decision-making.

In addition to enhancing process management at TCE-PE, the methodology adopted in this work provides a solid foundation for other subnational institutions, including state-level entities in Brazil, to implement similar solutions with minimal adaptation. With appropriate adjustments, the system architecture and approach can be extended to public institutions at various levels, both nationally and internationally, driving the modernization of data monitoring and analysis strategies across diverse governmental contexts.

To ensure the continuous evolution of the new process dashboard, future work is proposed, including the inclusion of new indicators as monitoring analyses are refined. Furthermore, other procedural modalities will be implemented to expand the system's scope and meet additional monitoring and analysis demands. The implementation of more advanced analytical functionalities, such as Machine Learning techniques and predictive analytics, is also envisioned.

- **Contributor Statement***:
  - **Rafael José Moura**: Conceptualization, Data Curation, Methodology, Validation, Writing – Original Draft.
  - **Maria Gizele Nascimento**: Conceptualization, Data Curation, Methodology, Validation, Writing – Original Draft.
  - **George Valença**: Validation, Writing – Review & Editing.
  - **Kellyton Brito**: Validation, Writing – Review & Editing.
  - **Glória Fraga**: Conceptualization, Data Curation, Project Administration, Supervision, Validation, Writing – Review & Editing.
  - **Sérgio Peixoto**: Data Curation, Validation, Writing – Review & Editing.
  - **Ermeson Andrade**: Conceptualization, Data Curation, Methodology, Supervision, Validation, Writing – Review & Editing.
- **Use of AI***: No artificial intelligence tools or services were used in the preparation of this work. The authors conducted all aspects of the work, including data analysis, writing, and review, independently, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Ahrend, N. (2014). Opportunities and limitations of bpm initiatives in public administrations across levels and institutions.

Al-Saqqa, S., Sawalha, S., & AbdelNabi, H. (2020). Agile software development: Methodologies and trends. *International Journal of Interactive Mobile Technologies*, *14*(11).

Andrade, A. C., Rocha, C. M. C., & Carpina, H. M. S. (2023). Painel de dados sociais para aprimoramento da administração da justiça: O caso do ministério público do distrito federal e territórios.

Ceccato, F. (2023). *A digital transformation process from qlik to power bi in a fashion firm* [Master's thesis, Università Ca' Foscari Venezia]. http://hdl.handle.net/10579/23228

Dascalu, E. D., Marcu, N., & Hurjui, I. (2016). Performance management and monitoring of internal audit for the public sector in romania. *Amfiteatru Economic Journal*, *18*(43), 691–705.

Dingre, S. S. (2023). Internal controls in the etl process. *Journal of Artificial Intelligence & Cloud Computing*. https://api.semanticscholar.org/CorpusID:268164357

Dumas, M., Rosa, L. M., Mendling, J., & Reijers, A. H. (2018). *Fundamentals of business process management*. Springer.

Fioretto, S., & Masciari, E. (2024). A conceptual framework for predictive process monitoring in public administration. *International Conference on Complex, Intelligent, and Software Intensive Systems*, 423–431.

Gulledge Jr, T. R., & Sommer, R. A. (2002). Business process management: Public sector implications. *Business process management journal*, *8*(4), 364–376.

Matheus, R., Janssen, M., & Maheshwari, D. (2020). Data science empowering the public: Data-driven dashboards for transparent and accountable decision-making in smart cities. *Government Information Quarterly*, *37*(3), 101284. DOI: https://doi.org/10.1016/j.giq.2018.01.006.

Mix, G. (2016). *Best practices for local government business intelligence implementations* [Master's thesis, University of Oregon]. https://hdl.handle.net/1794/21966

Mohamed, N. A., & Kulmie, D. A. (2023). Role of effective monitoring and evaluation in promoting good governance in public institutions. *Public Administration Research*, *12*(2), 48.

Munné, R. (2016). Big data in the public sector. *New horizons for a data-driven economy: A roadmap for usage and exploitation of big Data in Europe*, 195–208.

Negash, S. (2004). Business intelligence. *Communications of the Association for Information Systems*, *13*. DOI: https://doi.org/10.17705/1CAIS.01315.

Qlik. (2025). *Qlik sense* [Data analytics and business intelligence software]. https://www.qlik.com/

Samad, S., & Setyabudhi, A. L. (2023). Design of dashboard administration of the public sector. *Engineering and Technology International Journal*, *5*(01), 71–80.

Sanabia-Lizarraga, K. G., Carballo-Mendívil, B., Arellano-González, A., & Bueno-Solano, A. (2024). Business intelligence for agricultural foreign trade: Design and application of power bi dashboard. *Sustainability*, *16*(21), 9576.

Sprenkamp, K., Zavolokina, L., Angst, M., & Dolata, M. (2023). Data-driven governance in crises: Topic modelling for the identification of refugee needs. *Proceedings of the 24th Annual International Conference on Digital Government Research*, 1–11.

TCE-PE. (2015). Resolução nº 22/2015: dispõe sobre a constituição do processo eletrônico no sistema e-TCEPE e dá outras providências [Consulta ao Art. 46]. https://atosoficiais.com.br/tcepe/resolucao-n-22-2015-dispoe-sobre-a-constituicao-do-processo-eletronico-no-sistema-e-tcepe-e-da-outras-providencias

TCE-PE. (2025a). Atribuições do tce. https://www.tcepe.tc.br/internet/index.php/atribuicoes-do-tce

TCE-PE. (2025b). Electronic process system. https://etce.tce.pe.gov.br/

TCE-PE. (2025c). Public consultation. https://etce.tce.pe.gov.br/epp/ConsultaPublica/listView.seam

Tregear, R., & Jenkins, T. (2007). Government process management: A review of key differences between the public and private sectors and their influence on the achievement of public sector process management. *BPTrends, October 2007*.

Venkateswarlu, M., & Vasista, T. (2023). Extraction, transformation and loading process in the cloud computing scenario. *International Journal of Engineering Applied Sciences and Technology*, *8*, 232–236.

Vila, R. A., Estevez, E., & Fillottrani, P. R. (2018). The design and use of dashboards for driving decision-making in the public sector. *Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance*, 382–388.

Widjaja, S., & Mauritsius, T. (2019). The development of performance dashboard visualization with power bi as platform. *Int. J. Mech. Eng. Technol*, *10*(5), 235–249.

Digital Transformation, Technology, and Innovation: Analysis of Mayoral Candidates' Proposals in the 2024 Brazilian Municipal Elections

Daniel S. Valotto[a*], *Beatriz* B. B. Lanza[b], *Thiago* J. T. Ávila[c]

[a] Programa de Pós-graduação em Administração, Universidade Federal do Paraná (UFPR), Paraná, Brasil. danielvaloto@gmail.com. ORCID: 0000-0001-6381-7809

[b] IDB, Inter-American Development Bank, Paraná, Brasil. beatrizlanza@gmail.com. ORCID: 0000-0001-6388-0429

[c] Fundação Getúlio Vargas -Escola de Administração de Empresas de São Paulo - Doutorado em Administração Pública e Governo. thiago.avila@fgv.edu.br. ORCID: 0000-0003-4042-2243

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. With the advent of the Knowledge Society, Digital Transformation, and Digital Government, Brazilians have increased their presence and use of digital and knowledge resources to meet their needs. Whether in Government, the Economy, or Citizenship, the digital, knowledge, and innovation era has brought significant challenges and opportunities to Brazil, especially for large Brazilian municipalities. In this context, this study aimed to identify the proposals for Digital Transformation, Technology, and Innovation from candidates in the 46 municipalities with populations exceeding 500,000 inhabitants who were best positioned in the voting intention polls for the 2024 municipal elections. Methodologically, a qualitative study was conducted using the technique of documentary analysis of secondary data, with government plans of the best-positioned candidates in electoral polls from the 46 selected municipalities as the primary source. A nine-step protocol was used to select proposals containing one of the 31 key terms employed. A total of 2,557 proposals from 142 candidates were identified, with 1,268 (49.59%) related to Digital Government, 658 (25.73%) to the Digital Economy, and 631 (24.68%) to Digital Citizenship. With an average of 17 proposals per candidate, the main thematic areas of the proposals were related to Digital Services, Health, Education, Business, and Public Management. The analyzed proposals provide an overview of candidates' priorities and can support the development of public policies that reflect a more strategic perception of the role of digital tools in municipal development, aligned with the demands of an increasingly digital society.

Keywords. Provide Digital Government, Electoral Proposals, Government Plans, Public Policies, Digital Transformation, Digital Society, Digital Economy.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.960

1. Introduction

In recent decades, innovation has gained momentum as a necessary response in public and private organizations driven by the accelerated pace of changes in the political, economic, and social environments (Farias & Porrúa, 2016). These innovations have been facilitating Digital Transformation (DT) in organizations by improving activities, processes, skills, and business models (Demirkan et al., 2016; Piccinini et al., 2015) through Information and Communication Technologies and Information Systems (Takahashi, 2000).

With the growth of DT in everyday life, the use of digital services is growing in the public and private sectors, generating positive and negative impacts on the culture, functioning of organizations, and their employees and users (Vial, 2019). Penmetsa and Bruque-Camara (2021) identified three central elements of a digital nation in the knowledge society: digital society, digital economy, and Digital Government.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

From a government perspective, it is understood that in a world of change, governments need to be proactive, considering that new problems require new responses and old challenges require reanalysis (OECD & EUROSTAT, 2018). Thus, innovation in the public sector needs to move from a sporadic activity to a systemic one, where governments can be ready and able to face current and future challenges (OECD, 2018b).

Gil-Garcia et al. (2018) state that information and information technologies have become ubiquitous in the public sector and it is very difficult to think of a public problem or government service that does not involve them in a substantial way. Thus, we can understand Digital Government as the "use of Information and Communication Technologies (ICTs) to provide public services, aiming at greater speed, transparency and citizen engagement" (Layne & Lee, 2001; Le Blanc, 2020; Teo et al., 2008; United Nations, 2020).

According to Weerakkody et al. (2011), a Digital Government can increase efficiency, transparency and offer better public services to citizens and businesses. It will also help to improve public trust in relation to the perception of corruption, increase faster access to government information, reduce administrative costs and increase accountability (Tonggiroh, 2017).

In this sense, the OECD established a set of six dimensions that guide the transition from a traditional/electronic government to a Digital Government: User-centered administration to user-driven administration; From access to information to open by default; From a government as a service provider to a government as a platform for co-creation of public value; From reactive to proactive in the development of public policies and provision of services; Centered on information for a data-driven public sector; From the digitalization of existing processes to digital by design (OECD, 2014).

In Brazil, although the first Digital Transformation Strategy was developed in 2018, it was only in 2021 that the country was able to have its first Digital Government and Public Efficiency Law, Law No. 14,129/2021, known as the Digital Government Law, which establishes principles, rules and instruments for Digital Government and for increasing public efficiency in Brazil (Brasil, 2021).

However, in a country of continental dimensions like Brazil, formed by 27 Federative Units (FUs) and 5,570 municipalities, the implementation of Digital Government strategies is observed in a disproportionate and fragmented manner. The division of power between the federal and subnational governments is established by the Federal Constitution, which defines the exclusive and shared powers of each entity. Thus, each subnational location has its own governments and legislative assemblies (Ávila et al., 2023a).

Therefore, the implementation of policies for a Digital Government does not depend only on federal initiatives, but also on initiatives from subnational governments. A groundbreaking survey helped characterize this Brazilian complexity, in 2023, Ávila et al. (2023b) carried out a broad survey of the proposals of the candidates for Governor of the 27 Brazilian FUs in the 2022 elections, in order to identify in the candidates' government plans, proposals that contemplated perspectives of Digital Transformation, Technology and Innovation. A total of 1,343 proposals from 85 candidates were identified, of which 46% referred to Digital Government, 27% to Digital Economy and 27% directed to Digital Citizenship (Ávila et al., 2023b).

This survey made it possible to identify a favourable agenda especially for the Digital Government theme, directing the positioning of the FUs towards a digital government as a state policy, inserted in the organizational structure of the government, where structural public policies are formulated and decisions on structuring issues of the State are made (Ávila et al., 2023a).

However, when observing the 5,570 Brazilian municipalities, the disparities in access to infrastructure and ICTs are more pronounced, highlighting inequalities between municipalities regarding the adoption of Digital Government, indicating the opportunity to observe at a more basic level how municipal governments position themselves on this issue.

Elections for mayors in Brazil take place every four years and determine the head of the Executive Branch of each municipality. Candidates are chosen through direct elections, in which the winner is the candidate who obtains the absolute majority of valid votes, in accordance with electoral legislation supervised by the Superior Electoral Court (TSE).

The last election for mayors in Brazil took place in October 2024, with 15,574 candidates for mayor. In this scenario, based on the same methodology used in the study conducted by Ávila et al. (2023b), the proposals adhering to the adoption of initiatives focused on digital government in Brazilian municipalities were mapped. Thus, this article aimed **to identify the proposals for Digital Transformation, Technology, and Innovation from mayoral candidates of the 26 state capitals and 20 other municipalities with a population exceeding 500,000 inhabitants, who are best positioned in the voting intention polls for the 2024 elections**.

2. Background

2.1 Science, Technology and Innovation as an Innovation mechanism in the subnational public sector

Science and technology have been increasingly generating value for people through innovative activities. In the digital realm, society has absorbed various innovations into everyday life, such as the adoption of digital applications for banking transactions, purchasing products and services, supporting urban mobility, and even accessing public services (Ávila, Lanza & Valotto, 2023b). Innovations can be understood as the successful exploitation of ideas through the interaction of actors, generating new knowledge and the development of new solutions or the improvement of existing ones (OECD/Eurostat, 2018; Schumpeter & Swedberg, 1942).

In this sense, we observe the rise of Digital Transformation (DT), defined by Demirkan, Spohrer & Welser (2016) as a "profound and accelerated transformation of activities, processes, competencies, and business models to fully leverage the changes and opportunities brought by digital technologies and their impact on society in a strategic and prioritized manner." DT encompasses the deep changes occurring in society, the economy, and governments through the modernization of governance, the management of digital technologies, and, with the growing presence of DT in daily life, the use of digital services increases in both public and private sectors. This generates both positive and negative impacts on culture, organizational functioning, and the experience of employees and users (Vial, 2019).

Within this context, countries worldwide are witnessing one of the most significant transformations in history, as governments and companies have come to heavily depend on the Internet and technology to minimize the disruption caused by lockdowns (Soto-Acosta, 2020).

In a virtuous cycle of how Digital Transformation can support the development of Science, Technology, and Innovation, Ávila, Lanza & Valotto (2023b) highlight advantages such as: increased capacity for data and information processing; improved collaboration and knowledge sharing; facilitation of decision-making; process automation; and access to new data sources.

In the knowledge society, Penmetsa & Bruque-Camara (2021) conducted a study to identify the key elements of a digital nation, composed of three core components: a digital society, a digital economy, and a digital government. These authors point out that nations worldwide are facing challenges in integrating and simplifying their digital infrastructure, identifying six major categories of challenges in literature: people, technology, institutions, policy, economy, and sustainability.

Addressing this issue specifically in the public sector, innovation has been gaining momentum as a necessary response driven by the accelerated pace of changes in political, economic, and social environments (Farias & Porrúa, 2016). However, the OECD (2018) notes that although innovation is present in the daily routine of the public sector, it mostly occurs in a reactive or opportunistic manner rather than strategically. Consequently, government organizations are increasingly falling behind the pace and direction of changes occurring outside the public sector.

Another relevant factor stems from the changes in citizen profiles and attitudes in recent decades. Demographic shifts, higher education levels, greater access to information, and the unlimited capacity to establish connections have combined to create a more informed citizen, more aware of their rights, more participative, and therefore more demanding (Farias & Porrúa, 2016). This new citizen and societal profile generate new and greater demands for public services and policies and stimulates innovation and digital transformation in the public sector (Edler & Georghiou, 2007).

In this regard, public sector innovation must involve the notion of Digital Government, understood as the Digital Transformation of the public sector (Penmetsa & Bruque-Camara, 2021). Since the early 2000s, nations have initiated their digital (or electronic) government policies and strategies, especially driven by the New Public Management movement. According to Weerakkody, El-Haddadeh & Al-Shafi (2011), a Digital Government can increase efficiency, transparency, and deliver better public services to citizens and businesses. It also helps improve public trust by reducing perceptions of corruption, providing faster access to government information, lowering administrative costs, and enhancing accountability (Tonggiroh, 2017).

In this direction, the evolution of Digital Government around the world can be tracked through key international indices such as the “Digital Government Index – DGI” (Ubaldi, González-Zapata & Barbieri, 2020) and the United Nations’ “E-Government Development Index – EGDI” (United Nations, 2020). These indices and related studies compare the development of Digital Government across countries. However, research on this topic at the subnational level remains an area in need of further development.

The difficulty lies in the fact that these indices do not consider the local context of cities within countries, since it

is unlikely that national governments, responsible for the well-being of an entire country, fully understand the needs of communities in the same way that local governments do (Shackleton, Fisher & Dawson, 2004). Therefore, it is important to monitor the progress and shortcomings of innovative Digital Government practices at the subnational level (Edison, Ali & Torkar, 2013), so that medium- and long-term strategies can be developed by policymakers (Taques et al., 2021). For this purpose, it is essential to use appropriate metrics that reflect the stage of development in Digital Transformation and innovation.

3. Methodological Procedures

This is an initial and descriptive study that aims to map and classify municipal electoral proposals related to digital transformation. The analysis provides a general overview of how candidates are addressing digitalization across different dimensions of the knowledge society, laying the groundwork for deeper future investigations. To achieve the proposed objective, a qualitative research study was conducted using the methodology of documentary analysis of secondary data, specifically government plans of mayoral candidates in the 2024 municipal elections in Brazil. Among the 5,570 Brazilian municipalities, this study considered those with a population of at least 500,000 inhabitants, according to the country's official 2022 census, in addition to the 26 state capitals, resulting in 46 municipalities. The methodological protocol was based on nine main steps:

1. Downloading the database of mayoral candidates with registered candidacies on the official platforms of the Superior Electoral Court (TSE) or Regional Electoral Courts (TREs) on August 15, 2024. In the databases, with more than 15,000 registered candidates, the names of the candidates, Federal Units, party numbers, and acronyms were collected.

2. Identifying registered electoral surveys on TSE or TRE platforms to detect candidates representing at least 70% of the voting intentions in stimulated surveys (when candidates' names are announced to respondents) from August 16 to August 20, 2024. This criterion resulted in the selection of the 134 best-positioned candidates in the 46 municipalities eligible for the study. The electoral surveys included in this analysis were collected from 18 distinct institutes: Datafolha, Datatempo, Exata-BR, Futura Inteligência, Futura/100% Cidades, Imape, IPESPE, Methodus, Prefab Future, Quaest, Serpes, Vox Brasil Opinião e Pesquisas, OVALE/ÁGILI Pesquisas, Paraná Pesquisas, Todo Dia/Agili, Radar Inteligência, Real Time Big Data, and Record TV.

3. Downloading the government plans of the 134 best-positioned mayoral candidates in the electoral surveys via the TSE's DivulgaCand platform. When government plans were unavailable or incomplete, they were supplemented through candidates' and parties' platforms or media channels.

4. Updating voting intentions on September 10, 2024, to ensure candidates representing 70% of voting intentions in recent electoral surveys were included, aiming to reflect any changes in candidate standings.

5. Extracting government proposals that included a predetermined set of 31 key terms (in both Portuguese and English), defined by the research team as representative of the digital era: g*overno digital, transformação digital, tecno*, digital, digitaliza*, LGPD, cidade* inteligente*, smart cit*, sistema, aplicativo, app, internet, conectividade, Wi-fi, 5G, portal, website, inclusão digital, central de atendimento, inteligência artificial, machine learning, IA, AI, automa*, laboratório, startup, inova*, transparência, integração de dados, carta* de serviço, dados abertos*. The selection of these terms was informed by a review of relevant literature and public policy documents. Proposals were identified through a systematic keyword search across all documents. To ensure consistency and reduce bias, the coding was first tested in a pilot analysis, and a second researcher reviewed a sample of the results for verification.

6. Reviewing the selected proposals involved assessing their feasibility within the 2025–2028 government cycle. Only those proposals containing action-oriented language—verbs in the infinitive, future present, or present continuous—were retained. Each proposal was manually reviewed and classified according to predefined thematic and dimensional categories. To strengthen analytical reliability, coders followed a shared protocol, and discrepancies were resolved through discussion. This iterative process helped refine the coding categories and ensured alignment with the research objectives.

7. Classifying the proposals into one of three dimensions: Digital Government, Digital Society, or Digital Economy.

8. Classifying the proposals into 23 thematic government areas driven by Digital Transformation, Technology, and Innovation: Agriculture, Control and Accountability, Human Rights, Education, Employability, Sports and Leisure, Public Management, Housing, Inclusion, Infrastructure, Innovation, Artificial Intelligence, Legislation, Mobility, Business, Digital Platform, Health, Public Security, Digital Services, Sustainability, Tourism and Culture, Urbanism,

and Maintenance.

9. Repeating steps 3 to 8 after the first round of municipal elections for seven candidates incorporated from the second round of the 2024 municipal elections, who were not included in the initial delimitations but achieved a sufficient percentage to contest the second round, adding 199 new proposals. all data were condensed into a database available online for consultation (Ávila, Lanza & Valotto, 2024)

This methodological process resulted in 2,557 proposals from 142 candidates. For data analysis, techniques of descriptive statistics and content analysis of the proposals were applied.

4. Results and Analysis

Initially, the 2,557 mapped proposals were categorized among the three dimensions of the knowledge society proposed by Penmetsa and Bruque-Camara (2021), resulting in 2,168 proposals (49.6%) focused on digital government, 658 proposals aimed at the digital economy and 631 proposals linked to digital citizenship. Fig. 1 illustrates the results.

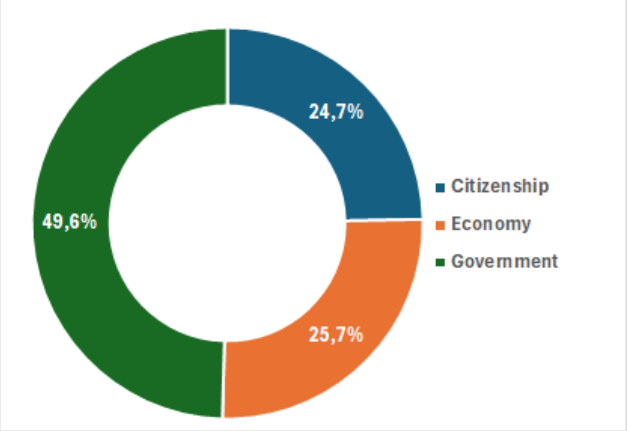


Fig. 1 – Distribution of proposals among the dimensions of the Knowledge Society.

The predominance of proposals focused on digital government indicates that candidates are placing emphasis on modernizing public administration, whether in internal processes or in the provision of public services to citizens. When analyzing the content of these proposals, it is possible to identify that a significant part of them revolve around topics such as digitalization of services, adoption of digital platforms, increased transparency, use or improvement of technological tools, improvement of public management, development of infrastructure, adoption of innovative solutions, among others.

As for the proposals aimed at the digital economy, there is a focus on the modernization and competitiveness of productive sectors through digital technologies. The focus is mainly on the digitalization of businesses through applications, development of technology hubs and parks, tax reductions for innovative businesses, social innovation programs and promotion of entrepreneurship. The main areas highlighted in this segmentation refer to tourism & culture, employability, digital services, innovative businesses such as startups, innovation ecosystems, sustainability and urban planning.

Regarding digital citizenship proposals, the proposals focus mainly on issues such as the implementation of free Wi-Fi access points, digital technological training and qualifications, social and digital inclusion among the elderly, modernization of social assistance, investments in telehealth, training and hiring of teachers, and digitalization of education. Among the priority areas identified in this dimension are mobility, health, education, public safety, infrastructure, and human rights.

The three dimensions were then cross-referenced with the proposals of each of the 46 municipalities included in the study. The distribution is shown in Table 1.

Tab. 1 - Distribution of dimensions by municipality

City	Government Proposals	Economy Proposals	Citizenship Proposals	Total Proposals
Aparecida de Goiânia	19	10	19	48

Aracaju	69	47	33	149
Belém	13	6	4	23
Belo Horizonte	24	14	8	46
Boa Vista	6	2	6	14
Campinas	29	11	4	44
Campo Grande	27	10	9	46
Contagem	10	5	4	19
Cuiabá	49	23	23	95
Curitiba	58	29	22	109
Duque de Caxias	20	8	26	54
Feira de Santana	11	18	8	37
Florianópolis	17	6	4	27
Fortaleza	34	16	18	68
Goiânia	26	11	21	58
Guarulhos	11	12	14	37
Jaboatão dos Guararapes	10	1	4	15
João Pessoa	22	17	34	73
Joinville	9	3	3	15
Juiz de Fora	5	2	1	8
Londrina	38	18	12	68
Macapá	22	10	13	45
Maceió	37	21	12	70
Manaus	48	19	21	88
Natal	42	21	17	80
Nova Iguaçu	11	1	5	17
Osasco	49	28	19	96
Palmas	33	44	20	97
Porto Alegre	14	12	9	35
Porto Velho	14	5	9	28
Recife	12	18	9	39
Ribeirão Preto	23	8	17	48
Rio Branco	15	20	10	45
Rio de Janeiro	14	17	20	51
Salvador	46	36	25	107
Santo André	41	15	18	74
São Bernardo do Campo	45	39	22	106
São Gonçalo	71	17	13	101
São José dos Campos	4	10	7	21
São Luís	7	4	1	12
São Paulo	65	14	22	101
Serra	62	7	21	90
Sorocaba	17	3	3	23
Teresina	19	6	9	34

Uberlândia	37	10	15	62
Vitória	13	4	17	34
Total	**1268**	**658**	**631**	**2557**

At least one proposal for this dimension was mapped in all locations. However, since the digital government dimension represents almost 50% of all mapped proposals, this category was also the most frequent among the municipalities, with a variation between 4 and 71 proposals, with an average of 28 proposals per municipality. The five municipalities with the highest number of proposals were: São Gonçalo (71); Aracaju (69); São Paulo (65); Serra (62); and Curitiba (58); On the other hand, the five municipalities with the fewest proposals in this dimension are: Joinville (9); São Luís (7); Boa Vista (6); Juiz de Fora (5); and São José dos Campos (4).

For proposals in the digital economy dimension, we observed a variation between 1 and 47 proposals, with an average of 14 proposals per municipality. The five cities with the most proposals in this category were: Aracaju (47); Palmas (44); São Bernardo do Campo (39); Salvador (36); and Curitiba (29); On the other hand, the six cities with the fewest proposals were: Sorocaba (3); Joinville (3); Boa Vista (2); Juiz de Fora (2); Jaboatão dos Guararapes (1); and Nova Iguaçu (1).

Finally, in the digital citizenship dimension, the proposals varied between 1 and 34, with an average of 14 proposals per city, as well as in the digital economy dimension. The five cities with the most identified proposals were: João Pessoa (34); Aracaju (33); Duque de Caxias (26); Salvador (25); Cuiabá (23); On the other hand, the nine cities with the fewest identified proposals were: Belém (4); Campinas (4); Contagem (4); Florianópolis (4); Jaboatão dos Guararapes (4); Joinville (3); Sorocaba (3); Juiz de Fora (1); São Luís (1).

The next analysis only looked at the number of proposals mapped by city. In this analysis, the ranking of municipalities was established by the total number of proposals and not by the Average Candidate Proposals, since the criterion considered was the greatest possible variety of proposals in a single municipality. Tab. 2 shows the distribution of the 10 municipalities with the largest number of proposals identified.

Tab. 2 – Top 10 municipalities by total proposals

FU	Municipality	Total Proposals	Candidates analysed	Average Candidate Proposals	Rank
SE	Aracaju	149	4	37	1
PR	Curitiba	109	5	22	2
BA	Salvador	107	2	53	3
SP	São Bernardo do Campo	106	4	26	4
RJ	São Gonçalo	101	2	50	5
SP	São Paulo	101	5	20	5
TO	Palmas	97	3	32	7
SP	Osasco	96	3	32	8
MT	Cuiabá	95	3	32	9
ES	Serra	90	3	30	10

The top 10 cities varied between 90 and 149 proposals. In order to deepen the analysis regarding the main themes addressed in these proposals, the frequency of the 23 thematic government areas driven by Digital Transformation, Technology, and Innovation was analyzed, focusing on the top five municipalities with the most mapped proposals.

Aracaju was the municipality with the largest number of identified proposals (149), being the city with the greatest amplitude among the others placed. The main thematic areas of these proposals are “Digital Services”, “Public Management”, “Business”, “Digital Platform” and “Employability”. In second place, Curitiba received 109 coded proposals, mainly on the topics of “Digital Services”, “Employability”, “Business”, “Public Security” and “Digital Platform”. The third municipality with the most mapped proposals was Salvador (107), with a predominance in the areas of “Employability”, “Digital Services”, “Business”, “Digital Platform” and “Education”.

São Bernardo do Campo appears in fourth place with 107 identified proposals, with a predominance of the topics

"Employability", "Business", "Health", "Sustainability" and "Mobility". The fifth place with the largest amount of mapped proposals were the municipalities of São Gonçalo and São Paulo, both with 101 proposals. While in São Gonçalo the predominant themes were "Health", "Business", "Digital Services", "Public Management" and "Mobility", in São Paulo the main themes of the proposals were "Health", "Business", "Digital Services", "Public Management" and "Mobility".

The 23 thematic government areas driven by Digital Transformation, Technology, and Innovation were then analyzed, now considering all 46 municipalities participating in the study, in order to identify the most frequent in each thematic area. The results are presented in Tab. 3.

Tab. 3 – Categorization of proposals into 23 thematic areas

Areas	Proposals	Share	Rank	Top municipality with most proposals in the area
Digital Services	276	10,8%	1	Aracaju (22)
Health	258	10,1%	2	Serra (16)
Education	232	9,1%	3	Duque de Caxias (16)
Business	211	8,3%	4	Palmas (21)
Public Management	209	8,2%	5	Aracaju (18)
Employability	192	7,5%	6	Aracaju (16)
Digital Platform	179	7,0%	7	Aracaju (16)
Mobility	171	6,7%	8	Manaus (11)
Sustainability	164	6,4%	9	Osasco (13)
Infrastructure	158	6,2%	10	Serra (11)
Public Safety	112	4,4%	11	Curitiba (9)
Innovation	92	3,6%	12	Rio de Janeiro; São Bernardo do Campo; São Gonçalo; Uberlândia (6)
Tourism and Culture	66	2,6%	13	Curitiba (8)
Inclusion	53	2,1%	14	Goiania (5)
Control and Accountability	52	2,0%	15	Natal (6)
Legislation	32	1,3%	16	Londrina (7)
Human Rights	31	1,2%	17	São Gonçalo (4)
Artificial Intelligence	25	1,0%	18	Curitiba; Fortaleza; Natal; Salvador; Santo André; São Paulo (2)
Urban Planning	23	0,9%	19	Palmas (3)
Janitorial	9	0,4%	20	Fortaleza; São Bernardo do Campo (2)
Sports and Leisure	6	0,2%	21	Salvador (2)
Agriculture	3	0,1%	22	Rio Branco (2)
Housing	3	0,1%	22	Palmas (2)
Total	**2557**	**100,0%**	**-**	**-**

Among the 23 areas covered, the theme "Digital Services" was the most frequent, with 276 proposals (10.8%). The proposals identified in this area mainly deal with digital management models integrated into online technology platforms or applications, implementation of digital systems in various spheres, use of online scheduling, development or improvement of digital portals for public services, investment in technological infrastructure to increase agility in the use of public services and adoption of virtual service methods. In second place, the theme "Health" was categorized into 258 proposals (10.1%), with proposals focusing on actions such as implementation or advancement in telehealth, Electronic Medical Records, development of an application or website to streamline care, online scheduling of appointments and exams, implementation of electronic panels, interoperability of information between services for appointments and exams, patient history and modernization of diagnostic and treatment equipment in health units.

The theme "Education" was the one with the third largest coding in the study, with 232 proposals (9.1%). The

proposals were mainly directed at modernizing computer lab equipment in schools, digital literacy initiatives, adoption of new information and communication technologies, access to innovative technologies and methodologies for teachers and students, implementation of virtual learning environments, cataloging, digitization and availability of school collections, expanding access to the internet in schools and digital training for teachers.

Regarding the themes with the fewest codifications in the study, we highlight "Agriculture" and "Housing", both with 3 codifications (0.1%). The proposals for "Agriculture" were related to the implementation of a land information portal, the establishment of a municipal agricultural calendar aligned with production chains, and investment in agricultural technology and rural extension with the aim of modernizing the sector. The proposals related to "Housing" were aimed at stimulating innovative projects that expand the supply of housing, the creation of a digital system for monitoring and evaluating housing policies, and the development of new technologies and methodologies that can be applied to housing policies.

Table 2 also allows us to analyze the municipalities with the most proposals in each thematic area. A total of 19 municipalities were identified, distributed across the 23 areas analyzed. Of these, 9 municipalities appear more than once. Aracaju has the highest frequencies in four areas: "Digital Services", "Public Management", "Employability" and "Digital Platform"; Palmas leads in three areas: "Business", "Urban Planning" and "Housing"; Curitiba is ahead in three: "Public Safety", "Inclusion" and "Artificial Intelligence"; Serra is in first place in two areas: "Health" and "Infrastructure"; Natal also appears ahead in two areas: "Control and Accountability" and "Artificial Intelligence"; São Gonçalo leads in two areas: "Innovation" and "Human Rights"; Fortaleza appears with the largest number of proposals in two areas: "Artificial Intelligence" and "Caretaking"; Salvador leads in two areas: "Artificial Intelligence" and "Sports and Leisure"; and São Bernardo do Campo is ahead in two areas: "Innovation" and "Caretaking".

The next analysis sought to focus specifically on the content of the collected proposals, analyzing the 31 key terms used to select the proposals that adhered to the objective of this study. Each proposal could contain more than one key term, thus, 4,626 key term encodings were applied. Fig. 2 presents a word cloud sizing the most recurrent terms in the proposals.

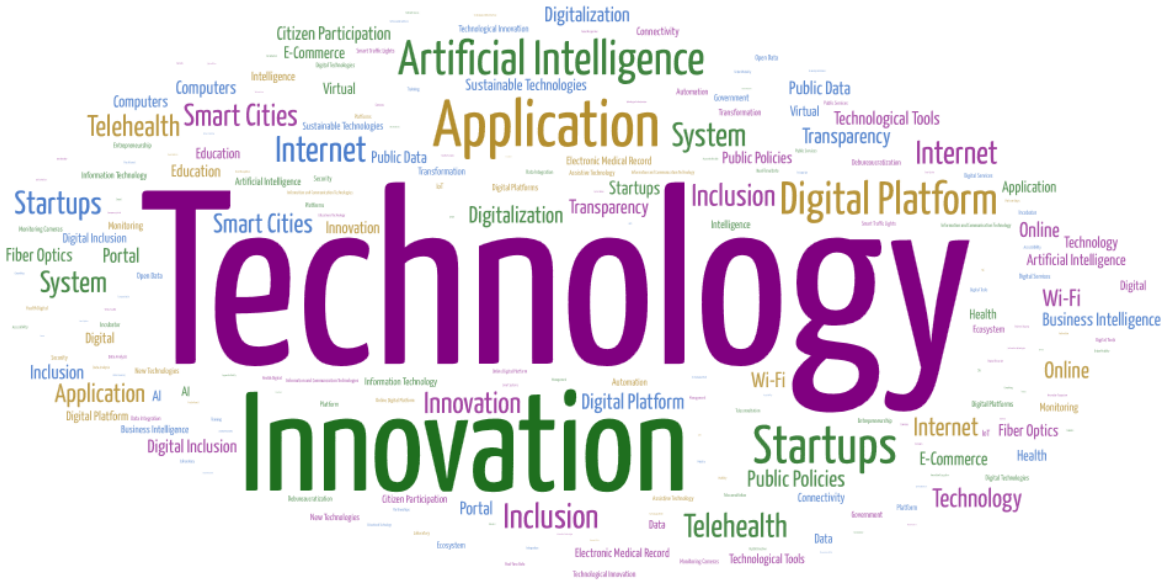


Fig. 2 – Key terms categorized in the proposals.

Fig. 2 shows that the term "Technology" was the most frequent, with 650 mentions. Next, the most recurrent terms were Innovation (371), "App" (175), "Startups" (142), "Artificial Intelligence" (129), "Digital Platform" (122), "Internet" (97), "Inclusion" (93), "System" (89) and "Telehealth" (88). Tab. 4 presents some real proposals that represent each of these terms.

Tab. 4 – Top 10 most frequent terms in proposals and examples

Key term	Original Proposal	Candidate	Municipality
Technology	"Promote the adoption of sustainable construction technologies and practices, with tax incentives for projects that use renewable energy, water	Eduardo Siqueira	Palmas

	reuse and ecological materials."	Campos	
	"Explore new technologies and international best practices to improve the efficiency of security operations and reduce costs, including the use of drones for patrolling and monitoring hard-to-reach areas."	Cristina Graeml	Curitiba
Innovation	"Explore new technologies and international best practices to improve the efficiency of security operations and reduce costs, including the use of drones for patrolling and monitoring hard-to-reach areas"	Anivaldo Luiz da Silva	Maceió
	"Establish, within the scope of the Municipal Executive Branch, the Fortaleza Technological Innovation Fund – FIT, with the objective of fostering technological innovation in the city, encouraging local companies to invest in scientific, technological and innovation research projects, with a view to developing new business models, economically sustainable and with respect for sustainability."	Wagner Sousa Gomes	Fortaleza
App	"Create a digital Labor Office (virtual platform with a mobile App), linked to the City Hall's digital office, to share information about ongoing projects, news about deliberations of the Municipal Labor Council and data on public funds, as well as make job opportunities available in the city to serve the unemployed and those looking for their first job"	Tarcísio Motta	Rio de Janeiro
	"Create an app factory (partnership between IMA and universities) and develop a community delivery platform and app ("iCamp"), which humanizes the work of app delivery drivers and other service providers"	Pedro Tourinho	Campinas
Startups	To facilitate a bank of innovative projects for public management, whether through competitions, qualification of professionals, or by promoting space for technical and academic students to develop their course completion work, aiming at a possible modernization of local public services, as well as being the stimulus for the creation of accelerator/incubator companies – Recruitment of startups.	Emilia Correa	Aracaju
	"Make a Public Center for Creative Economy viable, to attract, develop and disseminate initiatives in this sector with startup business hub incubators."	Marcelo Lima	São Bernardo Do Campo
Artificial Intelligence	"Launch a security application with artificial intelligence to monitor and protect women at risk, including a virtual panic button that facilitates immediate contact with the Municipal Guard."	Leonardo Barreto de Moraes	Porto Velho
	"Real-time monitoring of traffic and road conditions: Use high-definition cameras and artificial intelligence to coordinate rapid action and improve traffic."	Silvio Mendes	Teresina
Digital Platform	"We will modernize public services with the implementation of the E-CG Platform, which will integrate several online services into a single Platform"	Adriane Lopes	Campo Grande
	"Create the digital Platform for Urban Environmental Care, where citizens are registered on the Platform and rewarded through "Osascoin" for tasks within their home space."	Gerson Pessoa	Osasco
Internet	"Consolidate and expand the implementation of free internet access throughout the city (parks, squares, public buildings and public areas)"	Carlito Merss	Joinville
	"Promote free internet to all elementary school students in the municipal public school system to ensure technological education and digital inclusion"	Juliana Brizola	Porto Alegre
Inclusion	"Create Jovem Tech, a technology training program for low-income young people, with Technical Education and Technological Education modalities."	Tabata Amaral	São Paulo
	"Democratize access to technology and promote digital inclusion in the Municipal Public Education Network, using digital tools and resources to improve the quality of education and prepare students for the challenges of the 21st century."	Eder Mauro Cardoso Barra	Belém
System	"Implement Geospatialized System to promote the adequate management of urban space and promote the monitoring of public policies;"	Aline Paranhos Gurgel	Macapá
	"Implementation of Intelligent System: Develop and implement an intelligent system for monitoring, tracking and managing solid waste, using	Amom Mandel	Manaus

	technologies such as IoT (Internet of Things), big data and artificial intelligence."		
Telehealth	"Create the "Talk to Me Health" Project, which is a Telehealth service for teleconsulting, teleeducation and telediagnosis in priority areas, with an emphasis on primary health care. This project will be developed in partnership with higher education institutions that have a Telehealth center."	Janad Valcari	Palmas
	"Increase investments in Health with electronic medical records, implementation of electronic password panels in UBS, teleconsultations and improvement of information sharing between services for consultations and exams"	Marília Aparecida Campos	Contagem

When analyzing the top 10 key terms, as well as the respective examples of proposals, some intersections of areas can be observed, such as the use of digital technologies and innovations aimed at security (use of drones and artificial intelligence) or for education or inclusion initiatives, such as application development, training programs or provision of free internet.

It is also possible to establish an integration of solutions, such as apps and digital platforms for transparency, integration and digitalization of services. Another relevant aspect is the promotion of innovation and entrepreneurship through startups and innovation ecosystems that encourage technological development and modernization of public services.

Thus, it is clear that the proposals address a complementarity of themes, suggesting for example that digitalization (with terms such as "Digital Platform", "App" and "Internet") can serve as a basis for other innovation initiatives in areas such as education, health, mobility and public safety. It is also observed that the initiatives are not presented in isolation, where technology is seen as a driver for local development.

5. Conclusions

This study aimed to identify the proposals for Digital Transformation, Technology, and Innovation from mayoral candidates of the 26 state capitals and 20 other municipalities with a population exceeding 500,000 inhabitants, who are best positioned in the voting intention polls for the 2024 elections. The results indicated a predominance of proposals aimed at the digital government dimension (almost 50% of the total) at the municipal level, in line with the study by Ávila, Lanza & Valotto (2023b) who, when analyzing the same criteria in the elections of candidates for Governor in the 2022 election, identified 46% of the proposals also aimed at digital government.

This similarity demonstrates a tendency of governors at the subnational level in Brazil to modernize internal processes and the provision of public services through digitalization. The results also indicate a growing attention to digital transformation as a tool to boost the competitiveness of productive sectors and promote social inclusion. The analysis of the 23 thematic areas highlights a more targeted focus on "Digital Services", "Health" and "Education", while the main keywords ("Technology", "Innovation", "App", "Startups" and "Artificial Intelligence") point to the search for solutions that use technology as a basis for initiatives that complement each other, strengthening everything from public safety, education, health, employability, to digital training and innovation in the business sector.

When looking specifically at the municipalities, some cities stand out for the number of proposals and also for the diversity of areas addressed. However, it is important to emphasize that when looking at the proposals broadly, different strategies and priorities are revealed, which vary according to the context and local demands. The sharp economic differences in specific regions of Brazil can present an important barrier that limits the possibilities of innovation and adoption of technologies to advance the digitalization of services and advance digital government equally in the country.

This research has some limitations: (1) The data extraction was conducted from the perspective of the three researchers. A review of the government plans by other researchers might result in a different identification of the set of proposals. (2) Possible changes in candidate standings in electoral polls published after September 10, 2024, were not considered. (3) Some proposals from candidates who were not among the best-positioned may not have been considered. (4) Proposals that did not use any of the key terms adopted in the research were not considered.

Future research could deepen the qualitative analysis of the proposals' content, evaluating their level of innovation, feasibility, and alignment with existing public policies. It would also be relevant to investigate the territorial impact of the proposals, considering regional disparities in access to and priorities for digital transformation. Another

possibility is to analyze the relationship between candidates' profiles and the types of proposals presented, as well as to study how these proposals influence the electorate or are incorporated into government plans after the elections. Future research could also explore more qualitative dimensions of the 5,557 mapped proposals by, for instance, examining their applicability and tracking the implementation efforts of elected candidates. Moreover, subsequent studies may develop indicators to assess the effectiveness of policies in digital government, digital economy, and digital citizenship, thereby enabling a comprehensive evaluation of urban evolution within the context of digital transformation.

References

Ávila, T. J. T., Lanza, B. B. B., & Valotto, D. S. (2024). Base de Dados Sobre as Propostas dos(as) Candidatos(as) a Prefeito(a) das 26 Capitais dos Estados e 20 Outros Municípios com População Maior que 500.000 Habitantes para a Transformação Digital, Tecnologia a Inovação. https://doi.org/10.13140/RG.2.2.33829.41448

Ávila, T. J. T., Lanza, B. B. B., & Valotto, D. S. (2023a). Digital Transformation, Technology and Innovation in Brazilian States: The Pathways Proposed by Governors Elect 2023-2026. In *Proceedings of the 16th International Conference on Theory and Practice of Electronic Governance (ICEGOV 2023)* (pp. 8). ACM. https://doi.org/10.1145/3614321.3614366

Ávila, T. J. T., Lanza, B. B. B., & Valotto, D. S. (2023b). *Transformação Digital, Tecnologia e Inovação nos estados Brasileiros: os caminhos propostos para o período de 2023-2026*. Curitiba: RAGA Internacional.

Brasil. (2021). Lei nº 14.129, de 29 de março de 2021. Dispõe sobre princípios, regras e instrumentos para o Governo Digital e para o aumento da eficiência pública. *Diário Oficial da União: Seção 1*, Brasília, DF, 30 mar. 2021.

Demirkan, H., Spohrer, J., & Welser, J. (2016). Digital Innovation and Strategic Transformation. *IT Professional*, 18(6), 14–18.
Edison, H., Ali, N., & Torkar, R. (2013, maio 1). *Towards innovation measurement in the software industry*. Journal of Systems and Software, 86, 1390–1407.

Farias, P., & Porrúa, M. (2016). O novo protagonismo do cidadão na gestão pública. In *Governos que Servem - Inovações que estão melhorando a prestação de serviços aos cidadãos* (p. 116). Washington, D.C.: Banco Interamericano de Desenvolvimento.

Gil-Garcia, J. R., Dawes, S. S., & Pardo, T. A. (2018). Digital government and public management research: Finding the crossroads. *Public Management Review*, 20(5), 633–646. https://doi.org/10.1080/14719037.2017.1327181

Layne, K., & Lee, J. (2001). Developing fully functional E-government: A four stage model. *Government Information Quarterly*, 18(2), 122–136. https://doi.org/10.1016/S0740-624X(01)00066-1

Le Blanc, D. (2020). E-participation: A Quick Overview of Recent Qualitative Trends. *UN Department of Economic and Social Affairs (DESA)* Working Papers.

OECD. (2014). *OECD Recommendation on Digital Government Strategies*. Organisation for Economic Co-operation and Development.

OECD. (2018b). *O sistema de inovação do serviço público do Brasil - conclusões preliminares*. Escola Nacional de Administração Pública (Enap).

OECD; EUROSTAT. (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation (4th ed.)*. OECD Publishing. https://doi.org/10.1787/9789264304604-en

Penmetsa, M. K., & Bruque-Camara, S. (2021). A framework for building a sustainable digital nation: Essential elements and challenges. *Digital Policy, Regulation and Governance*, 23(3), 262–286.

Piccinini, E., Hanelt, A., Gregory, R. W., & Kolbe, L. M. (2015). Transforming Industrial Business: The Impact of Digital Transformation on Automotive Organizations. In Pro*ceedings of the 36th International Conference on Information Systems (ICIS 2015)*.

Shackleton, P., Fisher, J., & Dawson, L. (2004). *Evolution of local government e-services: The applicability of e-business maturity models*. In Proceedings of the 37th Annual Hawaii International Conference on System Sciences (IEEE Computer Society).

Schumpeter, J. A., & Swedberg, R. (1942). *Capitalism, socialism and democracy*. London: Routledge.

Soto-Acosta, P. (2020). *COVID-19 pandemic: Shifting digital transformation to a high-speed gear*. Information Systems Management, 37(4), 260–266.

Takahashi, T. (Org.). (2000). *Sociedade da informação no Brasil: Livro verde*. Ministério da Ciência e Tecnologia (MCT).

Taques, F. H., et al. (2021). *Indicators used to measure service innovation and manufacturing innovation*. Journal of Innovation & Knowledge, 6(1), 11–26.

Teo, T. S. H., Srivastava, S. C., & Jiang, L. (2008). Trust and Electronic Government Success: An Empirical Study. *Journal of Management Information Systems*, 25(3), 99–132. https://doi.org/10.2753/MIS0742-1222250303

Tonggiroh, M. (2017). Digital Government services in Papua. In *2017 Second International Conference on Informatics and Computing (ICIC). IEEE*. https://doi.org/10.1109/IAC.2017.8280656

Ubaldi, B., González-Zapata, F., & Barbieri, M. P. (2019). *Digital government index: 2019 results*. OECD

United Nations. (2020). 2020 *United Nations E-Government Survey*.

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, 28(2), 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

Weerakkody, V., El-Haddadeh, R., & Al-Shafi, S. (2011). Exploring the complexities of e-government implementation and diffusion in a developing country: Some lessons from the State of Qatar. *Journal of Enterprise Information Management*, 24(2), 172–196. https://doi.org/10.1108/17410391111106293

Government Data Science Teams: A Framework for Implementing Strategic Monitoring Solutions

Hugo Augusto Vasconcelos Medeiros [a *], *André Leite Wanderley* [b], *Diogo de Carvalho Bezerra* [c], *Carlos Alberto Gomes de Amorim Filho* [d], *Rafael Zimmerle da Nóbrega* [e], *Felipe Gustavo de Moraes Ferreira* [f].

[a] Secretaria Estadual de Planejamento de Pernambuco, Governo de Pernambuco, Recife, Pernambuco, Brasil, and Programa de Pós-graduação Profissional em Políticas Públicas, Universidade Federal de Pernambuco, Recife, Pernambuco, Brasil, hugoavmedeiros@gmail.com, 0000-0001-6249-0920.

[b] Secretaria Estadual de Projetos Estratégicos, Governo de Pernambuco, Recife, Pernambuco, Brasil, and Departamento de Estatística, Universidade Federal de Pernambuco, Recife, Pernambuco, Brasil, andre.leite@sepe.pe.gov.br, 0000-0002-4718-9766.

[c] Secretaria Estadual de Mobilidade e Infraestrutura, Governo de Pernambuco, Recife, Pernambuco, Brasil, and Núcleo de Gestão, Universidade Federal de Pernambuco, Caruaru, Pernambuco, Brasil, diogo.bezerra@semobi.pe.gov.br, 0000-0002-1216-8674.

[d] Secretaria Estadual de Projetos Estratégicos, Governo de Pernambuco, Recife, Pernambuco, Brasil, and Departamento de Economia, Universidade Federal de Pernambuco, Recife, Pernambuco, Brasil, carlos.agaf@gmail.com, 0000-0001-6315-8305.

[e] Secretaria Estadual de Projetos Estratégicos, Governo de Pernambuco, Recife, Pernambuco, Brasil, and Programa de Pós-graduação em Estatística, Universidade Federal de Pernambuco, Recife, Pernambuco, rafael.zimmerle@ufpe.br, 0009-0003-0800-9042.

[f] Secretaria Estadual de Projetos Estratégicos, Governo de Pernambuco, Recife, Pernambuco, Brasil, felipeferreira.govpe@gmail.com, 0009-0004-3086-849X.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025
Policy paper, DOI: https://doi.org/10.59490/dgo.2025.925

Abstract. This paper presents a framework developed by Pernambuco's Strategic Monitoring Data Science Team to design and implement data-driven solutions for monitoring public policies. Using an action research methodology, the study integrates data science, iterative development, and stakeholder engagement. Despite being major producers and consumers of data, governments still face significant challenges in applying data science for policy monitoring, including data quality issues, legal constraints, and institutional silos. Existing frameworks such as CRISP-DM, Scrum, and Kanban are either too technical or primarily focused on software development rather than the policy-driven decision-making required in government settings. The Strategic Monitoring Team was established within Pernambuco's Secretariat of Strategic Projects, comprising a Chief Data Scientist as team leader, a Project Manager, three Data Scientists specializing in modeling, engineering, and visualization, and a Trainee. The team operates through an iterative five-step process: Diagnose, which involves meetings with stakeholders to identify policy issues; Plan, where internal discussions define solutions; Act, which includes the development of dashboards, reports, and applications; Evaluate, to review whether the solutions address policy needs; and learn, focusing on documenting findings and improving tools. To enhance their workflow, the team adapted Scrum methodology by incorporating policy research alongside software development, tracking projects via Notion, and deploying solutions using R and Shiny Proxy. The study highlights that traditional frameworks such as Scrum and CRISP-DM require adaptations to effectively integrate research aspects and government governance structures. By bridging data insights with decision-making processes, the team successfully balances software development, policy research, and institutional needs. The findings emphasize the necessity of specialized data science frameworks tailored for government applications, ensuring a structured yet flexible approach to strategic policy monitoring through data-driven solutions.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Keywords. Government Data Science, Strategic Policy Monitoring, Agile Frameworks for Public Sector.

1. Introduction

This paper aims to report the construction of the framework used by Pernambuco's Strategic Monitoring Data Science Team (SMT) to develop and implement data solutions to monitor strategic public policies. The structure of the paper follows a variation of the proposition in Young and Quinn (2002), with introduction, methodology, results, and conclusion.

The introduction discusses the problem situation and the available alternatives and describes the Pernambuco's Strategic Monitoring Data Science Team. The methodology presents the problem statement, the method and the materials used by the team to create the solution. The results present the framework itself, and the products created by the team. The conclusion summarizes main points into recommendations for those who want no use the framework, discusses limitations and suggests follow-up steps.

1.1 The Problem

First, we must address the question concerning terminology and concepts. Analyzing the question, Saltz and Grady (2017) emphasize the absence of concepts and terms to describe data science and its process, team roles, etc. Aho et al (2021) indicates that there is also a confusion between data science and related concepts (like big data, data science, analytics, machine learning, artificial intelligence, etc.) due to a shared space. Provost and Fawcett (2013) emphasize that these other concepts tend to have a clearer connection with daily practice, resulting, many times, in a confusion between data science and its materials (like big data) or goals (like data-driven decision making).

One good summary of the question is offered by Brady (2019): big data and data science have different meanings but are frequently related to a new volume of data that comes with new methods, new questions, new ethical issues and societal change. Specifically, the author says that Data Science comprehends any process of gathering, representing, preparing, transforming, exploring, modeling, visualizing or presenting data, either using big or small data. Thus, even if big data and data science are different aspects, whit their own elements, the practical use and discussion about any type of data, especially in government, needs to be done along with the debate of data science, since the last governs the use of first to generate value.

Although Data Science is already producing societal changes and increasingly being used as an important tool for business and science (Klievink et al, 2016), according to Nielsen, Persson and Madsen (2019), there are still some barriers to a more complete implementation, which we can classify as technical barriers (like quality, storage and availability) and management barriers (like culture, perception and training).

The government is still starting to utilize data to make better decisions, improve efficiency or better understand social demands to solve public problems. This is a relevant issue, since in the landscape of data, governments are a major player in terms of owning and distributing data, and changes in public sector use of data have the potential to generate even greater impact (Filgueiras and Lui, 2023; Giest, 2017; Nielsen, Persson and Madsen, 2019).

When we think about public sector, all previous barriers also apply and we can add some others like data and information silos (Scott and Gong, 2021), lack of study reports (Nielsen, Persson and Madsen, 2019) and legislation about the use *per si* (Giest, 2017), and more compelling concerns about ethics, fairness and equality, which generates uncertainties and holds back a more complete use (Klievink et al, 2017).

One key element to promote and institute data science as a value approach is the construction of data science teams. Kim et al (2016) states that data scientists are an emerging role on traditional software development teams, but other authors like Aho et al (2021) contribute to show that data science teams multidisciplinary with data scientists coming from different backgrounds, with a recent trend to train data scientists on specific skills.

Both lines agree that, whilst there are some homogeneous aspects like experimentation and iterative development, the practical use of data science presents a large variation in variables like team composition, organization, roles and size; position in organization (internal / external); management framework and process; use of big or small data; project scope (from simply organizing data to advanced uses of machine learning).

Another common ground is that education and lack of definition about roles in data science teams are a key component. Saltz and Grady (2017) argue that in this context the formation of a data science team is still an issue, since it is difficult not only to train people, but to attribute team roles and to create team framework. Considering

the Brazilian case, De Toni and Dorneles (2022) say that the efforts to train public servants on data science is still recent and that there is a large variability on the use. Kim et al (2016) reinforces that, in many situations, unlike traditional development teams, Data Science teams focus more on skills than on roles and static attributions.

However, another relevant point, however, is that, even with different backgrounds and skill sets on Data Science Teams, the available frameworks are still focused or emerge from software engineering backgrounds, resulting on a lack of orientations regarding other Data Science tasks, such as research and study reports.

This scenario of low definition, high variability, and few specific studies on government data science teams leads to a problem-situation in which government data science teams need to create their own framework, comprehending team roles, scope of projects and development process, expanding the available ones to include missing parts, like research and study reports.

1.2 Alternatives

Saltz and Grady (2017) produced an interesting cross section study about different cases of frameworks for data science team organization, skills and roles, compared with the types of data scientists job positions on dice.com. The findings showed that the main roles are researcher, scientist, architect, analyst, programmer and engineer.

Expanding the first study, Saltz and Hotz (2020) conducted a new survey-based study, this time focused on projects frameworks. They found out that CRISP-DM was still the most used, reaching 49% of the respondents, followed by scrum (18%), kanban (12%), TDSP (4%) and SEMMA (1%). Customized frameworks (12%), others (3%) and none (2%) were also mentioned.

Resuming the two studies, we may say that: (i) available project frameworks focus more on methods / steps (CRISP-DM, TDSP, SEMMA) or governance / coordination (Scrum, Agile, Kanban) (i) the main framework, CRISP-DM was built in the late 1990s, before some of the actual technologies were even available; and (iii) of the organization frameworks only EDISON focused on researches data scientists.

Considering that available frameworks (i) comprehend only the methods or the management, (ii) are not suited for government, (iii) don't address the role of research on data science projects and teams, and that (iv) is common that data science teams feel the need to develop their own frameworks because of the range of skills, tasks and data need to develop their projects, after the research for alternatives, we reinforced our belief on needing to develop our own framework.

1.3 Problem Statement

The problem statement was done using the How Might We? – HWE (Brown, 2020) to produce a statement capable of solving and opened enough to allow innovative solutions: How might we create a data science framework comprehending team roles, scope of projects and development process, to increase the efficiency of data projects for strategic monitoring?

1.4 The Strategic Monitoring Team

The Strategic Monitoring is a Data Science Team focused on creating data solutions to extract value from data, In Pernambuco State (a Brazilian subnational government), the team is a Sub-secretariat of the State Secretariat of Strategic Projects, responsible for the implementation and monitoring of strategic public investments.

The team is composed of five public servants and one trainee, who gives support for different activities. Three members are data scientists that divide the tasks according to project thematic; one member is the project manager; and the other is the chief data scientist, also occupying the position of sub-secretary of strategic monitoring. Except for the project manager, who has a strong background in business and government, the members have strong academic backgrounds, with three PhDs.

Different tasks are performed according to specific project needs, but the main are data engineering and wrangling, exploratory data analysis, data modeling to predict and classify, DataViz, optimization to create prescription alternatives, construction of study reports, dashboards and presentations. In some cases, the team also develops data input software.

The team uses R as its main technology. R is used to tasks from data engineering to data modelling, and to create the templates used to develop apps with shiny framework, and study reports in .pdf or .html or presentations using reveal.js through quarto framework. The deploy is done using shiny proxy, which offers better load balance, routing and access control.

It is important no say that, since the team is responsible for strategic monitoring, the portfolio construction and project selection criteria is mainly top-down. The team receives demands from the secretary of strategic projects, the secretary of mobility and infrastructure or directly from the center of government.

The figure resumes the team's organization and tasks.

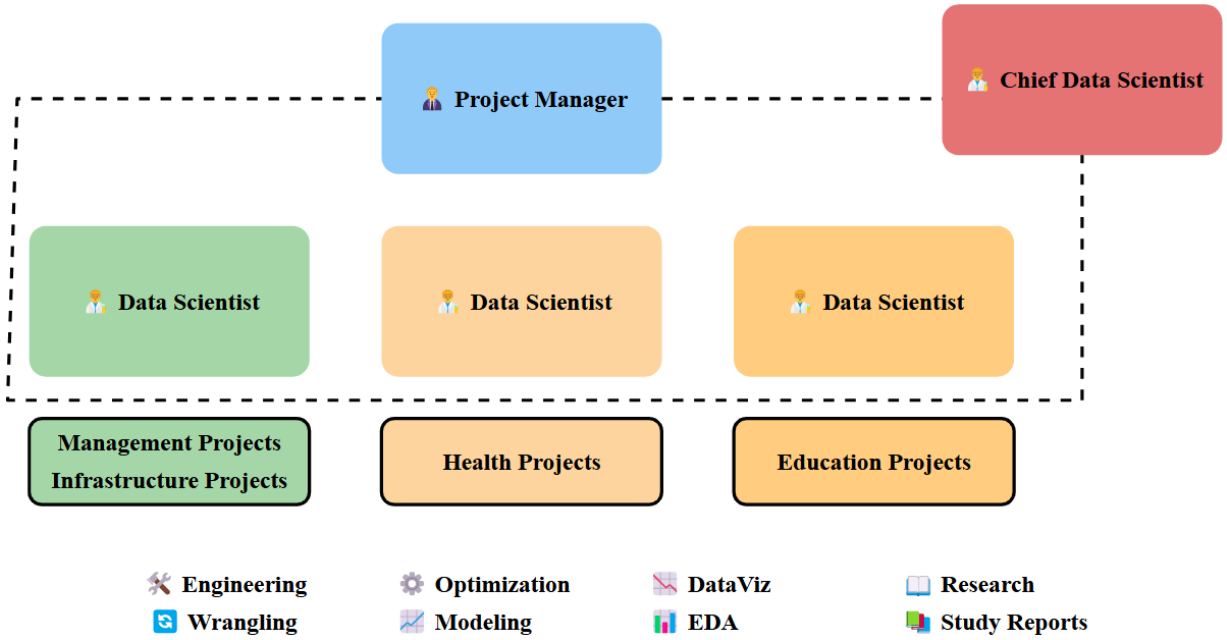


Fig 1 – Strategic Monitoring Team.

2. Methodology

2.1 Method

The Strategic Monitoring Team framework was created considering the literature of alternatives to manage data science team, the analysis of the team's empirical practice and the elements (artifacts, ceremonies and products) of scrum (Schwaber and Sutherland, 2020), using action research methodology as the conductor. The results are the framework design and details, a table comparing the artifacts, ceremonies and products of scrum with those used by the team, and a summary of the data products build so far. The discussion resumes the alternatives limitations to government data science teams and the learned lessons from the Strategic Monitoring Team.

For example, during the development of one of the products, the app Hortensias, it was always important to focus on problem-solving and practitioners' involvement, but also to document the innovation process and the software development. So, the leading methodology used was action research, which can be defined as a cycle process of diagnosis, plan, act, evaluate and document to improve practice or solve a problem, combining acting and inquiring about it (Tripp, 2005).

As argument by Ollila and Yström (2020), action research is an important method to conduct innovations because it is more capable to get practitioners involved, which tends to approximate solutions and problems, while generating richer insights and more significant knowledge.

Some authors as Saarikallio and Tyrväinen (2022) and Natarajan and Pichai (2024) have achieved success on utilizing action research to inquire about agile software development process, since the cycle nature of agile has an adequate fit to also cycle perspective of action research. But Action Research can offer contributions to Data Science Teams because it has a more robust approach to dealing with the research aspects of Data Science tasks.

Regarding data science specific techniques, the data engineering process uses the extract, transform and load – ETL framework (Kimball, and Ross, 2013), storing the final data with proper dimensions and metrics in a corporate GreenPlum distribution; the monitoring process uses exploratory analysis statistics and data visualization such as time series, key performance indicators, and data summaries (Tukey, 1980; Wickham, and Wickham, 2016; Staniak, and Biecek, 2019). Finally, in some cases the team uses machine learning and optimization techniques.

Thus, our methodology uses action research to review team roles, artifacts and ceremonies, considering integrating

research.

2.2 Materials

The team uses materials to perform its action research cycle the notion platform with a custom workspace, divided in:

- **Projects**. Page with data and information linked to current projects, including backlog, reunions, project chartet, etc.
- **Reunions**. Page with data and information linked to reunions, with focus on calendar, tasks and follow-up taks.
- **Notes**. Page with annotation and miscelania information that is note directly linked to any of the other pages.
- **Cerimonies**. Page with description of the cerimonies adopted by the team.
- **Databases**. Page with the databases used on other pages.

Other relevant material is the team landpage, called box (https://box.pe.gov.br/), in honor of George E. P. Box. The landpage concentrates the products developed by the team, offering a summary, a point of access and the link to the team repository on github, which has the codes and proof of concepts (POC) of all products.

3. Results

3.1 Action Research Cycle

Following literature indications, we created our own action research cycle, adapted to our DS team routines. But, before the cycle enters operation, it is necessary that a project be presented by the secretary or prospected by the team, and the project charter being written in general lines.

- **Step 1 – Diagnose**. Meetings with practitioners that live and understand the problem context, the pain points and the reasons why their occurs. The meetings were translated into high level requirements and follow-up tasks using notion. After the meeting, the team also concudcts research tasks (simple literature revision and bechmarking) to get a more general understand of the problem and to prospect what are the possible solutions or best practices. The meetings usualy take 2h to 3h, and is scheduled by the team's project manager.
- **Step 2 – Plan**. Meetings with the DS team to define discuss research findings, to define products design and features, to estimate time and to build the backlog. Notion is used to register and monitor tasks.
- **Step 3 – Act**. Hands-on, effectively developing the products based on the diagnoses and the research findings. The development is done using the templates available on the team package called vialactea. At this moment, the data scientist have individual daily meetings with the chief data scientist and the project manager.
- **Step 4 – Evalute**. Meetings with the same practitioners in step 1 with the goal to evaluate if the producuts solve the pain points. This steps gets a little confused with step 1, in the sense that practitioners tend to address new pain points continuasly as the previsou are solved. Once the project is deployed and delivered, it enters on a continuous process of strategic monitoring, being used in decision-making. At this point, the evauation is incorpored in monitoring reunions.
- **Step 5 – Learn**. Document the findings and lessons during the DS team meetings. Github repo is updated and the main lessons go to the R package vialactea to become default features in further projects and to be back implemented in previous solutions. Also, the products are deployed and their information is made available in the team landapge. This is a team moment, lead by the chief data scientist and the project manager.

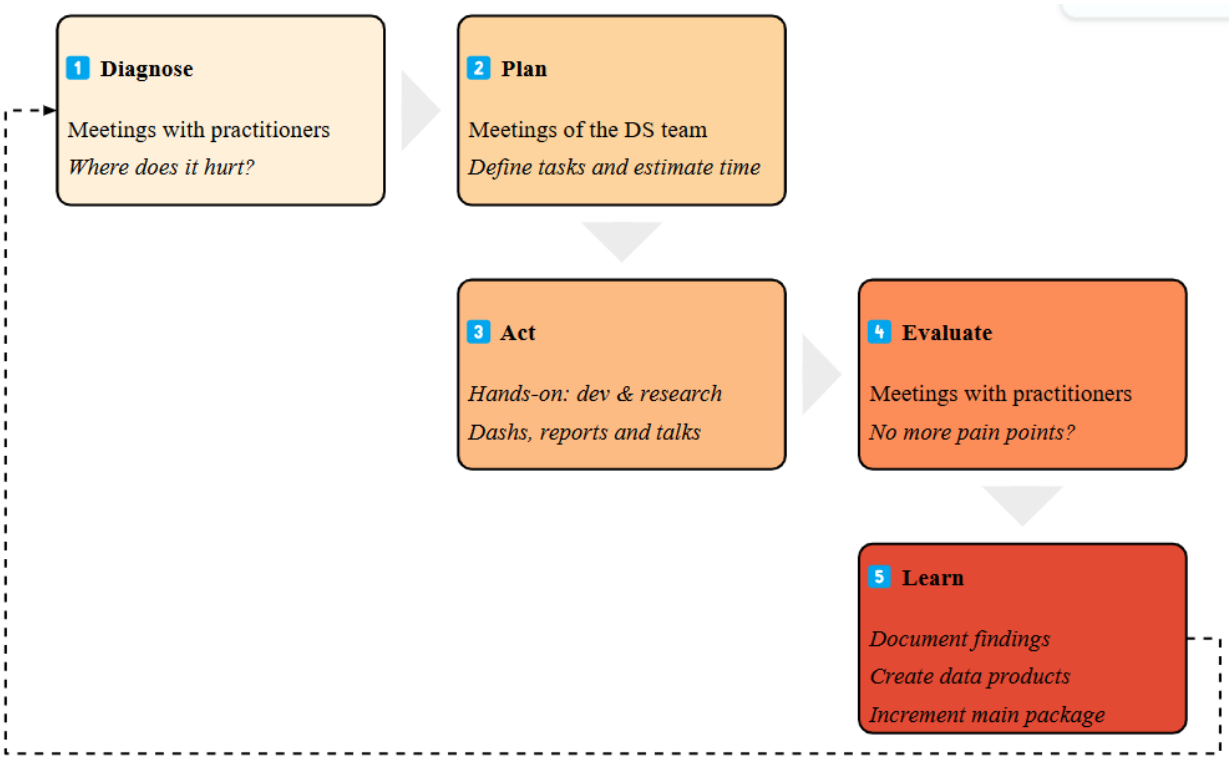


Fig 2 – Summary of the DS Team Action Research Cycle.

3.2 Artifacts, ceremonies and roles

Project management is done using a variation of scrum, in which the project manager acts as scrum master, and the data scientists act like product owners and development team. As POs, data scientists are responsible for interactions with demandant practitioners and business teams, and also for performing academic research to better perform data tasks. The chief data scientist deals with administrative demands but also as leader developer, being responsible for establishing the software developing standards, study report guides and research methods.

Thinking about the artifacts and the ceremonies, we may say that product backlog and sprint backlog are used, as also product increment. These artifacts are adapted to be used not only for software products, but also for research products, resulting, in this case in shorter backlogs with topics to be explored. The team has a weekly sprint, with planning and revision meetings occurring on the same day. Retrospective meetings are done once per month for software, and, for research, when the first summary of findings is done and when the presentation and report are done.

The following table compares scrum elements and the ones used by the team, detaching with * those that do not exist on Scrum.

Tab. 1 – Comparison of artifacts, ceremonies and roles on scrum and on Strategic Monitoring Team.

ELEMENT TYPE	SCRUM	STRATEGIC MONITORING TEAM
ARTIFACT	Product Backlog, Sprint Backlog, Product Increment	Used in software and research products
CEREMONIES	Backlog Refinement, Planning and Revision	Weekly in the same day
CEREMONIES	Daily	The same
CEREMONIES	Retrospective	Once per month
ROLE	Scrum Master	Project Manager
ROLE	Product Owner	Data Scientist
ROLE	Team member	Data Scientist and Chief Data

		Scientist
ROLE	Administration*	Chief Data Scientist

3.3 Products

The team products are divided into two main different axes: software products (apps, chatbot and packages) and research products (presentations and study reports).

Apps. Data Science Softwares that offer dynamic dashboards to interacte with data and automate analytics tasks like prediction and optimization. The apps have acces control and collect usage statistics. Some exemples are: (i) *Amparo*, an app to monitor highways construnction, focused on data engineering of 4 different data silos and dataviz; and (ii) *Hortensias*, an app to monitor public spendings, that also has a heavy use of data engineering and dataviz, but also focus on more complex tasks such as spending predictions and budget optimization.

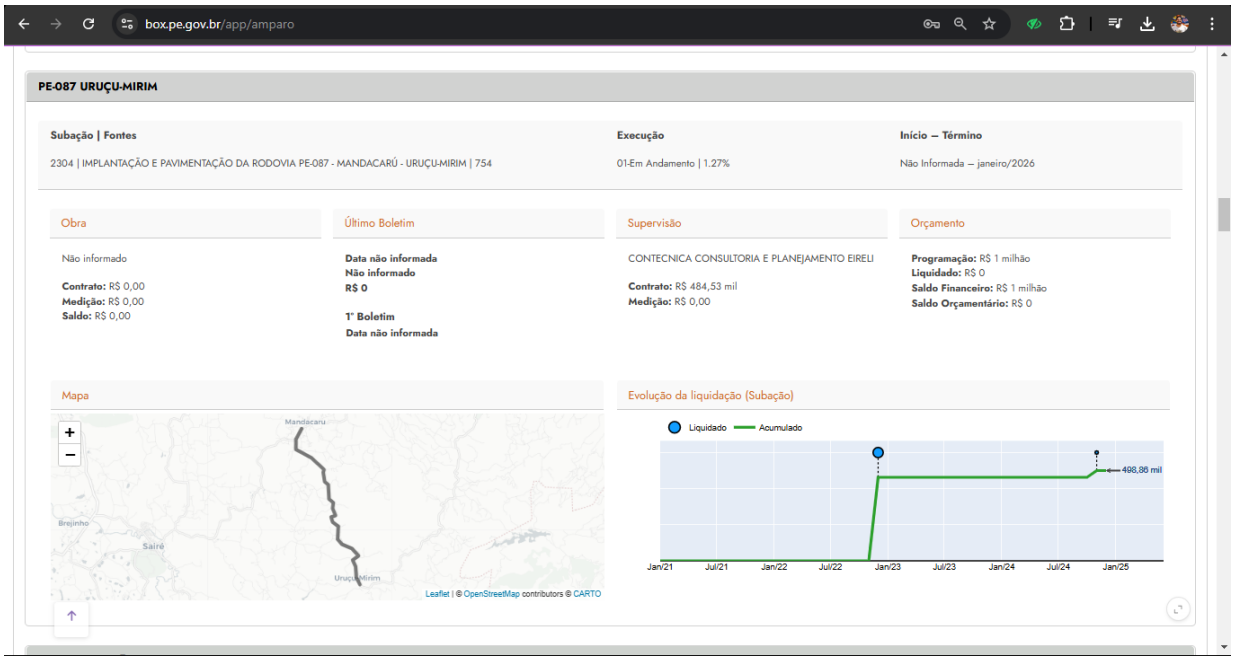


Fig 3 – Amparo App.

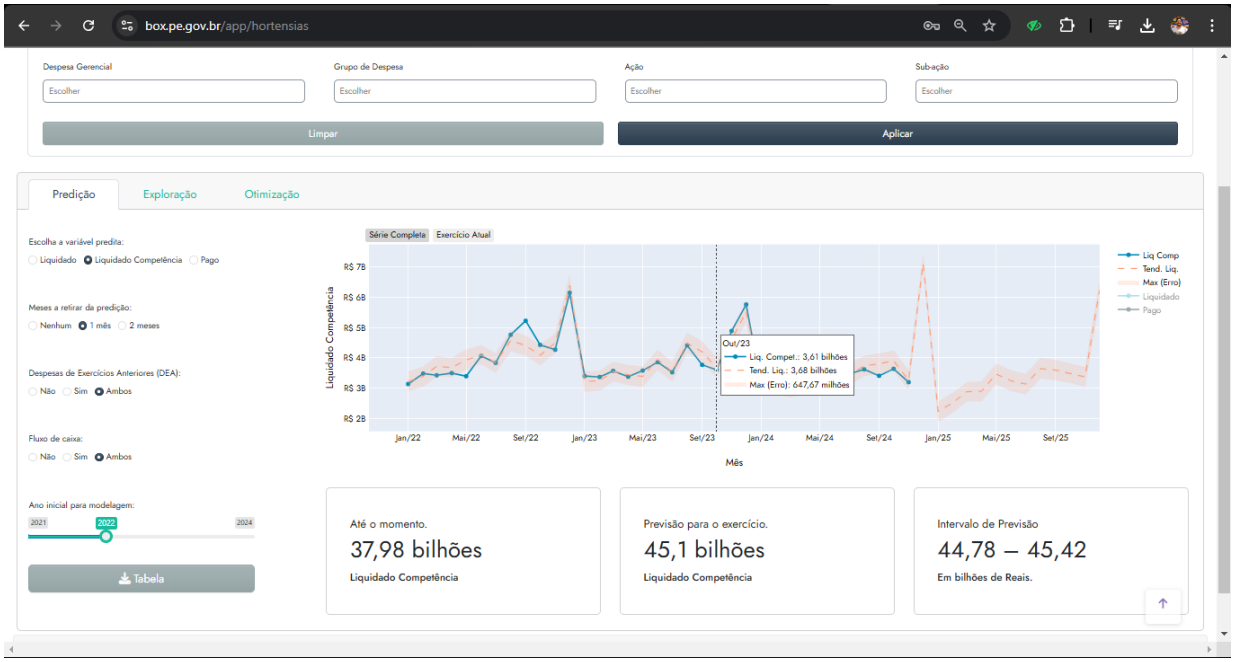


Fig 4 – Hortensia App.

Argos. Argos is our WhatsApp chatbot that offers just in time information to strategic users via text messages. Currently, Argos is capable of reading most of the databases used on apps and has commands to summarize and present data in text format.

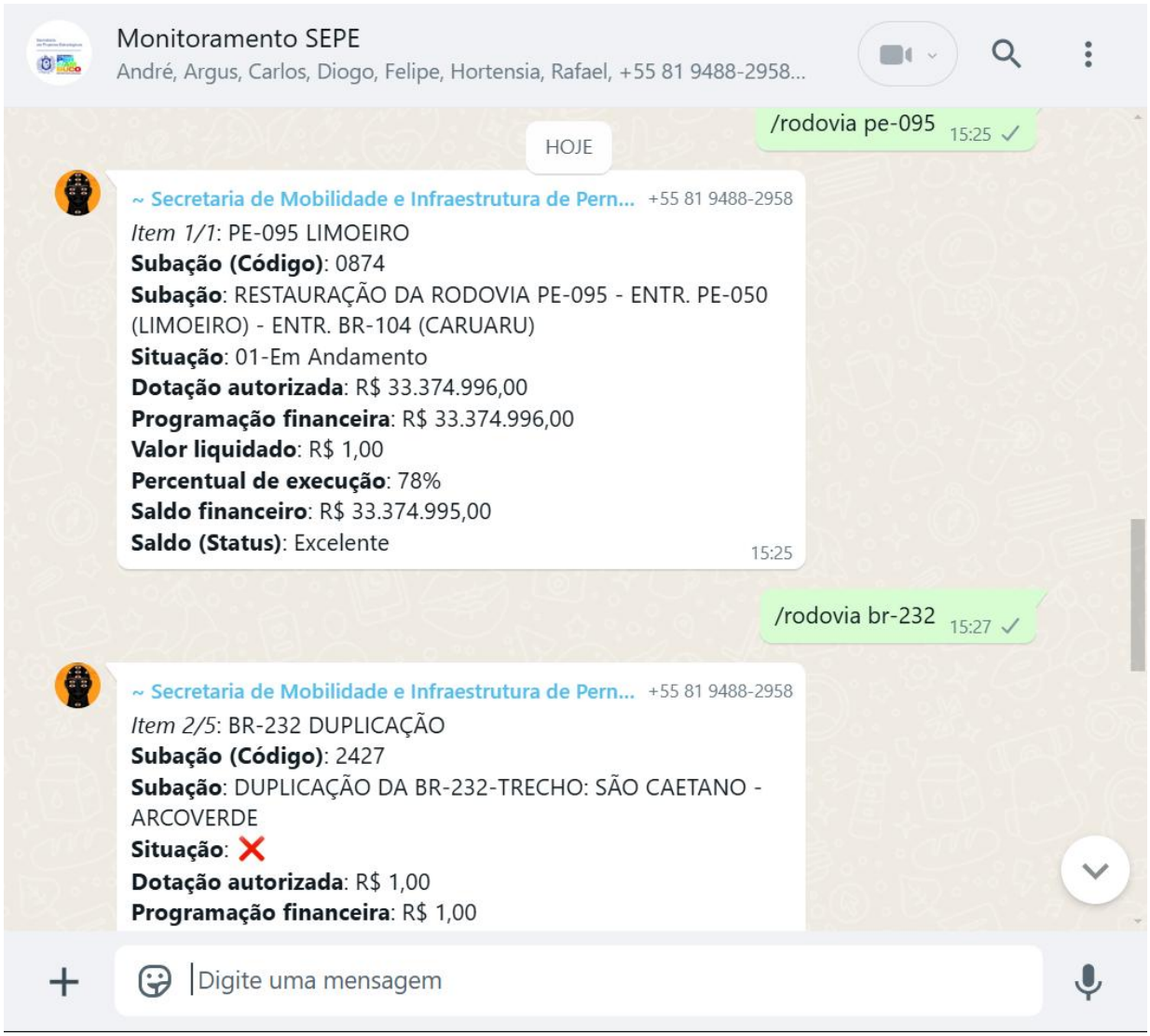


Fig 5 – Argos chatbot.

Packages. When the data science team creates solutions that may be used in other contexts, they are delivered in the form of a R package. The example is the BigDataPE an R package that provides a secure and intuitive way to access datasets from the BigDataPE platform.

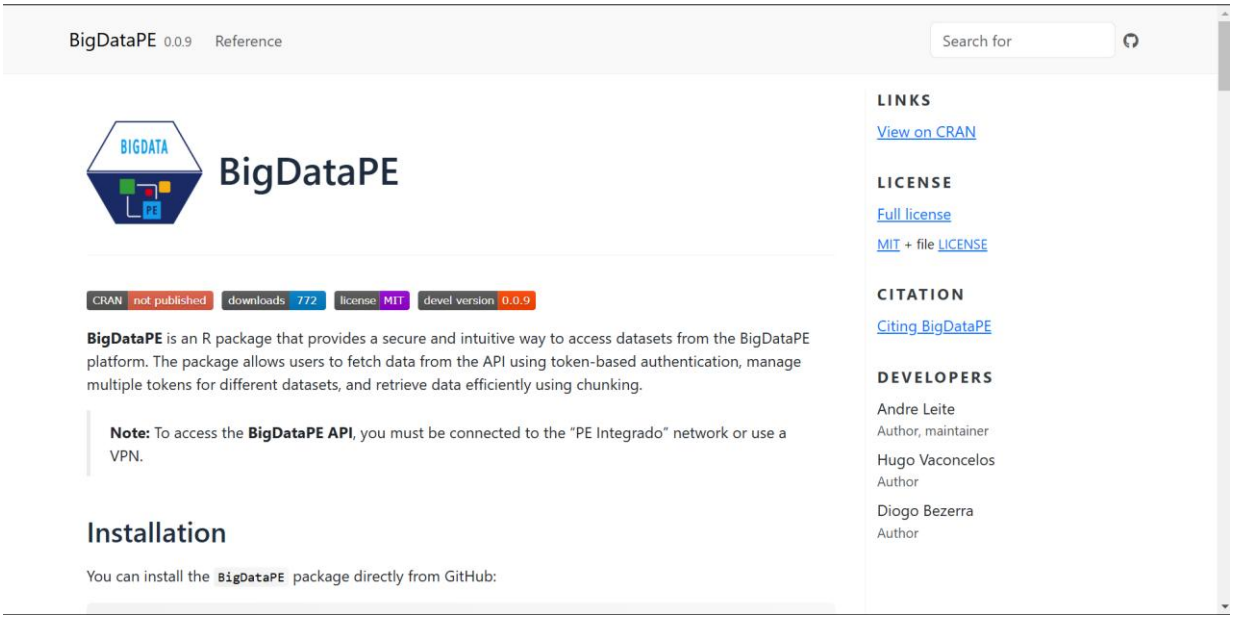


Fig 6 – Maternity study report.

Presentations. Data Science presentations based on research and data analysis. Less dynamic but with defined storytelling. One example is REDIPE presentation, which focuses on present the research and benchmarking of alternatives to manager data of public investments.

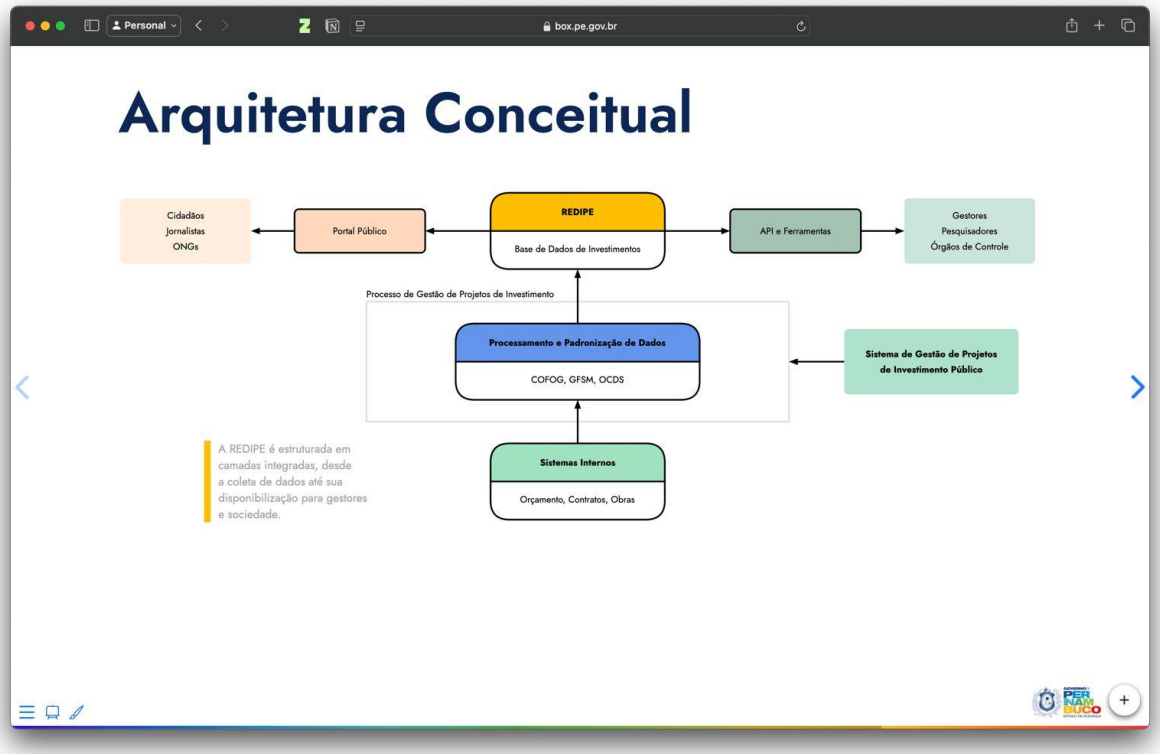
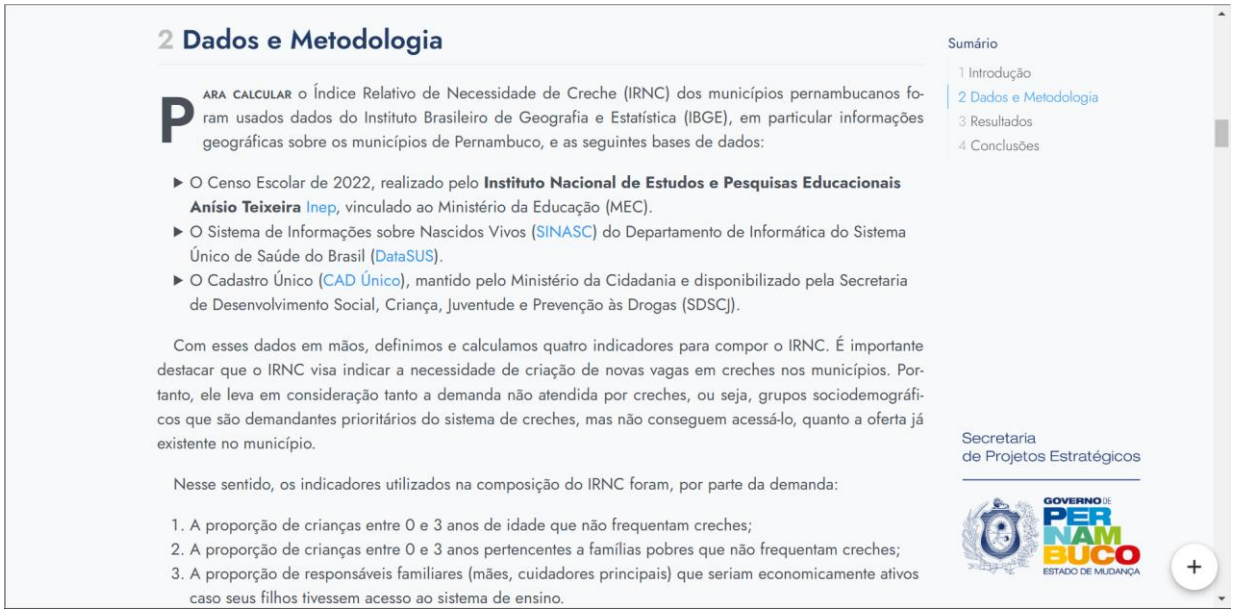


Fig 7 – REDIPE presentation.

Study Reports. Data science study reports based on research and data analysis. Less dynamic and with defined storytelling like the presentations. The description is denser and aimed at detailing all research aspects and data analysis. An example is maternity location analysis, which focuses on present the research and data analysis of early childhood education.



2 Dados e Metodologia

Para calcular o Índice Relativo de Necessidade de Creche (IRNC) dos municípios pernambucanos foram usados dados do Instituto Brasileiro de Geografia e Estatística (IBGE), em particular informações geográficas sobre os municípios de Pernambuco, e as seguintes bases de dados:

- O Censo Escolar de 2022, realizado pelo **Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira** Inep, vinculado ao Ministério da Educação (MEC).
- O Sistema de Informações sobre Nascidos Vivos (SINASC) do Departamento de Informática do Sistema Único de Saúde do Brasil (DataSUS).
- O Cadastro Único (CAD Único), mantido pelo Ministério da Cidadania e disponibilizado pela Secretaria de Desenvolvimento Social, Criança, Juventude e Prevenção às Drogas (SDSCJ).

Com esses dados em mãos, definimos e calculamos quatro indicadores para compor o IRNC. É importante destacar que o IRNC visa indicar a necessidade de criação de novas vagas em creches nos municípios. Portanto, ele leva em consideração tanto a demanda não atendida por creches, ou seja, grupos sociodemográficos que são demandantes prioritários do sistema de creches, mas não conseguem acessá-lo, quanto a oferta já existente no município.

Nesse sentido, os indicadores utilizados na composição do IRNC foram, por parte da demanda:

1. A proporção de crianças entre 0 e 3 anos de idade que não frequentam creches;
2. A proporção de crianças entre 0 e 3 anos pertencentes a famílias pobres que não frequentam creches;
3. A proporção de responsáveis familiares (mães, cuidadores principais) que seriam economicamente ativos caso seus filhos tivessem acesso ao sistema de ensino.

Sumário

1 Introdução
2 Dados e Metodologia
3 Resultados
4 Conclusões

Secretaria de Projetos Estratégicos

GOVERNO DE PERNAMBUCO ESTADO DE MUDANÇA

Fig 8 – Maternity study report.

4. Conclusion

The first point to address is that, as highlighted in the literature about data science teams, data science is a broad and complex field, deeply connected to other disciplines in science, technology, and innovation. During our research, we found no specific frameworks that fully aligned with our team's primary goal: creating data-driven monitoring solutions. Existing frameworks were either too generic—such as Scrum and Kanban—or too focused on technical data science workflows, often neglecting the research phase and the structured development of necessary products. This gap led us to develop our own tailored framework.

Action research proved to be a highly effective methodological approach for customizing our artifacts, ceremonies, and roles, as it integrates both the research and iterative development aspects of data science, providing structured guidance for inquiry and reflection on practice. This dual focus allows for continuous adaptation and improvement, making it particularly well-suited for governmental contexts, where rigid bureaucratic structures often clash with the need for flexibility and responsiveness.

One relevant limitation of such approaches as action research is the selection and confirmation bias, because the researches are very close to the problems they are investigating. Thus, adaptations of the framework must consider this limitation, and procced an adaptation to the context of each organization, since aspects like regulation, time size, governance, and number and resistance of data-silos vary from institution to institution.

Also, the adaptations of traditional agile framework are necessary due to public sector constraints, like a more rigid organizational structure, strong hierarchization and segmentation of activities, as well as severe restrictions regarding resource availability and staff training. One of the most challenging points is to balance the roles, since in original Scrum framework the Scrum Master and the Product Owner have framed activities and responsibilities, which need to be done by the development team. For this to work, it was very important to have a senior team, and to focus every data scientist on a theme portfolio. Nevertheless, those aspects have been experienced in other similar implementations in Brazil, as documented by different authors, like Vacari (2015), Rosa and Pereira (2021), and Guimarães et al (2025).

All things considered, and beyond the specific needs of our team, we believe that our framework addresses fundamental challenges faced by government data science teams. These include the difficulty of coordinating traditional hierarchical structures with matrix management approaches, as well as the broader struggle to balance agility with institutional requirements. Our framework offers a foundation upon which public sector organizations can customize agile elements while ensuring alignment with governance protocols.

When considering the public sector, additional challenges further complicate the implementation of data-driven approaches. Issues such as data and information silos, the scarcity of comprehensive study reports, and legal constraints regarding data usage create structural barriers to effective data science initiatives. Furthermore, ethical concerns related to fairness, transparency, and equality add layers of complexity, fostering uncertainties that can hinder the full adoption of data-driven methodologies. Addressing these barriers will require not only

technical solutions but also institutional and regulatory adaptations to create an environment where data science can thrive in the public sector.

At the moment we don't have a method to evaluate impact of the solutions regarding efficiency, efficacy, influence in decision-making or comprehension about social problems. Nevertheless, we understand that this is a general limitation of evaluating the impact of monitoring and business intelligence solutions.

As a continuous agenda, with more products being created, we aim to develop mechanisms for systematically collecting organic and structured feedback, ensuring a deeper understanding of user needs and experiences. Another pending issue is the transformation of our landing page into a more informative and user-friendly platform, enhancing transparency and accessibility. Finally, we recognize the need for a sustainable workflow for technological retrofitting, enabling the incorporation of lessons learned from previous projects into future iterations. These steps will contribute to the long-term sustainability and effectiveness of our data-driven monitoring solutions in the public sector.

References

Aho, T., Kilamo, T., Lwakatare, L. E., & Yaman, S. (2021). *Managing and composing teams in data science: An empirical study*. *In 2021 IEEE International Conference on Big Data* (Big Data). IEEE. https://doi.org/10.1109/BigData52589.2021.9671737.

Brady, H. E. (2019). *The challenge of big data and data science*. *Annual Review of Political Science*, 22(1), 297-323. https://doi.org/10.1146/annurev-polisci-090216-022929.

Brown, T. (2020). *Design thinking: Uma metodologia poderosa para decretar o fim das velhas ideias*. Elsevier.

De Toni, J., & Dorneles, R. (Orgs.). (2022). *Ciência de dados em políticas públicas: Uma experiência de formação* (Colaboração de N. Koga, H. Macedo & A. Pereira). Enap. https://repositorio.enap.gov.br/handle/1/7472.

Filgueiras, F., & Lui, L. (2023). Designing data governance in Brazil: An institutional analysis. *Policy Design and Practice*, 6(1), 41-56. https://doi.org/10.1080/25741292.2022.2065065.

Giest, S. 2017. "Big Data for Policymaking: Fad or FastTrack?" *Policy Sciences* 50 (3): 367–382. doi:10.1007/s11077-017-9293-1.

Guimarães, L. S., Toledo, G. L., Rodrigues, K. C. D. G., & Silva, P. N. (2025). Práticas ágeis no setor público: Estrutura de governança do Acordo de Reparação de Brumadinho à luz do framework Scrum. *P2P & Inovação*, 11(2), 1–28. https://revista.ibict.br/p2p/article/view/6847.

Kim, M., Zimmermann, T., DeLine, R., & Begel, A. (2016). The emerging role of data scientists on software development teams. In *2016 IEEE/ACM 38th International Conference on Software Engineering (ICSE)* (pp. 96-107). IEEE. https://doi.org/10.1145/2884781.2884783.

Kimball, R.; Ross, M. (2013). *The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling*. Indianapolis: Wiley.

Klievink, B., Romijn, B.-J., Cunningham, S., & de Bruijn, H. (2017). Big data in the public sector: Uncertainties and readiness. *Information Systems Frontiers*, 19(2), 267–283. https://doi.org/10.1007/s10796-016-9686-2.

Natarajan, T., & Pichai, S. (n.d.). Transition from Waterfall to Agile Methodology: An Action Research Study. *IEEE Xplore*. Retrieved from https://ieeexplore.ieee.org/document/10488855.

Nielsen, O. B., Persson, J. S., & Madsen, S. (2019). Why governing data is difficult: Findings from Danish local government. In A. Elbanna, Y. Dwivedi, D. Bunker, & D. Wastell (Eds.), *Smart working, living and organising* (Vol. 533, pp. XX-XX). Springer, Cham. https://doi.org/10.1007/978-3-030-04315-5_2.

Olilla, S., & Yström, A. (2020). Action research for innovation management: Three benefits, three challenges, and three spaces. *R&D Management*, 50(3), 396–411. https://doi.org/10.1111/radm.12407.

Provost, F., & Fawcett, T. (2013). *Data science and its relationship to big data and data-driven decision making. Big Data*, 1(1), 51–59. https://doi.org/10.1089/big.2013.1508.

Rosa, M. R. da, & Pereira, E. N. (2021). Metodologias ágeis no contexto da administração pública: Análise de estudos de caso de implementação ágil. *Revista do Serviço Público*, 72(2), 479–497. https://revista.enap.gov.br/index.php/RSP/article/view/4310

Saarikallio, M., & Tyrväinen, P. (2023). Quality culture boosts agile transformation—Action research in a business-to-business software business. *Journal of Software: Evolution and Process*, 35(1), e2504. https://doi.org/10.1002/smr.2504.

Saltz, J. S., & Grady, N. W. (2017). The ambiguity of data science team roles and the need for a data science workforce framework. In *2017 IEEE International Conference on Big Data (BIGDATA). IEEE*. https://doi.org/10.1109/BigData.2017.8258401.

Saltz, J. S., & Hotz, N. (2020). Identifying the most common frameworks data science teams use to structure and coordinate their projects. *2020 IEEE International Conference on Big Data (Big Data)*, 1615–1624. https://doi.org/10.1109/BigData50022.2020.9377813.

Scott, I., & Gong, T. (2021). Coordinating government silos: Challenges and opportunities. *Global Public Policy and Governance*, 1, 20–38. https://doi.org/10.1007/s43508-021-00004-z.

Schwaber, K., & Sutherland, J. (2020). The Scrum guide: The definitive guide to Scrum: The rules of the game.

Scrum.org. https://scrumguides.org.
Tripp, D. (2005). Action research: A methodological introduction. *Educação e Pesquisa*, 31, 443–466. https://doi.org/10.1590/S1517-97022005000300009.
Tukey, J. W. (1980). We need both exploratory and confirmatory. *The American Statistician*, 34(1,) 23–25. 10.1080/00031305.1980.10482706.
Vacari, I. (2015). *Um estudo empírico sobre a adoção de métodos ágeis para desenvolvimento de software em organizações públicas* (Dissertação de mestrado, Pontifícia Universidade Católica do Rio Grande do Sul). PUCRS Repositório Digital. https://tede2.pucrs.br/tede2/bitstream/tede/6189/2/471291%20-%20Texto%20Completo.pdf.
Wickham, H.; Grolemund, G. (2016). *R for Data Science: Import, Tidy, Transform, Visualize, and Model Data*. O'Reilly Media. .
Young, E., & Quinn, L. (2002). *Writing effective public policy papers: A guide for policy advisers in Central and Eastern Europe*. Open Society Institute. Retrieved from https://caw.ceu.edu/sites/caw.ceu.edu/files/attachment/basicpage/116/writingeffectivepublicpolicypapersyoungquinn.pdf.

How can E-Government respond to the Digital Divide? Two Case Studies from Brazil.

Bruno Andrade de Figueiredo [a], *Manuela Cortez da Cunha Cruz* [b].

[a] Escola de Administração de Empresas de São Paulo da Fundação Getúlio Vargas (FGV-EAESP), São Paulo, SP, Brazil, bruno.figueiredo@fgv.edu.br, ORCID number [0000-0003-1871-4426].

[b] Escola de Administração de Empresas de São Paulo da Fundação Getúlio Vargas (FGV-EAESP), São Paulo, SP, Brazil, manuelacortez.cruz@gmail.com, ORCID number [0000-0002-4095-2984].

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. This research explores how distinct municipal contexts in Brazil influence the design and implementation of digital public policies, focusing on two city-level digital initiatives. The study investigates the paradox of digital government efforts, which aim to enhance inclusivity and efficiency but often exacerbate the digital divide, particularly affecting underprivileged populations. This issue is significant for public administration, as understanding how local contexts shape policy outcomes is essential for creating inclusive and effective public services. Existing frameworks can fall short in addressing this puzzle because they often neglect the role of contextual variability and the necessary local adaptations to overcome digital exclusion. These frameworks overlook how sociotechnical factors specific to each locality impact user engagement and the success of digital policies. Building on this gap, we hypothesize that the adaptability of municipal governments to local demands and digital barriers is a decisive factor in user adherence and policy effectiveness. To address this question, we conducted a comparative analysis of two municipal digital initiatives: the "Ouvindo Nosso Bairro" participatory program in Salvador and the "Saúde Já Curitiba" digital health platform in Curitiba. These cases demonstrate how municipal governments have tackled digital barriers and tailored information and communication technology (ICT) solutions to meet the diverse needs of their populations. Our qualitative research design combines documentary analysis with interviews of program managers and participants. Fieldwork and primary data collection took place between October 2022 and January 2023. Using the digital divide lens, we analyze how local contexts influenced the development and outcomes of these initiatives. This study aims to contribute to the broader discourse on digital inclusivity by demonstrating how municipal governments can adapt public policies to bridge the digital divide. By offering insights into these adaptations, the research aligns with the Sustainable Development Goals, particularly those promoting inclusive and equitable societies, reducing inequalities, and fostering innovation in public administration.

Keywords. Digitalization, e-government, ICT, Digital Divide.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.962

1. Introduction

Following the global trend of government service digitization (Alston, 2018), Brazil has been implementing e-government initiatives at various levels of government and across different areas of social welfare. These initiatives are justified by claims that digital solutions promote greater efficiency, improved service delivery, transparency, and fraud prevention, among other benefits. However, these approaches transfer the responsibility to citizens, requiring them to independently access and manage social services through information and communication technologies (ICT) (Schou & Hjelholt, 2019).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

At the same time, especially in developing countries, digital exclusion remains a persistent reality that reinforces existing social inequalities. In Brazil, according to data from CGI.br. (2024), approximately 84% of the population aged 10 or older accesses the internet, meaning that more than 34 million (16%) Brazilians still do not use it. Among internet users, 73% used e-government services. With the urgent need to reduce poverty and inequality in the current decade and the growing body of literature on the subject, it is possible to observe that these two contexts - the digitization of public services and digital exclusion - seemingly contradictory, demonstrate the need to fully understand the consequences of digital welfare, particularly for the disadvantaged, poor, and digitally excluded, who tend to be those who need the benefits that public policies can bring the most. Therefore, to create public services that fully meet the needs of users, it is crucial to map and understand the current state of the provision of these services, including interactions, information flows, and data among public sector organizations and the public's experience (Welby & Tan, 2022).

This research addresses the adaptability of digital public policies based on their context, recognizing the multiple factors that cause digital exclusion of the local population. The main question that guided this research is "How can digital public policies be designed to maximize citizen engagement and ensure equitable access to services, while addressing the digital divide and adapting to local socioeconomic and technological contexts?", followed by two secondary questions "How can municipal governments design digital services that effectively address the diverse needs of digitally excluded populations?" and "What are possible municipal goverment mechanisms for alleviating the digital divide and improving engagement in digtial policies?". To answer these research questions, this article presents two case studies of the digitalization of municipal policies to understand how ICTs can be adapted in the public sector, especially considering technologies accessible to citizens from different backgrounds. Furthermore, we believe this research can assist researchers and policymakers in crafting more digitally inclusive public policies, as both cases studied showed the ability to adapt to make them accessible to a wider range of users.

Our research aligns with the context of research on digital exclusion, which considers sociodemographic variables to have a significant impact on public policy discussions. Neglecting power structures, norms and social structures, culture, and access to resources can deepen the inequalities already experienced by vulnerable citizens, further hindering their individual, social, and economic development. Thus, it also aligns with some of the United Nations' Sustainable Development Goals (SDGs), "the current conceptualization of sustainable development encompass the wider discourse on how solutions to needs of society can be not only economically viable, but also environmentally bearable, and socially equitable at the same time" (Medaglia & Damsgaard, 2020, p. 2). Through the course of the research, the authors identified aligned topics in four of the SDGs: Goal 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation; Goal 10 - Reduce inequality within and among countries; Goal 11 - Make cities and human settlements inclusive, safe, resilient and sustainable; and with a primary focus on Goal 16 - Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels (UN Brazil, 2024).

2. Theoretical Background

2.1 E-Government

The field of e-government evolved from Information Technologies (IT) usage in government, related to internal data processing and the inner workings of governments, to the adoption of ICTs, related to external processes, service provisions, or connections among different actors involved in smart governance (Grönlund & Horan, 2005; Heeks, 2001). Moreover, e-government is a plural field composed of multiple areas of study, such as smart governance (Meijer & Bolívar, 2015; Meijer et al., 2016; Przeybilovicz & Cunha, 2024; Tomor et al., 2019), e-participation (Cardullo & Kitchin, 2024; Cunha et al., 2013; Figueiredo et al., 2023; Muñoz & Bolívar, 2021; Przeybilovicz et al., 2022) or the digital divide and digital exclusion (Macaya et al., 2021; Schou & Pors, 2019; van Deursen & Helsper, 2015). Also, there is a growing literature about public value generated by e-government, such as improvements in public services, administration efficiency, citizens' well-being, or public trust in government. However, there is little research on the public value of e-government policies in developing countries, and fewer are still in the least developed ones (Twizeyimana & Andersson, 2019).

Heeks (2001) defines the contributions of e-governance into three domains, improvements in governments' inner processes, improving connections with citizens and digital services, and connecting with different actors in civil society. Twizeyimana & Andersson (2019) rearranged these domains into E-administration, E-services and E-citizens and E-society, thus increasing the importance of E-services to stand as their own domain and joining together E-citizen and E-society as a single domain. Multiple factors influence the adoption and acceptance of e-government policies (Hofmann et al., 2012). Those factors are different when considering the multiple actors involved in e-governance, for instance, trust in government, the type of technology chosen, or digital proficiency could have a direct impact on the adoption of a digital policy by citizens. Moreover, policy digitalization has a deeper impact on the roles of the actors involved and the nature of their interaction. (Lindgren et al., 2019).

Citizen's interaction and communication with the government changed with the internet due to multiple new

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

channels and services that began to be offered online. More than that, services that once required mediation through public officials at specific places and during work-hour time, could now be scheduled directly by citizens at any time and any place (Lindgren et al., 2019). But there is a barrier in the form of the technological artifact itself, and its capacity to adapt to the local context, that may hinder or improve accessibility. Technological artifacts should cater to the digital excluded by having a lighter, more responsive, intuitive, and accessible interface. Those characteristics would also improve the overall perception of the artifact, even to those that are not technologically excluded (Baatiema et al., 2023; Catalina-García & Galera, 2003; Kim et al., 2023; Zhang et al., 2022). The identification of the local needs can be critical for increasing the adoption of the artifact. Failing to identify the local necessities and dynamics could prevent users from engaging with the technology, for instance, such as with the lack of physical devices by low-income families in Argentina (Kim et al., 2023) or the instructions not being translated to Spanish when addressing Hispanic families in rural California (Schwal, 2022).

2.2 Digital Divide

Academic interest in the theme of digital exclusion arose in the 1990s and is directly linked to the digitization of governments and the increase in the use of the internet and personal computers. Since then, the concept of digital exclusion has been evolving, as well as technology and its relationship with society. The inability to use digital solutions happens when e-services are designed with the digital interface as the default or main channel of interaction, and it affects citizens at different levels of the digital divide (van Deursen & Helsper, 2015; Schou & Pors, 2019). Initially, the focus of the studies was only on access to the Internet, but currently, it is understood that digital exclusion occurs at three levels (Scheerder et al., 2017).

The first level of the digital divide regarded people who did not have access or connection to the internet. As technology became more accessible, the second level of the digital divide became more apparent as well, as it was related to the individual's ability to use technology. People who had access to technology and a connection to the internet could still be excluded due to not possessing the skills to use them. The third level of the digital divide comprehends people who have access to technology and the skills they could still be excluded due to not knowing how to extract concrete benefits from the use of the internet (van Deursen & Helsper, 2015; Scheerder et al., 2017).

The digital divide affects demographics and socioeconomic extracts differently. Factors such as gender, income, age, race, and education influence the likelihood of an individual being excluded (Helsper, 2010; Macaya et al., 2021). Segments of the population that already suffer from socioeconomic exclusion are most susceptible to facing digital barriers when accessing online governmental services that are designed with the digital interface as the standard or the sole interface (digital-by-default). In such cases, digital governmental services, such as online welfare, could reproduce existing inequalities for already disenfranchised populations (Allmann & Radu, 2023; Buchert et al., 2023; Schou & Pors, 2019).

3. Methodology

To help answer our research question, two case studies were conducted on municipal digital governance initiatives in different Brazilian contexts; one focused on citizen participation and the other on digital health. The "Ouvindo Nosso Bairro" program, initiated by the Salvador city government, is a participatory budgeting program that began in 2015. In 2017, the program was digitized through an online interaction platform with citizens, changing its format. The other case, the "Saúde Já Curitiba" program, is the digital health initiative of the city of Curitiba, launched in 2017. The "Saúde Já" app underwent several changes, including operational system changes and adaptations to meet new demands, such as those generated by the COVID-19 pandemic.

The data collection consisted of collecting primary and secondary data. The data were gathered through documentary research and interviews with program managers and participants. The articles "O pesquisador conversador no cotidiano" (Spink, 2008) and "Institutional vulnerability and trust in public agencies: Views from both sides of the street" (Spink et al., 2021) served as guides for the work and interactions in the field. Field diaries were produced with comments, perceptions, and dialogues with different actors during the field immersions. The interviews followed a snowball method in which initial contacts pointed to the next contacts for interviews. This method creates a chain sampling based on referrals from the initial interviews (Patton, 2014). Below are the documents collected for each case:

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Program	Primary data	Secondary data
Ouvindo Nosso Bairro Salvador	Semi-structured interviews with municipal managers and bureaucrats responsible for the program's implementation (7 interviewees in total). The interviews were conducted between October 2022 and January 2023.	Documents and official communications (18 documents from different sources), press releases, and articles about the program (5 documents from various sources).
	Semi-structured interviews with program participants and other citizens, such as local leaders, academics, and activists (14 interviewees in total). The interviews were conducted between October 2022 and January 2023.	
Saúde Já Curitiba	Semi-structured interviews with municipal managers and bureaucrats responsible for the program's implementation (5 interviewees in total). The interviews were conducted between November and December 2022.	Documents and official sources: Municipal Health Department, Municipal Council of Curitiba, Social Action Foundation, and Municipal Government of Curitiba.

Fig. 1 - Data collection for both programs. Created by the authors.

The data collection utilized in this research consisted of semi-structured interviews (primary data) and documentary research (secondary data). Data collection for both cases was approved by the Research Ethics Committee of FGV, the "Comitê de Conformidade em Pesquisas Envolvendo Seres Humanos" (CEPH). All research protocols followed meet the requirements of CEPH and adhere to research ethics. Audio recordings were transcribed, and key elements from the interviews were coded to analyze the data collected from them. The theoretical lens employed for data analysis of both cases was the Digital Divide. The field information is divided into a description of the two cases intertwined with quotes and excerpts from the data collection. In both cases, special attention was given to individuals at risk of being excluded from digital services, recognizing that the context and timing of digital programs can directly influence these citizens.

4. Case Studies

The case studies will be described chronologically. A timeline was created to compare both programs (Figure 2), and each case is described in its subsection.

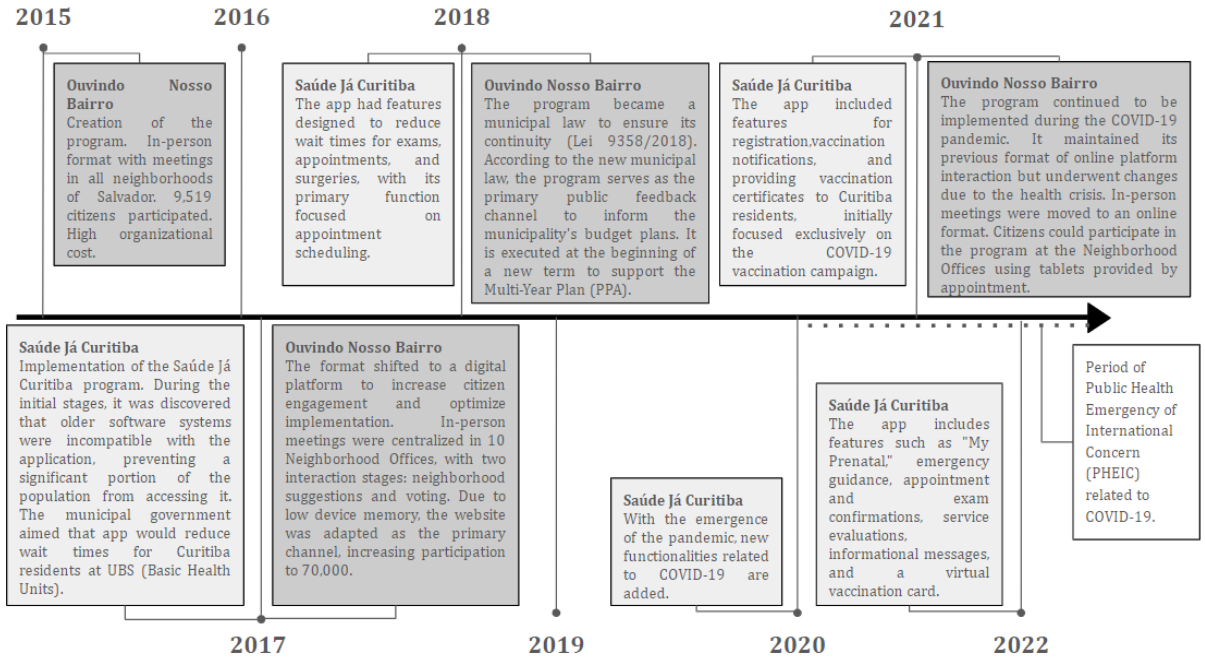


Fig. 2 - Comparative timeline of the Ouvindo Nosso Bairro and Saúde Já Curitiba programs. Created by the authors.

4.1 Ouvindo Nosso Bairro

The "Ouvindo Nosso Bairro" (ONB) policy was established in 2015 during a new management`s first term. The

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

implementation of the policy required significant political effort and was directly overseen by the mayor's office. The policy was an integral part of the administrative strategy to establish closer contact with the local population of Salvador. The first phase of the policy consisted of public hearings in each district of the city. Meetings were held at different times, on Wednesdays and Saturdays, in public places easily accessible to the local residents. In total, 152 meetings were held. (Matos et al., 2019; OGM - Ouvidoria Geral do Município, 2021). To ensure the continuity of the "Ouvindo Nosso Bairro" policy, it was passed as a municipal law by the city council, Law no. 9358/2018 This law requires the ONB to be conducted during the first year of a new municipal government term to substantiate the municipal budget plans (Gabinete do Prefeito Municipal do Salvador, 2018; Prefeitura Municipal do Salvador, 2021).

The second iteration of the policy took place during the administration's second term. This time, the administration brought a digitalization agenda and the ONB policy received a digital dimension through an online platform, created by the Companhia de Governança Eletrônica de Salvador (COGEL, literally translated as Electronic Governance Company of Salvador). This digital dimension aimed to increase the number of participants in the policy by centralizing participation in a smartphone application, and optimizing the implementation of the policy. The total number of participants increased from 9,519 participants to approximately 70,000. However, the policy lost part of its interaction. The face-to-face meetings held in each district were centralized at the ten subprefecture units (Matos et al., 2019).

The format of the "Ouvindo Nosso Bairro" changed due to its digitalization. The new format has four steps. The first step consists of citizens suggesting up to three infrastructure works for their neighborhood on the online platform. The results are then processed by the city hall and sent to the other secretariats, for technical and cost feasibility analyses. The approved results, based on the technical analysis, are returned to the citizens for voting on the online platform. At this step, citizens vote on their preferences from the approved list. After the voting is concluded, the results are published and the responsible secretariats start the most voted works for each neighborhood (Matos et al., 2019; Secretaria Geral de Articulação Comunitária e Prefeituras-Bairro, n.d.).

The administration took some precautionary measures regarding digital exclusion. The online process had the possibility of hybrid interaction and some key locations and public squares were equipped with free wifi connection for citizens. The hybrid policy worked with "Prefeituras-Bairro" units providing tablets and helping citizens participation. Also, city hall agents were positioned at high-traffic public places, equipped with tablets, to engage citizens to participate in the policy (Matos et al., 2019). After an initial test period, the administration found that the memory capacity of citizen's smartphones restricted the download of the application. So, the administration responded by modifying the ONB website to be more responsive, to accommodate all smartphones, and to become the main channel for interaction replacing the application. At the same time, a marketing campaign was launched aimed at informing citizens that the participation would take place through the policy's online webpage, as confirmed by interviewee 8:

Salvador is the city with most smartphones per habitants in the country (…) but, the idea of the application, was not a good idea. People had no memory on their cell phones, they used very simple cell phones, and that forced us to make a responsive system. Regardless of whether the citizen was on a very simple android, 16 gigs, or on a top-of-the-line iPhone, or on a top tablet, the system presented itself to him amicably and he could fill out the registration, and then fill in his answers in a simple manner. We didn't need citizens to download the application anymore, for them to participate. (…) we began to realize, during the first days, that we did not have a large number of downloads [of the application] in the stores, and we started to understand "hey, change that, turn the campaign now to just Access the Site" (Interviewee 8, "Ouvindo Nosso Bairro").

The digitization of the "Ouvindo Nosso Bairro" was inspired by the Digital Participatory Budget policy of Belo Horizonte (Matos et al., 2019). The Salvador administration was concerned with the voting fraud that happened at Belo Horizonte's policy, and this led them to adopt a different online user validation system. The Belo Horizonte policy validated the citizen's vote by the voter's title (Marquetti et al., 2008). For the "Ouvindo Nosso Bairro", validation occurs through the individual taxpayer ID number ("Cadastro de Pessoa Física", CPF). This process requires the validation of the citizen's document with the Treasury Secretariat's ("Secretaria da Fazenda") database and, if there is no parity, validation with the Special Department of Federal Revenue of Brazil's database is required, which incurs a cost, as stated by interviewee 8:

(…) These guys can start generating CPFs, do you know of CPF generators? All it takes is parity... And I said to the director that it's going to have a cost... If we need to criticize the CPF, that is one thing. You know, just to check the parity, whether it matches or not, so you let the guy in. But for you to make sure that the person exists, I have to go to the Treasury Secretariat. And if, for some reason, that person is not there in our base if it is in our base, it has no cost, understood? But if I have to get it from the Receita Federal [Federal Revenue of Brazil], I know it has a cost. So, the director said, "ok, we're going to do it". The first step was for the person to enter with their CPF, and then we validated if that person existed. (Interviewee 8, Ouvindo Nosso Bairro).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The third “Ouvindo Nosso Bairro” iteration took place in 2021. The policy continued with the same previous format, however, due to the COVID-19 pandemic, it had to be adapted to meet the sanitary restrictions. Synchronous meetings were maintained in an online format. Hybrid interactions still occurred within the 10 “Prefeituras-Bairro” units, upon prior scheduling by citizens. There was a reduction in the total number of participants to 53,882, combining approximately 21,000 votes from the online suggestion stage and 32,000 votes from the online voting stage (Secretaria de Comunicação, 2021b, 2021a).

4.2 Saúde Já Curitiba

Before understanding the Saúde Já Curitiba program and, more importantly, its rapid adaptability, it is necessary to observe that digitizing healthcare has been ongoing since 1999. Saúde Já Curitiba is just one element of this process. In 1999, an information system was implemented throughout the Primary Care Network. The system, then Cartão Qualidade Saúde (CQS), integrated citizen records, establishments, and procedures based on the patient's electronic medical record. CQS pioneered capturing reliable real-time information, facilitating the monitoring of the work process (Secretaria Municipal de Saúde de Curitiba, 2023a). In 2012, CQS was replaced by e-Saúde, a system still in use (as of May 2023). Beyond the functions that CQS already performed, e-Saúde also integrated all areas of the Municipal Health Secretariat into a single system: Primary Care; Urgency and Emergency; Dentistry; Epidemiological and Sanitary Surveillance; Control; Evaluation; Audit; and Regulation. During interviews, elements of a more applied and comprehensive vision of digital health were sought, especially regarding how managers assess the integration of digital resources into the community and healthcare infrastructure. As demonstrated by Interviewee 2 (Saúde Já) in this interview excerpt:

If I have good facilities, good technology equipment to treat the patient there: take an X-ray, do a CT scan... But also information about that patient, I can better understand their problem, and solve their problem, right? But at the same time, when I build a system like this, no matter how first-world it may be, no matter how fantastic it is... In terms of applied technology, it is useless if it does not consider [for instance] whether Dona Francisca, who lives in Caximba [a poor neighborhood of Curitiba], will benefit from it. If I start from the premise that I will add technology and shift in-person care to other activities, I will leave these people without care and not improve their care. (Interviewee 2 - Saúde Já).

Starting this greater integration of citizens with the system in 2017, the Municipal Government of Curitiba, under pressure from the mayor, implemented the Saúde Já App. Initially, the main concern was eliminating early morning queues for scheduling appointments at UBS. The app then began to function for appointment scheduling. However, in the first few months, it was noted that a large portion of the population could not access Saúde Já because users used smartphones with much older software than what the app supported, causing Saúde Já not to run or even download on these devices. Here, we have the first major transformation of the Saúde Já app: the configuration was changed to make the app compatible with all smartphone operating systems. Interviewee 3 (Saúde Já) reflects on the use of tools and technological innovations in healthcare without falling into the trap of "innovating just for the sake of innovation," especially when considering the perspective of public health:

You need to work with a healthcare system that accommodates technological innovations, but technological innovations have to be designed to serve something... they have to make a difference, and that's where our app became this great link." (Interviewee 3 - Saúde Já)

The Municipal Health Plan of Curitiba 2022-2025 (Secretaria Municipal de Saúde de Curitiba, 2023b) highlights that the Saúde Já app, in addition to scheduling appointments, has new functions. One is the "Meu Pré Natal" (My Prenatal) function, aimed at pregnant women, providing information about pregnancy stages, including a contraction calculator to indicate the right time to go to the maternity ward during childbirth. Another function is guidance for urgent cases, including traffic accidents, medical and dental emergencies, sexual violence, and HIV contact. Furthermore, the app offers appointment and exam confirmations, with a history and transaction code stored within the app, and the ability to evaluate any care provided in the UBS or the service provider network. There are also informative messages about health programs and actions conducted in the UBS, as well as a virtual vaccination card that includes vaccination history, pending vaccinations, and notifications of vaccination campaigns. In 2020, with the COVID-19 pandemic, integration with the Telemedicine Center was added, as part of the pandemic response strategy, along with medical video consultations, general health service guidance, appointment scheduling, and system e-health registration updates. Thus, the pandemic forced the second transformation of Saúde Já Curitiba, adding these new and important features to combat the pandemic.

Impacted by the adaptations required to address the pandemic spread of COVID-19, the search for the expansion, qualification, and modernization of public health services is reflected in products and services aimed at integrating technology into humanized healthcare in Curitiba: connectivity, intelligence, and database applied for the benefit of the population. Electronic medical records, video consultations, and telehealth services are aligned with new initiatives for specialized care and health surveillance, marking the evolution of services in all their breadth (Secretaria Municipal de Saúde de Curitiba, 2023b, p. 158). This discourse of adaptation and innovation is observed

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

in the projects, guidelines, and approved proposals in the Municipal Health Plan of Curitiba 2022-2025 (Secretaria Municipal de Saúde de Curitiba, 2023c).

4.3 Cases intersections

Both the "Ouvindo Nosso Bairro" and "Saúde Já Curitiba" programs have shown the importance of the municipal management's concern with the digital divide, and how it molded both programs. In Salvador, the management had to adapt to the difficulties imposed by digitization. Their initial internet access precautions were insufficient for the population to participate in the program. The technology had to be adapted to the local population's hardware restrictions. The city's administrations changed the channels of interaction with the program, from the application to the website, and made it more responsive to all devices. The "Saúde Já Curitiba" program also faced difficulties with older operating systems. The application had to be adapted to work on all operating systems to serve the city's entire population. Figure 3 illustrates the relationship between the challenges faced in both cases and also links them to the three levels of digital exclusion.

CHALLENGES			
	First level/internet access divide People who do not have access or connection to the internet	**Second level/skills divide** People who are unable to use digital tools	**Third level/beneficial outcomes of Internet use** People who are unable to gain real-world value or benefits from their use of technology
Ouvindo Nosso Bairro Salvador	- Low memory capacity of the smartphone devices - Lack of internet access by part of the population	- Illiteracy rate among the adult population of Salvador. - Citizen's struggle with using and understanding the website.	- Citizens don't have a long-term memory and understanding of the policy. - Citizens don't know about the policy's existence. - Citizens being manipulated by local leaders into voting without fully understanding the policy. The policy became a "Local leader's dispute" for their work.
Saúde Já Curitiba	- Users had smartphones with much older software than what the app supported - Lack of internet access by part of the population	- Citizens struggle with creating an account, logging in and/or solving technological problems	- Lack of knowledge among citizens to address their health issues using the available tools - Citizens did not see benefits in using an app rather than going to the UBS

Fig. 3 - Comparative challenges of the Ouvindo Nosso Bairro and Saúde Já Curitiba programs. Created by the authors.

During the pandemic, "Saúde Já Curitiba" incorporated sanitary guidelines and was integrated with the Telemedicine Center. On the other hand, "Ouvindo Nosso Bairro" underwent adaptations to continue running, despite the difficulties imposed by the sanitary requirements. Synchronous meetings were held in digital format and, to assist the population with challenges, the program continued to be run in a hybrid format by appointment. These and other solutions (Figure 4) were necessary for the continuity of the programs and the increase in engagement.

SOLUTIONS			
	First level/internet access divide People who do not have access or connection to the internet	**Second level/skills divide** People who are unable to use digital tools	**Third level/beneficial outcomes of Internet use** People who are unable to gain real-world value or benefits from their use of technology
Ouvindo Nosso Bairro Salvador	- Migration from the application platform (required higher memory to download) to a webpage. - The web page's interface was made lighter to facilitate user access and voting. - Free internet access points were installed at key locations of the city. - Hybrid policy: on-site city officials were positioned at key locations in Salvador with a tablet to help citizens participate in the policy. It was also possible to participate locally at each Prefeitura-Bairro unit.	- Hybrid policy: on-site city officials at key locations of Salvador and Prefeitura-Bairro street-level bureaucrats would help people with participation. - The webpage interface was made easier and simpler for citizen registration and interaction. - Backoffice: Validate citizens' registration through their CPF (Individual Taxpayer Registration) with the Receita Federal (Federal Revenue) database.	- Disclosure of the policy through media/social media channels. - Disclosure of the different steps of the policy, from voting to implementation and work inaugurations.
Saúde Já Curitiba	- The app configuration was changed to make the app compatible with all smartphone operating system	- The Telemedicine Center with a phone number was created to address citizens' accounts and technological problems	- Increased promotion of the Saúde Já Curitiba app - Mandatory use of the app during the COVID-19 vaccination program - Addition of more features and services

Fig. 4 - Comparative solutions of the Ouvindo Nosso Bairro and Saúde Já Curitiba programs. Created by the authors.

The "Ouvindo Nosso Bairro" and "Saúde Já Curitiba" cases demonstrate the importance of addressing the digital divide through the adaptation of municipal policies. Both faced technological challenges, such as hardware and operating system limitations, which required shifts to more inclusive platforms. During the COVID-19 pandemic, the programs showcased resilience by integrating telemedicine and hybrid participation formats, ensuring continued service and engagement. Figures 3 and 4 highlight how these challenges and solutions addressed the three levels of the digital divide.

5. Discussion

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The cases studied exposed the need for adaptations when introducing new technologies to the population. Both programs were able to adapt to better meet the demands and needs of their citizens. Beyond the cases mentioned, it is highlighted that digital government practices must ensure that public services are planned and provided in such a way that the benefits of digital transformation are available and accessible to all, including those who depend on face-to-face interactions. Therefore, it is necessary to look both inward and address the context and governance (such as administrative structures), as well as outward, focusing on the needs of users throughout their experience with public service, regardless of whether it is delivered by mail, telephone, in person or through a digital device (Welby and Tan, 2022). Each e-policy studied faced challenges during its launch and only managed to have a higher number of users once they were adapted to minimize the local barriers, confirming the need for adaptation of e-policies to its context to reach a higher number of people (Baatiema et al., 2023; Catalina-García & Galera, 2003; Kim et al., 2023; Zhang et al., 2022).

The COVID-19 pandemic was a period that forced the digitalization of many municipal services. Successful policies during the pandemic were the ones that understood their contextual challenges regarding the digital divide and adapted the program, especially through the use of more responsive interfaces and the inclusiveness of different channels and devices for communication with citizens (Acosta-Vargas et al., 2022; Baatiema et al., 2023; Kim et al., 2023). The different levels of the digital divide created barriers that needed to be addressed by the municipal government for their policies to reach a higher number of users. In both cases, citizens already had access to technology in the form of smartphones and yet, due to the diversity of the types of smartphones, the policies did not originally reach citizens. Smartphone limitations, such as the memory capacity, or older models with outdated versions of the operation system, were major limitations in the technology that required the policies to be redesigned. When considering the different levels of the digital divide, the redesigns of the policies were aimed to address the first and the second levels by providing more access to citizens, either through alternative channels, by asynchronous and on-premise attendances, or by adapting the e-policy/platform to cater to more devices. However, the third level of the digital divide (van Deursen & Helsper, 2015) did not receive that much attention from the municipal governments and it was only partially considered through the disclosure of the policies.

The digital divide is more nuanced than just the three levels mentioned above, such as the characteristics of the population and of the local context and how they impact citizens' accessibility and use of e-services (Macaya et al., 2021). However, both e-policies studied did not account for these nuances in their actions toward mitigating the digital divide and increasing the policies reach to the population. We positioned that the e-policy should incorporate strategies to reach out to these different population strata to overcome the digital divide. For instance, Panganiban (2018) showed how simple solutions tailored to a specific population increase the reach of an e-policy, such as creating a more informal setting for an ICT teaching center that would encourage a shy and rural population for attend it, or incorporating already known technologies instead of proposing new ones.

Answering the Research Questions

Through the two case studies, it was possible to draw some conclusions about the policy designs that helped the digital policies reach a higher number of citizens by addressing the digital divide at different levels, thus answering our initial question, “How can digital public policies be designed to maximize citizen engagement and ensure equitable access to services, while addressing systemic inequities and adapting to local socioeconomic and technological contexts? The following suggestions compile our findings in e-policy design and also answer our secondary questions on possible mechanisms that improve the reach to citizens by addressing the digital divide. These recommendations are also responding to Madsen et al. (2014) in the need for bridging research in e-government with practice:

- Backoffice: municipalities may experience hardships with database parities when validating citizens' registration in the e-policy. A possible solution is to validate the ID with a citizen registration database at the federal level, such as with a federal revenue agency. Validation is important to guarantee the safety of the users as well as the validity of the e-policy.

- Policy design addressing the first level of the digital divide: responsive and lighter interface. Prepared to run on multiple platforms, either by web browser or applications that are light (low-memory consumption and responsive) and can run on multiple operating systems, even in older, outdated versions. Also, on-premises possibilities for technology use and access at key locations are important to guarantee access to technology and to the internet in contexts where they are not easily available to all citizens.

- Policy design addressing the second level of the digital divide: all e-services should be hybrid with on-premise and other types of asynchronous citizen support, such as telephone channels. The more different types of channels supported, the easier it will be for citizens to troubleshoot or access assistance in using the e-service, as well as accessing the service offline in traditional on-premise formats.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- Policy design addressing the third level of the digital divide: the third level of the digital divide is more challenging to address. Different mechanisms were employed in the cases studied to instigate a long-term memory and understanding of the policy, but some of the results were not fully successful. Those mechanisms included investment in the disclosure of the policy through different media/social media channels, mandatory use of the application during the COVID-19 pandemic, and even the addition of more features to the application/e-service. We argue that there should be more public deliberation with citizens to better explain the e-service, and e-services in general, to raise their awareness, especially targeting segments of the population that face more challenges in accessing and understanding e-services, based on race, age, gender, income, and education (Macaya et al., 2021).

6. Conclusion

The study addresses the role of municipal governments in designing equitable digital public policies while dealing with a partially digitally divided population. It also underscores the critical need for adaptive and inclusive digital public services, policies, and programs so citizens do not become unassisted of basic government services - for example, in Saúde Já Curitiba, the program ensures public health access. By analyzing the "Ouvindo Nosso Bairro" and "Saúde Já Curitiba" programs, the article highlights the challenges and solutions in implementing inclusive e-services and it becomes evident that municipal governments must account for local technological, socioeconomic, and contextual barriers to ensure broader citizen engagement.

The study emphasizes the importance of designing digital services that address all three levels of the digital divide: access, skills, and outcomes. Local adaptability emerged as a crucial factor, demonstrated by the implementation of responsive platforms, hybrid access models, and user-centered designs that cater to diverse population needs. As happened during the COVID-19 pandemic, when both programs showcased resilience by incorporating innovative solutions such as the Telemedicine Center and hybrid participation formats, ensuring continuity and inclusivity. From these findings, critical lessons for policymakers include the necessity of hybrid approaches that integrate digital and in-person services to enhance accessibility, the importance of iterative adjustments that account for local technological and socioeconomic contexts, and the need to go beyond access by addressing digital literacy and fostering the meaningful use of technology. These insights underscore the importance of adaptability and inclusivity in the development of effective digital public policies.

Following Twizeyimana & Andersson's (2019) main application domains of e-policies, our findings were concentrated in the e-service domain. More research could be done specifically looking at the other domains. Specifically, more research on the E-Administration domain could help understand the impacts of the digital divide and possible solutions to mitigate them from the inner perspective of the government. Also, more research on e-service at the local level could improve our findings with different inputs from other cases and experiences in how e-policies could be adapted to answer the digital divide.

Acknowledgement

- **Funding or Grant:** Doctorate scholarships (CAPES and CNPq).
- **Use of AI***: During the preparation of this work, the authors used ChatGPT (OpenAI) to translate findings and citations from Portuguese to English. After using this tool, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and takes full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Acosta-Vargas, P., Novillo-Villegas, S., Salvador-Acosta, B., Calvopina, M., Kyriakidis, N., Ortiz-Prado, E., & Salvador-Ullauri, L. (2022). Accessibility analysis of worldwide COVID-19-related information portals. *International Journal of Environmental Research and Public Health*, *19*(19), 12102. https://doi.org/10.3390/IJERPH191912102

Allmann, K., & Radu, R. (2023). Digital footprints as barriers to accessing e-government services. Global Policy, 14(1), 84–94. https://doi.org/10.1111/1758-5899.13140

Alston, P., United Nations Human Rights Council, Special Rapporteur on Extreme Poverty and Human Rights, & Secretariat, United Nations Human Rights Council. (2018). Report of the Special Rapporteur on extreme poverty and human rights on his mission to the United States of America: Note by the Secretariat. United Nations. https://digitallibrary.un.org/record/1629536

Baatiema, L., Sanuade, O. A., Allen, L. N., Abimbola, S., Hategeka, C., Koram, K. A., & Kruk, M. E. (2023). Health system adaptations to improve care for people living with non-communicable diseases during COVID-19 in low-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

middle income countries: A scoping review. Journal of Global Health, 13, 06006. https://jogh.org/2023/jogh-13-06006

Buchert, U., Kemppainen, L., Olakivi, A., Wrede, S., & Kouvonen, A. (2023). Is digitalisation of public health and social welfare services reinforcing social exclusion? The case of Russian-speaking older migrants in Finland. Critical Social Policy, 43(3), 375–400. https://doi.org/10.1177/02610183221105035

Catalina-García, B., & Galera, M. D. C. G. (2003). Innovation and hi-tech tools in journalism education: The Wooclap case. Doxa Comunicación. Revista Interdisciplinar de Estudios de Comunicación y Ciencias Sociales, 2022(34), 19–32. https://doi.org/10.31921/DOXACOM.N34A1141

Cardullo, P., & Kitchin, R. (2018). Being a 'citizen' in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland. GeoJournal 2018 84:1, 84(1), 1–13. https://doi.org/10.1007/S10708-018-9845-8

CGI.br. (2024). Pesquisa sobre o uso das tecnologias de informação e comunicação nos domicílios brasileiros: TIC Domicílios 2024.

Cunha, M. A., Coelho, T. R., & Pozzebon, M. (2013). The Use Of ICT In Public Decision-Making Participation. European Conference on Information Systems.

Figueiredo, B. A. de, Przeybilovicz, E., & Cunha, M. A. (2023). Citizen Participation Level in Smart Governance: A Literature Review. AMCIS 2023 Proceedings. https://aisel.aisnet.org/amcis2023/sig_egov/sig_egov/11

Gabinete do Prefeito Municipal do Salvador. (2018, March 20). Lei Ordinária 9358 2018 de Salvador BA. https://leismunicipais.com.br/a/ba/s/salvador/lei-ordinaria/2018/936/9358/lei-ordinaria-n-9358-2018-institui-o-programa-ouvindo-nosso-bairro

Grönlund, Å., & Horan, T. A. (2005). Communications of the Association for Information Systems Communications of the Association for Information Systems Introducing e-Gov: History, Definitions, and Issues Introducing e-Gov: History, Definitions, and Issues. https://doi.org/10.17705/1CAIS.01539

Heeks, R. (2001). Understanding e-Governance for Development. SSRN Electronic Journal. https://doi.org/10.2139/SSRN.3540058

Kim, K. K., McGrath, S. P., Lopez Solorza, J., & Lindeman, D. (2023). CIC 2022: The ACTIVATE Digital Health Pilot Program for diabetes and hypertension in an underserved and rural community. Applied Clinical Informatics, 14(4), 644–653. https://doi.org/10.1055/A-2096-0326/id/jr202301ra0017-37/bib

Lindgren, I., Madsen, C. Ø., Hofmann, S., & Melin, U. (2019). Close encounters of the digital kind: A research agenda for the digitalization of public services. Government Information Quarterly, 36(3), 427–436. https://doi.org/10.1016/J.GIQ.2019.03.002

Macaya, J. F. M., Ribeiro, M. M., Jereissati, T., dos Reis Lima, C., & Cunha, M. A. (2021). Gendering the digital divide: The use of electronic government services and implications for the digital gender gap. Information Polity, 26(2), 131–146. https://doi.org/10.3233/IP-200307

Madsen, C. O., Berger, J. B., & Phythian, M. (2014). The Development in Leading e-Government Articles 2001-2010: Definitions, Perspectives, Scope, Research Philosophies, Methods and Recommendations: An Update of Heeks and Bailur. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 8653 LNCS, 17–34. https://doi.org/10.1007/978-3-662-44426-9_2

Matos, E. O., Barros, S., & Carreiro, R. (2019). "Ouvindo nosso bairro": Um estudo sobre a participação política local por meio de multiplataformas. In M. G. Massuchin, E. U. Cervi, F. Cavassana, & C. Q. Tavares (Eds.), Comunicação e política: Interfaces em esferas regionais (pp. 203–227). EDUFMA. https://www.researchgate.net/publication/336810444_Ouvindo_nosso_bairro_um_estudo_sobre_a_participacao_politica_local_por_meio_de_multiplataformas

Medaglia, R., & Damsgaard, J. (2020). Blockchain and the United Nations Sustainable Development Goals: Towards an agenda for IS research. In Proceedings of the Pacific Asia Conference on Information Systems (PACIS).

Meijer, A., & Bolívar, M. P. R. (2015). Governing the smart city: a review of the literature on smart urban governance: International Review of Administrative Sciences, 82(2), 392–408. https://doi.org/10.1177/0020852314564308

Meijer, A. J., Gil-Garcia, J. R., & Bolívar, M. P. R. (2016). Smart City Research: Contextual Conditions,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Governance Models, and Public Value Assessment. Social Science Computer Review, 34(6), 647–656. https://doi.org/10.1177/0894439315618890

Muñoz, L. A., & Bolívar, M. P. R. (2021). Different Levels of Smart and Sustainable Cities Construction Using e-Participation Tools in European and Central Asian Countries. Sustainability 2021, Vol. 13, Page 3561, 13(6), 3561. https://doi.org/10.3390/SU13063561

OGM - Ouvidoria Geral do Município. (2021). Programa Salvador Bairro a Bairro. OGM - Ouvidoria Geral do Município. http://ouvidoria.salvador.ba.gov.br/index.php/projeto/programa-salvador-bairro-a-bairro

Panganiban, G. G. F. (2018). E-governance in agriculture: digital tools enabling Filipino farmers. Https://Doi-Org-Ez91-Periodicos-Capes-Gov-Br.Sbproxy.Fgv.Br/10.1080/17516234.2018.1499479, 12(1), 51–70. https://doi.org/10.1080/17516234.2018.1499479

Patton, M. Q. (2014). Qualitative research & evaluation methods: Integrating theory and practice (4ª ed.). https://books.google.com/books/about/Qualitative_Research_Evaluation_Methods.html?hl=pt-BR&id=ovAkBQAAQBAJ

Prefeitura Municipal do Salvador. (2021). Salvador PPA 2022-2025. http://casacivil.salvador.ba.gov.br/orcamentos/PPA_2022_2025/include/projeto_lei_e_mensagem/3.Princ%EDpios_de_Elabora%E7%E3o.pdf

Przeybilovicz, E., & Cunha, M. A. (2024). Governing in the digital age: The emergence of dynamic smart urban governance modes. Government Information Quarterly, 41(1), 101907. https://doi.org/10.1016/J.GIQ.2023.101907

Przeybilovicz, E., Cunha, M. A., Geertman, S., Leleux, C., Michels, A., Tomor, Z., Webster, C. W. R., & Meijer, A. (2022). Citizen participation in the smart city: findings from an international comparative study. Local Government Studies, 48(1), 23–47. https://doi.org/10.1080/03003930.2020.1851204

Scheerder, A., van Deursen, A., & van Dijk, J. (2017). Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. Telematics and Informatics, 34(8), 1607–1624. https://doi.org/10.1016/J.TELE.2017.07.007

Schou, J., & Hjelholt, M. (2019). Digitalizing the welfare state: Citizenship discourses in Danish digitalization strategies from 2002 to 2015. Critical Policy Studies, 13(1), 3–22. https://doi.org/10.1080/19460171.2017.1333441

Schou, J., & Pors, A. S. (2019). Digital by default? A qualitative study of exclusion in digitalised welfare. Social Policy & Administration, 53(3), 464–477. https://doi.org/10.1111/SPOL.12470

Schwal, M. A. (2022). El confinamiento y la vuelta a clases en Argentina: Relatos de docentes sobre la desigualdad en pandemia. Texto Livre, 15, e38009. https://doi.org/10.35699/1983-3652.2022.38009

Secretaria de Comunicação (SECOM). (2021a). Prefeitura inicia obras mais votadas no Ouvindo Nosso Bairro 2021 – Prefeitura Bairro. Prefeitura de Salvador. https://prefeiturabairro.salvador.ba.gov.br/prefeitura-inicia-obras-mais-votadas-no-ouvindo-nosso-bairro-2021/

Secretaria de Comunicação (SECOM). (2021b). Primeira etapa do Ouvindo Nosso Bairro registra 21 mil solicitações – Prefeitura Bairro. Prefeitura de Salvador. https://prefeiturabairro.salvador.ba.gov.br/primeira-etapa-do-ouvindo-nosso-bairro-registra-21-mil-solicitacoes/

Secretaria Geral de Articulação Comunitária e Prefeituras-Bairro. (n.d.). Ouvindo Nosso Bairro - Salvador. Retrieved January 23, 2023, from http://ouvindonossobairro.salvador.ba.gov.br/index.php

Secretaria Municipal de Saúde de Curitiba. (2023a). Histórico da Secretaria. Prefeitura Municipal de Curitiba. https://saude.curitiba.pr.gov.br/a-secretaria/historico-da-secretaria.html

Secretaria Municipal de Saúde de Curitiba. (2023b). Rede de serviços do SUS Curitiba. Prefeitura Municipal de Curitiba. https://saude.curitiba.pr.gov.br/a-secretaria/rede-de-atencao.html

Secretaria Municipal de Saúde de Curitiba. (2023c). Plano Municipal de Saúde de Curitiba 2022-2025. Prefeitura Municipal de Curitiba. https://saude.curitiba.pr.gov.br/images/PMS%20com%20resoluções%20e%20errata.docx.pdf

Spink, P. K. (2008). O pesquisador conversador no cotidiano. Psicologia & Sociedade, 20(Edição Especial), 70–77. https://doi.org/10.1590/S0102-71822008000400010

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Spink, P., Lotta, G., & Burgos, F. (2021). Institutional vulnerability and trust in public agencies: Views from both sides of the street. Governance, 34(4), 1057–1073. https://doi.org/10.1111/gove.12574

Tomor, Z., Meijer, A., Michels, A., & Geertman, S. (2019). Smart Governance For Sustainable Cities: Findings from a Systematic Literature Review. Https://Doi-Org-Ez91-Periodicos-Capes-Gov-Br.Sbproxy.Fgv.Br/10.1080/10630732.2019.1651178, 26(4), 3–27. https://doi.org/10.1080/10630732.2019.1651178

Twizeyimana, J. D., & Andersson, A. (2019). The public value of E-Government – A literature review. Government Information Quarterly, 36(2), 167–178. https://doi.org/10.1016/J.GIQ.2019.01.001

United Nations (UN) Brazil. (n.d.). Sustainable Development Goals (SDGs). Retrieved November 7, 2024, from https://brasil.un.org/pt-br/sdgs

van Deursen, A. J. A. M., & Helsper, E. J. (2015). The Third-Level Digital Divide: Who Benefits Most from Being Online? 10, 29–52. https://doi.org/10.1108/S2050-206020150000010002

Welby, B., & Tan, E. (2022). OECD Going Digital Toolkit Policy Note: Designing and delivering public services in the digital age. OECD. https://www.researchgate.net/publication/360701545_OECD_Going_Digital_Toolkit_Policy_Note_Designing_and_delivering_public_services_in_the_digital_age/stats

Zhang, B., Peng, G., Liu, C., Zhang, Z. J., & Jasimuddin, S. M. (2022). Adaptation behaviour in using one-stop smart governance apps: An exploratory study between digital immigrants and digital natives. Electronic Markets, 32(4), 1971–1991. https://doi.org/10.1007/s12525-022-00538-y/tables/2

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Integrating an Online Management System into Technical Schools: A Step Toward Digital Transformation

Suellen Lages[a], *Pedro Clarindo da* Silva Neto[b*], *Elmo Batista de* Faria[c], *Josiel Maimone de* Figueiredo[d], *Arthur Octávio Oliveira* Confessor[e]

[a]Departament of Computing - Federal Institute of Mato Grosso, lages.suellen@estudante.ifmt.edu.br, 0009-0002-5350-1629.

[b]Departament of Computing- Federal Institute of Mato Grosso, pedro.neto@ifmt.edu.br, 0000-0002-4195-624X.

[c]Institute of Computing - Federal University of Mato Grosso, elmo@ic.ufmt.br, 0000-0002-5336-7848.

[d]Institute of Computing - Federal University of Mato Grosso, josiel@ic.ufmt.br, 0000-0001-8569-7684.

[e]Departament of Computing - Federal Institute of Mato Grosso, arthur.confessor@estudante.ifmt.edu.br, 0009-0009-0784-3661.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. This article presents the implementation of the Unified Public Administration System (SUAP) in technical schools across the State of Mato Grosso, Brazil, as a key initiative in the state government's digital transformation strategy. Developed in collaboration with UFMT, IFMT and SECITECI, the project aimed to modernize educational governance by replacing fragmented, manual processes with a centralized, cloud-based platform. By integrating SUAP into school administration, the initiative enhanced transparency, streamlined workflows, and standardized digital services across urban and rural institutions, reinforcing social cohesion and reducing regional disparities in access to technology. The project addressed critical challenges such as infrastructure limitations, data security, and resistance to change. Custom solutions were implemented, including improved Moodle integration and enhanced SUAP functionalities for certificate management and user permissions. A collaborative, agile approach guided the development process, ensuring that technical teams, policymakers, and educators worked together to build a robust and scalable system. Additionally, a comprehensive capacity-building program equipped staff and students with the necessary digital literacy skills to maximize system adoption. Results demonstrated significant impact, with 719 students, 124 technical staff, and 190 teachers actively using the system, alongside the migration of over 800 historical records. By aligning with the State of Mato Grosso Digital Strategic Agenda (2023–2027), this initiative exemplifies how subnational governments can leverage digital transformation to optimize public services, enhance institutional efficiency, and foster digital inclusion. The success of SUAP in Mato Grosso provides a replicable model for other regional administrations seeking to modernize governance and ensure equitable access to digital public services.

Keywords. Applied computing, E-government, Information systems, Public Education Modernization
Research paper, DOI: https://doi.org/10.59490/dgo.2025.965

1. Introduction

Efficiency in public administration is inherently tied to the ability to deliver services effectively while optimizing resources. Digital transformation plays a crucial role in this process by integrating technologies that

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

enhance resource management and enable the development of more innovative services (Daßler et al., 2024). The implementation of digital systems allows real-time monitoring of service and project execution, thereby reducing inefficiencies and increasing transparency in public policies and resource management. However, the adoption of these technologies often faces resistance, particularly due to inadequate infrastructure and insufficient professional training, factors that may limit their expected positive impact on service quality (Silva et al., 2019).

In the context of public schools, the Unified Public Administration System (SUAP) was created in 2006. The Federal Institute of Rio Grande do Norte (IFRN) has continuously improved this software platform as a solution for digitizing administrative and academic management in public institutions. Over the years, SUAP has evolved to meet the needs of schools, universities, federal institutes, and other public organizations throughout Brazil. With a robust set of features, including approximately 24 modules designed to support institutional management, the system offers tools tailored to different user profiles, such as administrative staff, students, and contractors. By prioritizing usability, SUAP ensures an intuitive and accessible interface, establishing itself as an effective tool for institutions seeking to modernize their administrative and academic practices (Costa, 2016).

Due to its functionalities and efficiency in various institutions, SUAP was introduced into technical schools in the state of Mato Grosso as part of the project presented in this work. The SAEPT project aimed to modernize administrative and academic management through digital technologies such as cloud computing. Developed in partnership with the Institute of Computing (IC) at Federal University of Mato Grosso, Federal Institute of Mato Grosso, and the Mato Grosso State Department of Science, Technology, and Innovation (SECITECI), the project sought to improve the efficiency of school management activities, focusing on the organization of teaching and administrative processes.

This paper is organized into four main sections, in addition to this Introduction. The next section, titled *Research Methods*, outlines the objectives, methodologies, and processes used to implement SUAP and the associated technological improvements. *Background* provides an overview of the context and main challenges faced by the technical schools in the State of Mato Grosso, highlighting the need for modernization and improved management systems. In *Results and Discussion*, the outcomes of the project are presented, emphasizing the impact of SUAP on administrative efficiency and educational management. Finally, *Conclusion* reflects on the project's achievements, lessons learned, and its broader implications for the modernization of public administration and technical education.

2. Research Methods

The implementation project of the **Sistema de Gestão das Escolas Técnicas Estaduais (SAEPT)**, linked to the research project *"Application of Cloud Computing Technologies to Educational Management Environments"*, was initiated with its first meeting on January 8, 2024. This project aimed to enhance educational management through the integration of cloud computing technologies, focusing on the development and implementation of a robust Academic Management System tailored to the needs of technical schools in the State of Mato Grosso. The project was developed in partnership with the **Institute of Computing (IC)** at the **Federal University of Mato Grosso**, the **Federal Institute of Education, Science and Technology of Mato Grosso**, and the **Mato Grosso State Department of Science, Technology, and Innovation (SECITECI)**. The primary objective was to create a technological solution capable of streamlining administrative and academic processes while ensuring efficiency, scalability, and user satisfaction.

2.1. Project Phases and Methodological Approach

The project was structured into nine distinct phases, each designed to ensure a systematic and comprehensive implementation of the SUAP system. These phases are outlined below:

1. **Data Collection and Requirements Analysis**: This initial phase involved gathering data and analyzing the specific requirements of the technical schools. It included understanding existing administrative and academic processes, identifying pain points, and defining the functional and non-functional requirements for the new system. Workshops and interviews with stakeholders were conducted to ensure a comprehensive understanding of institutional needs.

2. **System Design and Customization**: Based on the collected data, the team designed and customized the SUAP system to meet SECITECI's specific requirements. This phase included developing new modules, adapting existing features, and integrating the system with platforms such as Moodle for online learning.
3. **Cloud Service Deployment and Monitoring**: The core system was deployed on a cloud infrastructure to ensure scalability and reliability. This phase involved configuring virtual machines, setting up load balancers, and implementing continuous monitoring tools to track system performance and identify potential issues in real time.
4. **System Adaptation and Optimization**: The system was further adapted to address the unique needs of individual school units. This included optimizing the user interface for different roles (students, teachers, and administrative staff) and configuring specific features such as certificate management and user permissions.
5. **Data Migration and Security**: A critical phase involved migrating historical data from legacy systems to the new platform. This process required careful planning to maintain data integrity and security. Measures such as encryption and access controls were implemented to safeguard sensitive information.
6. **System Testing and Evaluation**: Comprehensive testing was conducted to evaluate the system's performance, usability, and reliability. This included functional testing, stress testing, and user acceptance testing (UAT) to ensure the system met predefined requirements and was deployment-ready.
7. **Training and Capacity Building**: To facilitate a smooth transition, comprehensive training sessions were organized for the SECITECI IT team and end-users, including teachers, students, and administrative staff. Training materials, such as manuals, video tutorials, and interactive workshops, were developed to support user adoption.
8. **On-Site Support and Troubleshooting**: The project team provided on-site support to resolve technical issues during the initial deployment phase. This included troubleshooting, bug fixing, and real-time assistance to ensure the system operated as intended.
9. **Final Reporting and Documentation**: In the final phase, a detailed project report was prepared, documenting all stages of the implementation process, lessons learned, and recommendations for future improvements. This report serves as a valuable resource for ongoing system maintenance and scalability.

To better illustrate the sequence of interactions between the State Government, researchers, cloud infrastructure, and end-users throughout the project phases, Figure 1 presents a structured workflow diagram.

2.2. Team Structure and Collaborative Approach

The project team was organized into three main groups, each with distinct responsibilities:

- **Mapping Team**: This team documented and structured the administrative and academic processes of the technical schools. Using the **HEFLO** tool, they created detailed flowcharts in BPMN (Business Process Model and Notation) format, providing clear visualizations of workflows and identifying areas for improvement. These flowcharts were crucial for aligning the SUAP system with the actual needs of the schools.
- **Training Team**: Focused on capacity building, this team developed instructional materials and organized training sessions for diverse user groups. They created comprehensive manuals, video tutorials, and interactive workshops. The team also leveraged the **Moodle** platform to deliver online training courses, enhancing accessibility and flexibility for users.
- **Infrastructure Team**: Responsible for the technical implementation of the system, this team managed server configuration, network setup, and security measures. They ensured the system was deployed on a robust and scalable cloud infrastructure, implementing features such as data backup, redundancy, and disaster recovery. The team also configured firewalls, SSL certificates, and external monitoring tools to guarantee the system's security and reliability.

2.3. Agile Methodology and Project Management

The project adopted an **agile methodology**, specifically the **Scrum framework**, to manage tasks and ensure timely delivery. Scrum was selected for its ability to foster collaboration, increase productivity, and adapt to

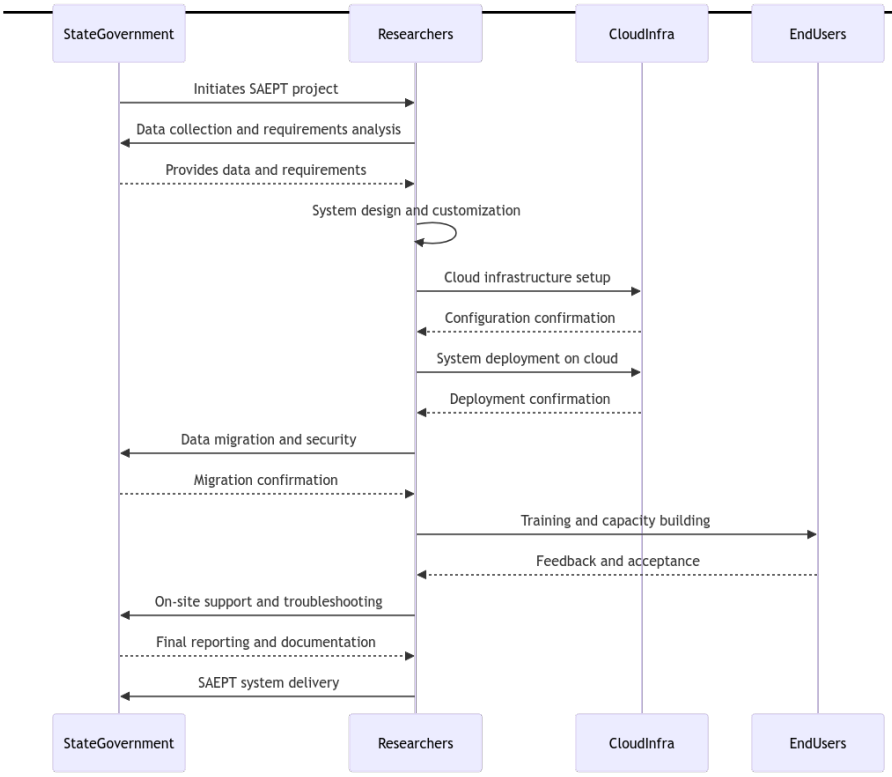


Fig. 1 – Sequence diagram of the SAEPT project phases and interactions.

changing requirements. The project was divided into **sprints**, each lasting two weeks, during which specific tasks were completed and reviewed. The use of **OpenProject**, a free software tool integrated with Scrum, facilitated task management, progress tracking, and communication among team members.

The agile approach allowed the team to quickly respond to feedback and make necessary adjustments throughout the project. Regular sprint reviews and retrospectives assessed progress, identified challenges, and implemented improvements. This iterative process ensured the final product met stakeholder needs and was delivered within the agreed timeline (Lages et al., 2024).

2.4. Communication and Project Management Tools

Effective communication and project management were essential for the successful implementation of the SAEPT project. Figure 2 illustrates the various tools and processes employed to ensure seamless collaboration and efficient management. **Meetings** were regularly scheduled to define objectives, establish actions, and record minutes, ensuring alignment among all team members. **OpenProject** was utilized to manage resources, control deadlines, and organize tasks, offering a comprehensive platform for tracking progress. For **training**, the Moodle platform facilitated certificate issuance, course delivery, and performance evaluation. Additionally, **Heflo** was employed to map workflows and monitor key performance indicators (KPIs). The **support team** played a vital role in maintaining infrastructure, providing technical assistance, automating processes, and managing the network. This structured approach was instrumental in maintaining project momentum and ensuring its successful completion.

2.5. Challenges and Solutions

One of the main challenges encountered during the project was **resistance to change** from some users, particularly those accustomed to manual processes. To address this, the training team developed tailored programs and provided ongoing support to help users transition to the new system. Additionally, a **support channel** was implemented to allow users to report issues, ask questions, and receive real-time assistance.

Another significant challenge was ensuring **data security and privacy**, especially given the sensitive nature of student and staff information. The infrastructure team implemented robust security measures, including

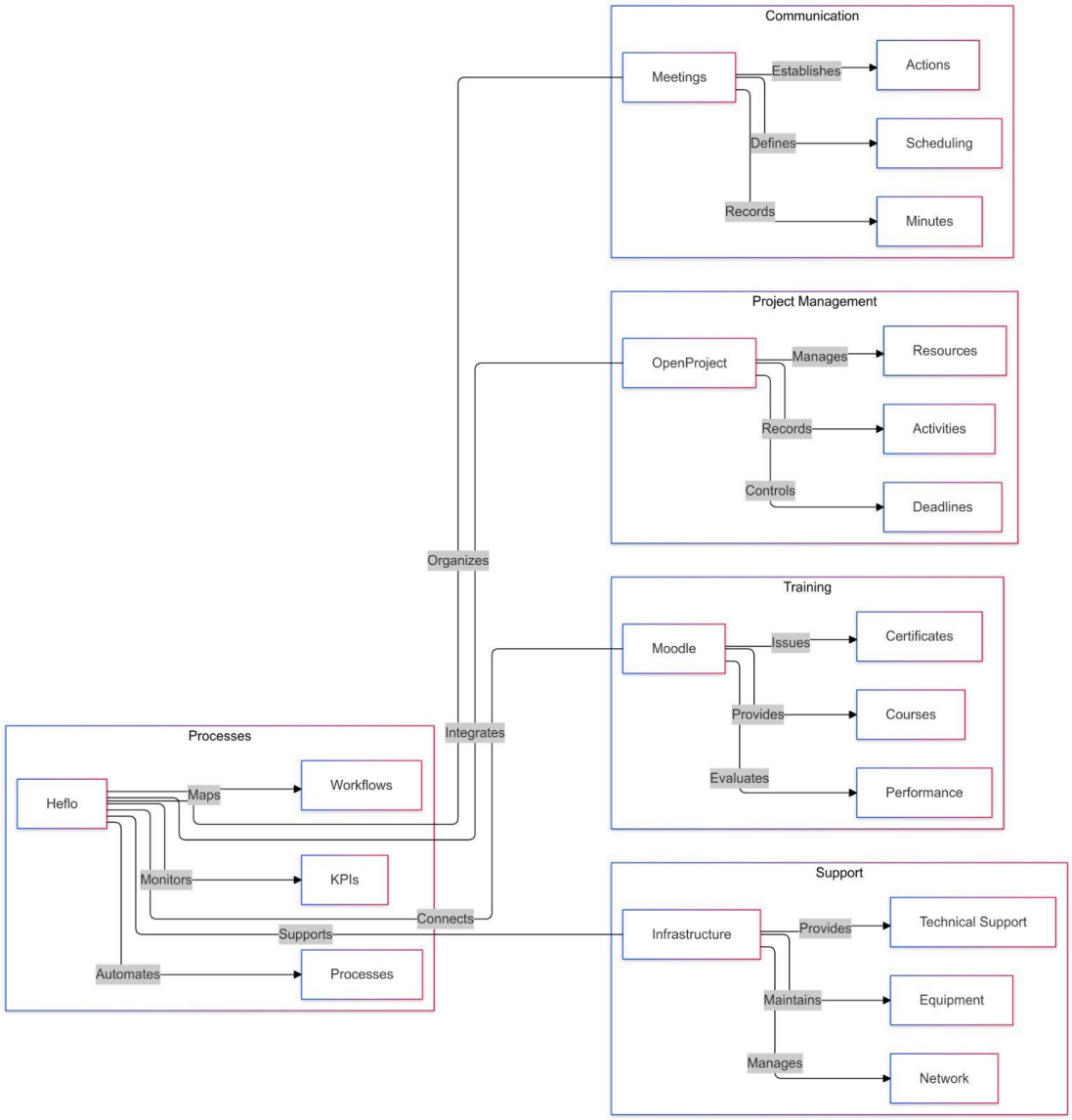


Fig. 2 – Diagram illustrating communication, project management, training, and support tools used in the SAEPT project.

encryption, access controls, and regular security audits, to protect data and ensure compliance with relevant regulations.

The methodological approach adopted in this project underscores the importance of a **collaborative and iterative process** in implementing complex technological solutions. By combining agile project management, detailed process mapping, and comprehensive training, the team successfully deployed the SUAP system in Mato Grosso's technical schools. This approach not only ensured the system's implementation but also established a foundation for future scalability and continuous improvement.

3. Background

The State of Mato Grosso, Brazil's third-largest by territorial extension, spans 903,357 km^2 in the central-west region. Its geographic and cultural richness is unparalleled, encompassing three globally significant biomes: the Amazon Rainforest, the Pantanal wetlands, and the Cerrado savanna. This biodiversity hotspot coexists with a multicultural heritage shaped by African, Portuguese, Spanish, Indigenous, and Chiquitano influences, fostering a unique socio-environmental identity (Prates, 2014). Despite efforts to preserve Indigenous traditions and ecosystems, the state's economic backbone—agribusiness and commodity exports—has driven

rapid urbanization and infrastructure demands. Between 2002 and 2022, Mato Grosso emerged as Brazil's fastest-growing state economy, increasing its share of the national GDP by 1.2 percentage points, a testament to its strategic role in national development (Instituto Brasileiro de Geografia e Estatística (IBGE), 2024).

However, this growth has exacerbated regional disparities. The state's vast territory, while economically productive, poses significant challenges for equitable access to public services, particularly in remote municipalities. Rural-urban divides are stark: while urban centers like Cuiabá (the capital) benefit from advanced infrastructure, rural areas struggle with limited connectivity and institutional support. These disparities extend to the education sector, where technical schools—Escolas Técnicas Estaduais (ETECs)—play a pivotal role in bridging workforce demands and vocational training.



Fig. 3 – State Technical Schools of Mato Grosso: Contrasting infrastructures. Left: ETEC Poxoréo (rural focus on agriculture); Right: ETEC Cuiabá (urban courses in IT, healthcare, and administration). Adapted from (Secretaria de Ciência, Tecnologia e Inovação de Mato Grosso (SECITEC), 2024).

As illustrated in Figure 3, the dichotomy between rural and urban ETECs reflects the state's socio-economic contrasts. ETEC Poxoréo, located 250 km from the capital, prioritizes agricultural and animal husbandry programs tailored to local agrarian needs. In contrast, ETEC Cuiabá offers advanced courses in Information Technologies, Nursing, and Occupational Safety, supported by modern IT infrastructure. This disparity underscores the need for adaptable administrative systems capable of addressing diverse regional requirements while maintaining statewide coherence.

The 17 ETECs across Mato Grosso currently serve approximately 1,750 students through partnerships between the State Department of Science, Technology, and Innovation (SECITECI) and the State Education Secretariat(SEDUC). By 2025, the network aims to expand to 4,000 enrollments across 25 courses, including integrated high school programs and post-secondary vocational training (Téo Meneses, 2024). Yet, until recently, administrative practices lagged behind these ambitions. Manual processes, such as spreadsheet-based student record-keeping, dominated operations, leading to frequent errors, data fragmentation, and inefficiencies in interdepartmental coordination. These limitations hindered scalability and contradicted the state's modernization goals.

To address these challenges, the Government of Mato Grosso launched its Digital Strategic Agenda (2023–2027) through Decree No. 338/2023. This policy framework prioritizes digital transformation in pub- lic administration, emphasizing bureaucracy reduction, innovation, and cross-sectoral technological integration (Governo de Mato Grosso, 2023). Within this context, the Unified Public Administration System (SUAP) emerged as a cornerstone for modernizing technical education management. Originally developed by the Federal Institute of Rio Grande do Norte (IFRN) in 2006, SUAP's modular design and focus on usability align with Mato Grosso's objectives to streamline workflows, automate certificate issuance, and centralize data across geographically dispersed institutions. By adopting SUAP, the state aims to harmonize its dual identity: preserving regional specificity while advancing toward a digitally unified governance model.

4. Results and Discussions

The team, divided to meet the project's demands within the agreed timeline with the institution, carried out its activities in an integrated and focused manner to achieve the project's objectives. Each team played specific yet complementary roles that were essential to the initiative's success.

With the deployment of all software tools, the teams adopted an agile methodology akin to Scrum to carry out the overall activities. The workflow was structured into groups of sprints, with each sprint spanning two weeks. Each team developed a backlog listing all deliverables, which were then prioritized and allocated to specific sprints. New requests were added to the backlogs as they arose and followed the same process.

The Mapping team was responsible for creating detailed workflows using the Heflo software tool, mapping the steps for utilizing the system's functionalities, such as adding sectors, enrolling students, and other activities. Figure 4 illustrates one of these workflows, detailing the process of enrolling in a school diary. The process begins with navigating through the "Teaching" menu, followed by searching for and selecting the student, and culminating in the confirmation of the enrollment. Complementing this work, PDF manuals enriched with images were created to clearly explain the system's features. These initiatives not only facilitated user understanding but also enabled the team to perform system testing, ensuring its functionality and alignment with the project's requirements.

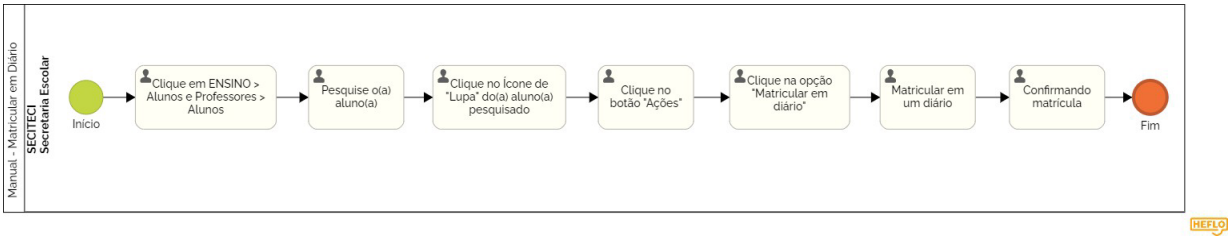


Fig. 4 – Example of process mapping: Enrollment in a course

Additionally, the team developed a website with the goal of centralizing and providing support materials in a practical and accessible manner. In Figure 5, it is possible to see that the homepage of the site presents tutorials and workflows detailing the system's functionalities, providing easy access to essential information. The platform organizes PDF manuals, tutorial videos produced by the training team, as well as news related to the training sessions. The site was structured into specific sections covering administrative features, teachers, students, training, and process workflows, allowing intuitive navigation and targeted support for the different needs of users.



Fig. 5 – Home page of the website of the project, where tutorials and workflows detailing the system's functionalities are readily available.

I record the administrative and pedagogical processes of the institutions, such as school registration actions, teachers' activities, and the organizational structure of schools and the SECITECI headquarters. These assessments were crucial in adjusting the system to the specificities of each institution, ensuring that the main routines were taken into account. Furthermore, the team created detailed flowcharts of the planned interactions for the new system, using the Heflo tool to generate BPMN-format mappings. These diagrams documented steps such as the student's first access to the system, overall grade history, and teachers' use of the class journal, among others. The flowcharts played a strategic role, serving not only to validate the system but also as training material for users, facilitating the understanding of functionalities by both students and staff.

The training team devoted itself to the capacity building of different user groups, including managers, teachers, students, and administrative teams from state technical schools and SECITECI. Their activities focused on creating instructional materials, manuals, and in-person and online training sessions to ensure a smooth transition and mastery of the system's functionalities by the involved parties. The manuals developed included

detailed, step-by-step guides for various system operations that are essential to the daily routines of technical school units, as can be seen in Figure 6. These operations included ticket submission, grade entry, transfers, enrollments, and the issuance of certificates and diplomas, among others. Additionally, the team produced materials specifically tailored for students, covering actions such as system access, grade consultation, and credit recognition requests.

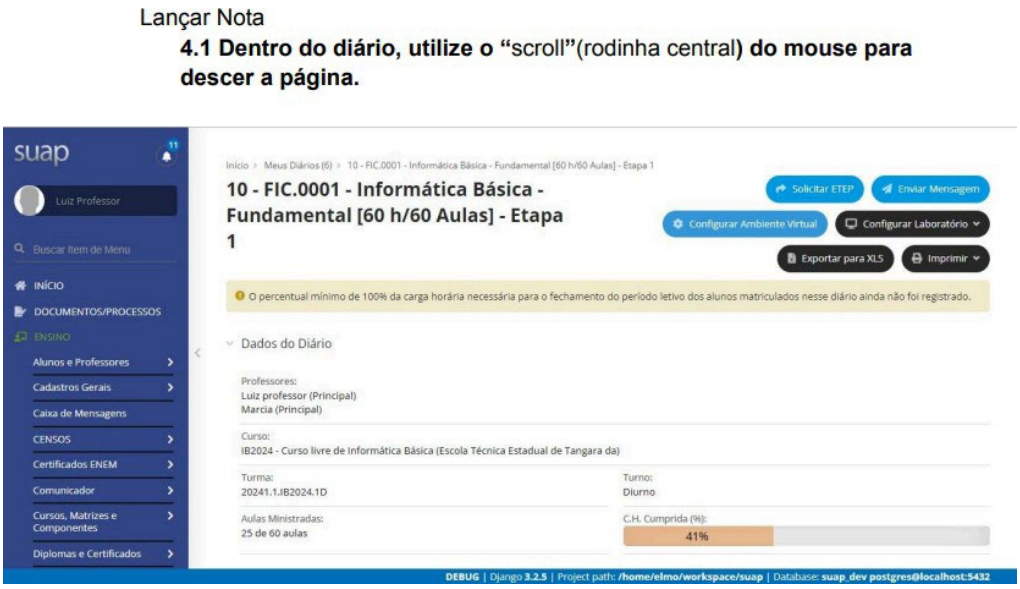


Fig. 6 – Example of PDF Manual: How to Enter Grades.

A notable highlight was the creation of multimodal content, including tutorial videos and diagrammed presentations, which significantly facilitated the assimilation of information. The team developed scripts, recorded and captioned video lessons, and configured a Moodle platform for course delivery. These materials were further enriched with asynchronous content, available in both video and PDF formats for future reference. Interactive resources, such as Kahoot quizzes, were also employed to provide a dynamic and engaging learning experience. This combination of synchronous and asynchronous learning formats enables a more personalized educational journey, catering to the individual needs of students and fostering self-directed learning (Chernov et al., 2021). As illustrated in Figure 7, an example of a video tutorial published on YouTube by the training team showcases this approach. In total, 47 tutorials were produced, combining text and video formats, covering the main functionalities of SUAP. These resources were designed to train users and ensure the efficient use of the system (Universidade Federal de Mato Grosso & Núcleo de Tecnologia da Informação (NUTI), 2024).



Fig. 7 – Example of a video tutorial published on YouTube by the training team.

Tr ts, including in-person sessions, online synch hese varied formats allowed the training to

reach a diverse range of users effectively. Thus, the methodology was tailored to meet the specific needs of each group, with personalized training for managers, teachers, and administrative staff. In Figure 8, one of the in-person training sessions held with school managers is highlighted. The environment fostered direct interaction between participants and the training team, creating a conducive space for addressing questions and collaborative learning. During these sessions, participants received guidance on critical functionalities and had the opportunity to ask questions about the use of the SUAP system. The Moodle platform was used as the main training environment. This included creating specific courses for each audience, preparing classes with test student data, organizing content into stages, and adding explanatory videos and PDFs. This effort ensured that all users had access to clear and accessible resources, promoting autonomy in using the system.



Fig. 8 – One of the several training sessions conducted with the school managers.

The infrastructure team was responsible for ensuring that the technological architecture was functional and aligned with the project's demands. The activities included from the initial configuration of servers to the continuous monitoring and maintenance of the virtual machines (VMs) that support the system. Among the first actions carried out, the requirements gathering and the configuration of the production environment stood out, including the installation of SUAP and auxiliary servers such as Moodle and OpenProject. This stage involved complex adjustments, such as the configuration of Django servers with Gunicorn and PostgreSQL databases, in addition to the creation and testing of DNS entries for the various services used.

The team focused its efforts on adapting and optimizing the technological environment, performing tasks such as firewall configuration, SSL certificate management for secure system access, and external server monitoring. Furthermore, specific configurations were customized, such as adjustments to the upload capacity of the Moodle training environment and modifications to SUAP to meet institutional needs, including certificate issuance and user permission management. As illustrated in figure 9, it is possible to see one of the pages of the Moodle platform, essential as an asynchronous teaching tool, enabling a flexible learning experience tailored to the users' needs (Archan & Egger, 2023). Regarding technical support, a support channel was created to clarify user questions, solve technical issues, and identify and correct system bugs.

To ensure the continuity of the project and the protection of data, backup systems, redundancy and failure recovery solutions were implemented and new servers were configured, creating a robust and reliable infrastructure, enabling the system to withstand adverse situations.

The implementation of SUAP in the technical schools of the State of Mato Grosso was achieved through the collective efforts of the project teams, representing a milestone in the modernization of administrative and academic management in the state's technical education system. As a centralized platform, SUAP streamlines processes, enhances user experience, and addresses the specific needs of these institutions. With 719 students, 124 technical staff members, 190 teachers, and 800 records of previous courses already registered, the impact and scope of the system are evident (Universidade Federal de Mato Grosso & Núcleo de Tecnologia da Informação (NUTI), 2024). By fostering more efficient management, SUAP directly benefits administrators, teachers, and students, laying a solid foundation for future improvements and expansions in educational infrastructure. As shown in Figure10, the SUAP login screen provides secure access to different users, facilitating



Fig. 9 – Web page of the Moodle platform, where online training and activities were made available for managers and students.

their interaction with the platform.

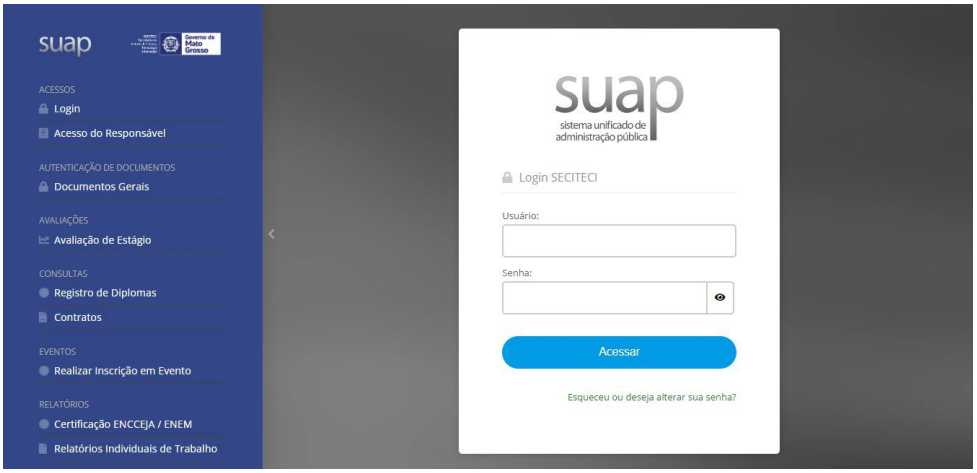


Fig. 10 – Login screen of the SUAP system

Additionally, the homepage (Figure 11) centralizes administrative and academic functions. This initiative reinforces the state's commitment to modernizing public administration, contributing to efficiency and innovation in the educational sector (Governo de Mato Grosso, 2023).

5. Conclusions

The successful implementation of SUAP in the technical schools of Mato Grosso highlights the role of digital government in fostering social cohesion and reducing inequalities through technological innovation in public administration and education. By modernizing administrative processes and integrating digital tools, this initiative has not only enhanced efficiency in school management but also contributed to a more equitable and inclusive education system, particularly in a geographically and socioeconomically diverse state like Mato Grosso.

One of the most significant impacts of this project has been its ability to bridge the digital divide between urban and rural technical schools. Historically, schools in remote areas have faced challenges such as limited administrative support, fragmented student records, and inefficient communication channels. The deployment of SUAP has mitigated these issues by centralizing data, automating processes, and providing digital access to educational and administrative resources, ensuring that all institutions—regardless of their location—operate under the same robust governance framework. This harmonization of school management practices directly

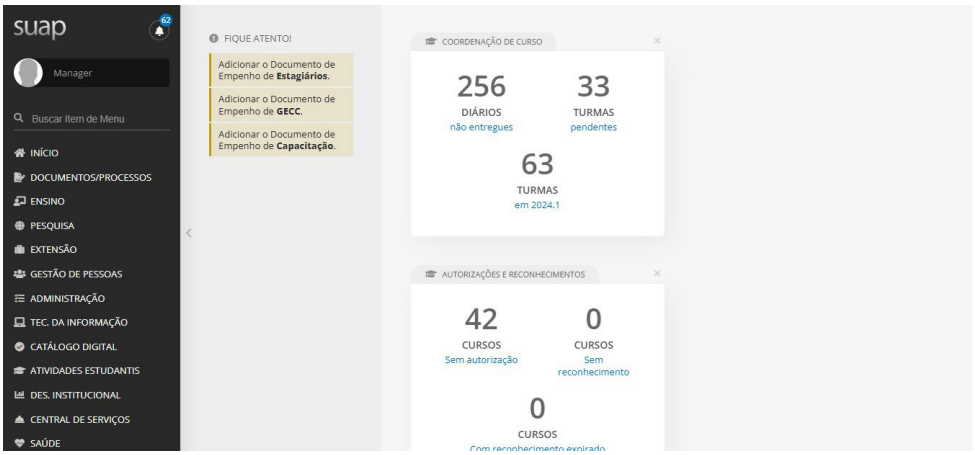


Fig. 11 – Home page of the SUAP system.

contributes to reducing educational disparities and promoting social cohesion by guaranteeing equal access to high-quality institutional support.

Beyond improving internal efficiency, SUAP has also fostered greater transparency and accountability in educational governance, reinforcing public trust in digital government initiatives. The integration of cloud computing, secure authentication mechanisms, and real-time monitoring has enhanced data security and accessibility, empowering both educators and policymakers to make informed decisions. Moreover, by streamlining bureaucratic processes and minimizing administrative inefficiencies, the system has allowed technical schools to focus more on their core mission: providing students with the skills and knowledge necessary for their social and professional development.

This initiative aligns with Mato Grosso's broader Digital Strategic Agenda (2023–2027), which prioritizes digital transformation as a tool to enhance public services, reduce bureaucracy, and foster innovation. The success of the SAEPT project underscores how digital governance can drive institutional modernization, facilitating the delivery of more effective and people-centered services. Furthermore, this case study demonstrates how public sector digitalization can be leveraged not only to optimize workflows but also to create more inclusive policies that address systemic inequalities.

The lessons learned from this project provide a replicable model for other regions seeking to implement digital solutions in education and beyond. Future developments should focus on further expanding SUAP's functionalities, integrating predictive analytics for decision-making, and incorporating adaptive learning tools to support students from diverse backgrounds. Additionally, sustained investment in digital literacy programs for educators and administrators will be essential to ensuring the long-term sustainability and effectiveness of the system.

Ultimately, this project reaffirms the transformative potential of digital government in fostering social cohesion and reducing inequalities in public education. By leveraging technology as a mechanism for inclusion, transparency, and efficiency, SUAP serves as a concrete example of how digital governance can empower communities, strengthen public institutions, and create more equitable educational opportunities. As digital government continues to evolve, initiatives like this will play a crucial role in ensuring that technological advancements serve as a catalyst for social and economic development, reinforcing education as a fundamental pillar of a just and cohesive society.

Acknowledgement

- **Funding or Grant**: Research funded by the Mato Grosso State Department of Science, Technology, and Innovation (SECITECI).
- **Contributor Statement**:Conceptualization, Writing – Original Draft: Suellen Lages, Pedro Clarindo da Silva Neto, Elmo Batista de Faria, Josiel Maimone de Figueiredo Writing - Review & Editing: Suellen

Lages and Arthur Octávio Oliveira Confessor; Methodology: Suellen Lages and Pedro Clarindo da Silva Neto; Supervision: Pedro Clarindo da Silva Neto, Elmo Batista de Faria, Josiel Maimone de Figueiredo

- **Use of AI**: During the preparation of this work, the authors used ChatGPT in order to translate the article into English. After using this tool, the authors reviewed, edited, made the content their own and validated the outcome as needed, and takes full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest

References

Archan, D., & Egger, C. (2023). The promotion of teaching excellence via an asynchronous moodle course. *INTED2023 Proceedings*, 5125–5132. DOI: https://doi.org/10.21125/inted.2023.1329.

Chernov, V., Klas, S., & Shaharabani, Y. F. (2021). Incorporating kahoot! in core engineering courses: Student engagement and performance. *Journal of Technology and Science Education*, *11*(2), 486–497. DOI: https://doi.org/10.3926/JOTSE.1269.

Costa, M. M. d. N. (2016). Análise da usabilidade do sistema unificado de administração pública (suap) do ifrn [Trabalho de Conclusão de Curso, Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte - Pau dos Ferros]. http://memoria.ifrn.edu.br/handle/1044/919

Daßler, L., Hein, A., & Krcmar, H. (2024). Innovating public services: Drivers and challenges of innovation labs in the co-production of e-government services. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 711–720. DOI: https://doi.org/10.1145/3657054.3657138.

Governo de Mato Grosso. (2023). Decreto nº 338, de 20 de junho de 2023 - institui a agenda estratégica digital do governo de mato grosso ara o período de 2023 a 2027 [Acessado: 26 de setembro de 2024]. https : / / app1 . sefaz . mt . gov . br / Sistema / Legislacao / legislacaotribut . nsF / 07fa81bed2760c6b84256710004d3940/608a79e5ffaf057c042589dc004b9ad5?OpenDocument

Instituto Brasileiro de Geografia e Estatística (IBGE). (2024, November). Em 2022, PIB cresce em 24 unidades da federação [Editoria: Estatísticas Econômicas | Irene Gomes | Arte: Helga Szpiz]. Retrieved December 19, 2024, from https: / / agenciadenoticias. ibge. gov. br/ agencia- noticias/ 2012- agencia- denoticias/noticias/41893-em-2022-pib-cresce-em-24-unidades-da-federacao

Lages, S., Confessor, A., Neto, P., Faria, E., & Figueiredo, J. (2024). Metodologias ágeis aplicadas na automatização da gestão acadêmica de escolas técnicas do estado de mato grosso. *Anais do XII Workshop de Computação Aplicada em Governo Eletrônico*, 269–271. DOI: https://doi.org/10.5753/wcge.2024.2022.

Prates, F. (2014, August). *A rica diversidade cultural de mato grosso*. SECEL. Retrieved December 19, 2024, from https://www.secel.mt.gov.br/-/a-rica-diversidade-cultural-de-mato-grosso

Secretaria de Ciência, Tecnologia e Inovação de Mato Grosso (SECITEC). (2024). Fotos: Galeria de Fotos | Banco de Imagens [Accessed: 2024-01-08]. https://www.secitec.mt.gov.br/fotos

Silva, J. C. S., Procópio, D. B., & Mello, J. A. V. B. (2019). O impacto da tecnologia da informação na administração pública: Uma revisão sistemática. *P2P E INOVAÇÃO*, *6*(1), 191–205. DOI: https://doi.org/10.21721/p2p.2019v6n1.p191-205.

Téo Meneses. (2024, November). *Seciteci apresentadados daeducaçãoprofissional e tecnológicade Mato Grosso durante evento nacional* [Acessado em: 13 de novembro de 2024]. SECITECI. https://www.secitec.mt.gov.br/w/seciteci-apresenta-dados-da-educa%C3%A7%C3%A3o-profissional-e-tecnol%C3%B3gica-de-msto-grosso-durante-evento-nacional

Universidade Federal de Mato Grosso, I., & Núcleo de Tecnologia da Informação (NUTI). (2024). *SAEPT: Implantação de sistema de gestão acadêmica. Documento de Homologação Final* (tech. rep.). Universidade Federal de Mato Grosso. Cuiabá, Brasil.

The implementation of an integrated education data system at national level: the Sistema Gestão Presente.

Fabíola Peres [a], *Carla* Silva [b], *Ana Beatriz* Fernandes[c].

[a] Núcleo de Excelência em Tecnologias Sociais (NEES), Universidade Federal do Alagoas (UFAL); Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Antropologia, Porto Alegre, RS, Brazil.

fabioladecarvalholeite@gmail.com

[b] Núcleo de Excelência em Tecnologias Sociais (NEES), Universidade Federal do Alagoas (UFAL); Universidade Federal do Rio Grande do Sul, Programa de Pós-Graduação em Políticas Públicas, Porto Alegre, RS, Brazil.

carla.silva@nees.ufal.br

[c] Núcleo de Excelência em Tecnologias Sociais (NEES), Universidade Federal do Alagoas (UFAL); Universidade de Brasília (UnB), Brasília, Brazil. anabeatriz.fernandes@nees.ufal.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. This article analyzes the implementation of the Sistema Gestão Presente, an initiative of NEES (UFAL) in partnership with the Ministry of Education for the interfederative integration of educational data, with the aim of optimizing data management and supporting educational programs at a national level. This study highlights the main challenges faced during the process of implementing this system, using as a repertoire the discussion about data governance, which has already existed in Brazil for some decades. Based on focus groups, one-on-one meetings, discussion groups and experience reports, the article brings together challenges and strategies in four categories: 'Programa Pé-de-Meia business rules challenges', 'Service challenges', 'Follow-up and monitoring challenges' and 'Technological challenges'.

Keywords. data governance, implementation, public policies, education.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.967

1. Introduction

Digitalization has become a strategic priority for many governments around the world, especially about data governance and the implementation of public data management systems. The integration of educational data, in particular, has proved to be a complex but crucial challenge for improving public policies in the education sector. In Brazil, one of the most recent and significant examples of this attempt at digital transformation is the Sistema Gestão Presente, an initiative aimed at the interfederative integration of educational data at a national level. Developed by the Núcleo de Excelência em Tecnologias Sociais (NEES/UFAL) in collaboration with the Ministry of Education (MEC), this system seeks to optimize the management of educational information and subsidize important programs, such as the Programa Pé-de-Meia.

However, implementing such a comprehensive and complex system is no simple task, and various challenges arise along the way. Interfederative integration between states, municipalities and the federal government, which is necessary for the Sistema Gestão Presente to be fully operational, requires harmonization of data, standards and protocols that are often difficult to establish, given the diversity of local realities and the lack

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of adequate infrastructure in some regions. Furthermore, implementing digital systems in public contexts involves overcoming obstacles related to political, cultural and organizational issues. In this scenario, understanding the challenges faced by subnational governments (states, municipalities and other federative entities) and the strategies adopted to overcome them is fundamental to the success of digital transformation in the education sector.

The aim of this article is to identify the main challenges faced in implementing the Sistema Gestão Presente and to report on the strategies developed to deal with them. Through this case study, which takes on the characteristics of an action research project, the experiences of the different actors involved in the process were analyzed, with an emphasis on the follow-up and monitoring methodologies, meeting local demands, and the specifics of the qualification criteria for the Programa Pé-de-Meia. This study is part of the broader context of digital transformation in the public sector and contributes to understanding the obstacles and solutions applied in the process of educational data governance between the different federal levels of government.

The methodology adopted for the research is mostly qualitative, with a case study of the Sistema Gestão Presente. For data collection, focus groups were used, as well as one-on-one meetings, discussion groups and experience reports from the system users. The data was analyzed using content and discourse analysis techniques, allowing for a deeper understanding of the dynamics involved in implementing the system and the different strategies developed to overcome the challenges identified. The analysis also made it possible to identify lessons learned and good practices that can be applied in similar contexts.

The results obtained show that various strategies have been implemented to ensure the effectiveness of the Sistema Gestão Presente. Data visualization tools were created, such as Business Intelligence (BI) and reports aimed at different actors, with a view to continuous monitoring and follow-up. General and specific training was provided, as well as individualized support according to the needs of each case. In the context of the Programa Pé-de-Meia, specific functionalities were developed, such as the identification of people deprived of their liberty and new functionalities aimed at Youth and Adult Education (Educação de Jovens e Adultos - EJA). Finally, the system now has additional features, such as the ability to activate and inactivate enrolments and send data in .xsl file format, optimizing the management of educational information.

2. Methodology

The fact that this research team also manages the implementation of these policies means that the process of identifying the challenges and defining the strategies to solve them has the characteristics of 'action research'. According to Foster (1971), this is a

> type of applied social research, which differs from other varieties by the immediate involvement of the researcher in the action process and where the intention of the parties is to get involved in the change that comprises the properties of the system itself.

This methodology aims to investigate and solve a problem at the same time, in other words, “it has a dual commitment: to find and implement solutions to problems” (Drago, 1989, p. 66). The action research that led to the reflections and improvements listed in this article is in line with the in itinere evaluation process that management and monitoring coordination carry out during the policy implementation stage. This is the category of evaluation that takes place during implementation and corresponds to monitoring, the purpose of which is to monitor processes and make the necessary adjustments to policies (Secchi, 2015).

Each of the challenges listed in this text (Programa Pé-de-Meia business rules challenges; Follow-up and monitoring challenges; and Technological challenges) had its own techniques for collecting data and identifying problems, as well as methodologies for structuring strategies to solve or mitigate them. In general, the vast majority used qualitative survey techniques, with the exception of the Follow-up and Monitoring Challenges, where qualitative and quantitative data analysis techniques were combined. The table below systematizes the techniques used by each of the fronts:

Fig. 1 - Research techniques used in each of the axes of analysis.

Analytical axis	Mapping the challenges	Definition of strategies
Business rules challenges of the Programa Pé-de-Meia	One-on-one meetings and discussion groups between consultants and operators.	Focus groups, participant observation and discourse analysis of technical reports.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Follow-up and monitoring challenges	Discussion groups with consultants and federal managers, as well as ex-post monitoring of implementation (clustering and analysis of quantitative data).	Discussion groups with federal managers, implementation teams and data scientists and dynamic mapping of user experience of interaction with the tools.
Technological challenges	One-on-one meetings and discussion groups between consultants, operators and federal managers.	Discussion groups between the technological development team, the implementation team and federal managers, followed by technical action to implement improvements to the system.

In the case of the Programa Pé-de-Meia Business Rules Challenges, in typical action-research fashion, data and information were collected during the implementation process by the implementing agents themselves - consultants who have constant contact with the Secretariats during the 15-day data submission window each month. The difficulty was detected through contact with the operators of the networks that offer EJA, in one-on-one meetings and discussion groups held between August 26 and September 13, 2024. To define the strategies for incorporating EJA into the PDM system and business rules, focus groups were held with all the state networks, online, between September 19 and 24, 2024.

The groups were divided so that there were three state networks in each room, with the exception of the state of Rio Grande do Sul, which had to be interviewed individually due to unforeseen circumstances. The rooms were divided as follows: (1) Acre, Paraíba, Goiás; (2) Amapá, Rondônia, Minas Gerais; (3) Rio Grande do Norte, Roraima, Sergipe; (4) Pernambuco, Paraná, Tocantins; (5) São Paulo and Maranhão; (6) Rio Grande do Sul; (7) Alagoas, Pará, Rio de Janeiro; (8) Amazonas, Distrito Federal, Mato Grosso; (9) Ceará, Mato Grosso do Sul and Santa Catarina. Subsequently, a discourse analysis of the meeting minutes, participant observation and a technical report were carried out.

As with the previous challenge, the identification of the Follow-up and Monitoring Challenges comes from the experience of the researcher-authors themselves, who work in and manage the policy implementation process. Therefore, the action-research process itself made it possible to map out these challenges, either through the demands for data received in discussion groups with the implementation consultants and the Federal Managers, or through the in itinere evaluation inherent in the policy cycle. The implementation process itself, therefore, and its actors, raised the need for monitoring, clustering and analysis of the data received by the System. In order to overcome this challenge, discussion groups were held with federal managers, implementation teams and data scientists between October 2024 and February 2025, in addition to mapping the user experience of interacting with the data visualization tools created. The process of creating the tools began in August 2024, and the stages of delivering the monitors and dashboards have already begun, with all the products expected to be delivered by the end of the first half of 2025.

In the case of the Technological Challenges, the process has different characteristics from the others, mainly because it involves direct changes to the system itself. The consultants continued to be key players in mapping the challenges, in addition to the group meetings and technical reports issued. These challenges were identified in individual meetings between the consultants and the networks and in discussion groups with the networks, held daily during the 15-day window for sending data in the month. These moments of collective discussion with the networks take place online, are led by the implementation team and are open to all those who have signed up to the Sistema Gestão Presente.

The demand to improve the system's ability to receive files in .xls format arose during the first data submission window, which took place from April 3 to 12, 2024, but gained momentum during the following window, between May 2 and 10 of the same year. On the other hand, the improvement in viewing multiple enrollments was not directly raised by the Networks, but was observed in the operators' reports to the consultants in the individual meetings and collective discussions of the June (June 1-14, 2024) and July (July 29-August 9, 2024) windows.

The solutions to the problems identified were already clear during their mapping. However, it took an effort on the part of the technological development team to implement these changes in the system. After opening an internal protocol on these demands for improvements, various discussion groups were held between the technological development team, the implementation team and federal managers, leading to technical action to implement improvements to the system. From the detection of the challenge, through the discussion stages, to the system improvements, it took five months of work on each demand.

The methodological procedures used both for mapping the challenges and for defining the strategies reinforce the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

importance of combining action research and in itinere analysis of the public policy implementation process. Although each of the challenges listed here has its own particularities in terms of the techniques used, all the strategies have a common goal: inducing the use of the system by the adhering Networks and improving the platform's user experience.

3. Data Governance in Brazil

According to ENAP (2019) "the government is an information institution": it consumes information and produces information. "Its performance, in all areas, is linked to this information". From this understanding, and in view of the digital revolution that processes, data and functions have experienced in the last 50 years, trends and changes in previously established management models have emerged. Along these lines, Enap (2022) cites the "New Public Governance" as a model that "seeks to meet the demands of an increasingly complex society from a network approach with various actors to govern" (Enap, 2022, p. 4), and which involves aspects such as the promotion of e-government, the intention of open government and the integrated development of services together with the government.

In this ecosystem, one of the strands linked to NPG is identified as "Digital Age Governance" (DEG) and represents a trend developed from the facilitation of ICTs (Information and Communication Technologies). This strand is characterized by "the incorporation of various political, cultural and institutional systems" (Fraga, 2020). It is in the context of this administrative reform, based on an innovative context such as digital transformation, that new governance practices are being designed and implemented. A major challenge for public institutions in this scenario is not to repeat, in the virtual environment, the shortcomings of physical structures, such as confusing government information that is ill-prepared to meet new social demands (Nogueira Junior, 2019).

Within the scope of the Digital Age Governance (DAG) fronts, a specific approach is being developed for data management in the context of digital transformations, e-government and open government. The term "Data Governance" is used to describe this approach. According to Enap (2019, p. 5),

> in short, Data Governance is responsible for managing the principles of organizing and controlling data and information. This management involves interfacing with various other functions and establishes corporate policies and guidelines for governing data, as well as assigning roles and responsibilities.

Data Governance covers a very broad scope, going beyond simply defining norms and standards, or controlling and allowing access to information. It also involves a more detailed approach to the organization's strategic data, analyzing and designing the processes that produce and consume it. In this vein, Enap (2019, p. 5) further defines Data Governance as the set of policies, processes, people and technologies that have the "objective of improving the efficiency of management processes and data quality, in order to promote operational efficiency, as well as guaranteeing the reliability of information that supports decision-making".

In Brazil, digital government actions began to be structured in the 2000s. With the aim of prioritizing the use of ICTs to democratize access to information, expand popular participation in the construction of public policies and improve the quality and effectiveness of services to citizens, the "Electronic Government" (e-Gov) was built. This project was a milestone in the development of e-government in the country, materialized in the adoption of digital platforms and the availability of public services online, and represented Brazil's accompaniment of international trends in the digitalization of public administration, aligning itself with global initiatives to promote greater transparency, efficiency and digital inclusion.

The development of Data Governance strategies in Brazil by the federal government has become increasingly important in recent years, with the aim of guaranteeing the efficient and secure management of public information. The creation of national policies, such as National Open Data Policy[1] and the Lei Geral de Proteção de Dados Pessoais (LGPD) (National Open Data Policy and the General Data Protection Law)[2], for example, illustrate the commitment to promoting transparency in access to data and guaranteeing the privacy and security of personal information. Figure 2 shows the timeline of actions involving Data Governance in Brazil, within the scope of the Federal Government:

Fig. 2 - Timeline: evolution of Data Governance in Brazil.

2000	2001	2002	2003	2004

[1] A set of guidelines and strategies established by the Brazilian government under Decree No. 8,777 of May 11, 2016, to promote transparency and make public data available in an accessible, structured and open way to the population.

[2] The Lei Geral de Proteção de Dados Pessoais (LGPD) (The General Personal Data Protection Law), Law No. 13,709, was sanctioned on August 14, 2018 and came into force in September 2020. It establishes rules on the collection, storage, use, processing and sharing of personal data in Brazil, with the aim of guaranteeing citizens' rights to privacy and the protection of their personal data.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- Policy E-gov - Social Information Program - Electronic Government Executive Committee (CEGE)	- Public Infrastructure Keys - E-Government Portal	- Website Rede Governo	- Infovia Brasília Network Communications - Management Committee for the Internet in Brazil	- Portal da Transparência (Transparency Portal)
2005	**2006**	**2007**	**2008**	**2009**
- E-governo Interoperability (e-ping) - Website E-procuração - National Program for Public Management/ Debureaucratization	- Portal da Inclusão Digital (Digital Inclusion Portal) - Survey of the Evolution of Services with e-Government Indicators	- Electronic Government Accessibility Model (eMAG) - Accessibility Site Evaluator (ASES)	- Web Standards (ePWG) - National Spatial Data Infrastructure (NSDI) - General Information Technology Strategy (EGTI)	- Citizen's Decree: simplification and integration of public services
2010	**2011**	**2012**	**2013**	**2014**
- National Broadband Program - ICT e-Government Survey	- Interministerial Committee for the National Open Government Action Plan	- Accessible websites for people with disabilities - Access to Information Act - National Open Data Infrastructure (INDA) - Brazilian Open Data Portal	- Digital Cities Program - Decree no. 8.135: Data communication with the federal government	- Civil Rights Framework for the Internet - VLibras (automatic digital translator of Libras through the Brazilian Sign Language) - Digital Government Identity - Decree No. 8.243: Social Participation in National Policy - Portal Participa.
2015	**2016**	**2017**	**2018**	**2019**
- Brazil Much Simpler Program - National Electronic Process (PEN)	- Decree No. 8.638: Digital Governance Policy - Digital Governance Strategies (EDG) - Decree 8.777: Open Data Policies - Digital Citizenship Platform - Decree No. 8.789: Federal Data	- Decree No. 9.094: Simplification of the Public Service - Decree No. 9.203: Federal Governance Policy - Govdata platform launched - Forecast of services using "Brazilian Citize"	- Decree No. 9.319: National Digital Transformation System and Brazilian Strategies for Digital Transformation (EDigital) - Order no. 107: revised version of the Digital Governance Strategies (DGS) - General Data Protection Law (Law No. 13.709/2018)	- Decree No. 10.046: Data Sharing Governance and Citizen Base Register and the Central Data Governance Committee - Decree No. 9.723: establishes the CPF as a sufficient instrument and substitute for the presentation of other documents - Decree No. 9.929: National Civil Registry Information System – Sirc
2020	**2021**	**2022**		
- Decree No. 10.332: Digital Government Strategy for the period 2020 to 2022 - 18 strategies and more than 50 initiatives with a portfolio of more than 1000 digital transformation projects - Decree No. 10.403: Governance in Data Sharing and the Citizen's Base Register and the Central Data Governance Committee.	- Law 14.129/2021: Digital Government to increase public efficiency	- Decree No. 10.996 of March 14, 2022, amends Decree No. 10.332 of April 28, 2020, which establishes the Digital Government Strategy for the period 2020 to 2022 - brings GovTechs closer to the country's digital transformation actions.		

It is on the path (and in the qualification) of these technologies that the Sistema Gestão Presente emerges. At the same time as establishing government policies and guidelines for collecting and sending educational data at national level, the partnership between NEES and MEC develops and strengthens the management of this data, with the aim of qualifying and guaranteeing the reliability of the information that supports important decision-making. Data interoperability and cross-referencing with other government databases (Gestão Presença,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

CadÚnico, Receita Federal, Inep, Ideb) are just some of the innovations proposed by the SGP, which has undoubtedly drawn on many lessons learned at the forefront of Data Governance in Brazil.

Interoperability frameworks, digital identity systems and data infrastructure are among the most common key enablers mobilized to promote an environment conducive to the dynamics necessary for the growth of digital government.

The Sistema Gestão Presente

Developed by the Center of Excellence in Social Technologies (NEES/UFAL) for the Ministry of Education, the Sistema Gestão Presente (SGP) is the latest innovation in data governance in Brazil. Recently institutionalized by Mec Ordinance No. 234, of April 2, 2025, the SGP is part of the "MEC Gestão Presente - Basic Education Data Platform", which aims to

> foster and adopt digital government instruments in the management of basic education policy, at federal, state, district and municipal levels, in order to ensure that school information is collected and shared in a standardized and effective manner (BRASIL, 2025).

The formalization of the Sistema Gestão Presente in the Ordinance confirms the commitment in Brazil, mentioned by OECD (2018, p.116), to develop digital government through "legislation that regulates the use of digital technologies in the public sector, the economy and society". The platform gathers data related to education across the country, integrating state, municipal and federal networks, from basic education to higher education. The aim of the system, in addition to becoming a robust database of education in Brazil, is to enable school administrators to monitor the educational trajectory of the students in their networks, support school management and mitigate school dropout.

Currently (as of April 2025), the system receives registration data on students and their legal guardians, as well as data related to school enrollment and attendance. The scope and quantity of data gathered in the SGP also reinforces another major objective of the initiative: the integration of education data with various public policies (federal, state and municipal). In this sense, the SGP aims to simplify the process of sending and receiving education information related to various educational policies.

The implementation of the Sistema Gestão Presente was strategically aligned with the launch and implementation of the Programa Pé-de-Meia, an initiative to encourage the permanence and completion of high school for students enrolled in the public education network, launched by the Ministry of Education in 2024. To guarantee students' access to the incentives, which is directly linked to student attendance data, state and municipal Departments of Education, as well as federal education systems, must send student enrollment information via the SGP. In the Pé-de-Meia module, the platform verifies the student's eligibility to receive the incentives by comparing data sent by the education networks and systems with data from the Ministry of Social Development (MDS) and forwarding the information for account opening and payment to Caixa Econômica Federal (Federal Savings Bank).

In addition to integrating education data (basic and higher education), simplifying the process of sending and receiving information for public policies, and supporting educational and school management, the implementation of the Sistema Gestão Presente facilitates access to information (both by public administration and the general population) and relieves the burden on civil servants of the Departments, who, before the system, had to send the same data to different channels related to the various existing public policies. It is envisioned that, with the SGP, all policies will be "fed" by the same system, avoiding cumulative and disorganized data processes.

4.1. SGP Implementation: Challenges

Implementation is the phase in which the outlined alternatives are executed, transforming laws and guidelines into actions. According to Howlett, Ramesh, and Perl (2013), implementation is the phase of putting previously made decisions into practice, involving the actions of bureaucrats and the use of necessary instruments. The implementation phase is crucial, as the execution of a policy determines its effectiveness. According to Pires (2017), the way implementation occurs can affect individuals' access to public goods and services, impacting the overcoming of social inequalities. However, implementation is complex, interactive, and often uncontrollable, as it needs to adjust to the reality of situations, which can diverge significantly from what was planned (LOTTA, 2019).

To implement the Sistema Gestão Presente, the greatest need is data. How can all educational networks in Brazil be induced to send data on their high school students? To this end, a combination of strategies was designed by the public policy management of NEES, in dialogue with the Ministry of Education. The benefit granted by the Programa Pé-de-Meia undoubtedly already induces a large part of the networks to send information. But what processes are carried out for this sending? How is the sending done? By whom is the sending done?

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The school networks (municipal, state and federal) appoint up to five employees who will be responsible for sending the data to the Sistema Gestão Presente. They are called “operators”. These professionals will be registered on the Simec[3] portal and, consequently, the SGP development team will add them to the system's users. Operators will enter the platform using their login already used in the Gov.br system[4]. With this access, the operator will be able to send data, monitor the processing of this data, check the status of enrollments and students eligible for the Programa Pé-de-Meia.

Taking advantage of the dialogue with the Programa Pé-de-Meia - which is based on students' monthly attendance - the Sistema Gestão Presente receives monthly data from the education networks. For approximately 15 days of each month, the system is “open” for receiving student data: from student registration, enrollment, attendance, transfers and completion. The data sent in during these 15 days will be processed in the remaining 15 days of the monthly cycle and will release student payments. The Sistema Gestão Presente receives data in two ways: by spreadsheet and by API. The strategy is to be able to cover departments with different structures and technologies and, at the same time, make the operator's job as easy as possible.

In order to cover the diversity of secretariats and make the operator's job easier, assistance and support strategies have been developed within the scope of the Sistema Gestão Presente. The main ones are the team of consultants, the training schedule and the support materials. The team of consultants was designed to support the networks and provide more personalized support, with a close eye on the realities and needs of each one. These consultants have been divided by region and state and are on call to answer questions and guide public managers and operators during the 15-day “data submission window”, but remain available for the rest of the month.

These same consultants are responsible for conducting training and on-call sessions for operators during the data submission window. The training sessions offered cover all the data submission processes in the Sistema Gestão Presente (registration, submission of frequencies and reporting of transfers and conclusions), for the two submission formats (spreadsheet and API) and the business rules of the Programa Pé-de-Meia (general rules, eligibility and payment). During these moments, the step-by-step processes are presented and the main doubts about each one are listed. In addition to this, there are also moments specifically for “questions and answers”, where any questions the operators may have been answered.

A series of support materials on the SGP was developed to provide support to operators outside of the training and on-call sessions and to concentrate the consultants' demands on the most complex cases. The most complete and requested material is the “Sistema Gestão Presente Manual”. This document details every step-by-step involved in each of the system's processes, listing the most frequently asked questions and pointing out exceptions and points of attention. The material, made available in PDF format to all operators, also provides various other secondary materials, such as screen recording videos of the processes and guides for filling in each column of the spreadsheets that are received in the System.

Even if various strategies are developed, both in terms of policy design and implementation, there will always be unexpected situations and challenges along the way. In the case of the Sistema Gestão Presente, this was no different. Although various processes, plans and procedures were created to facilitate its implementation, a number of challenges were faced in its first cycle of operation. The next section will deal specifically with these challenges, listing the solutions developed to overcome each one.

4.2 Challenges Faced

Brazil is a federative republic made up of three levels of government: municipal, state and federal. Federative units have the organizational autonomy to manage available resources and establish efficient processes and routines, develop strategies and implement policies according to the local reality. As a result of this autonomy, the lack of a unified education system in Brazil represents a major challenge, as each school network has the autonomy to organize itself pedagogically and administratively. Along these lines, the OECD (2019) has already mentioned the importance, for the coherent and sustainable implementation of digital government policies, of “coordinated public sector efforts across all sectors and levels of government”. But this autonomy, which is essential for dealing with the diverse educational and administrative realities of different contexts, can represent a challenge when implementing educational policies at national level.

The challenges encountered in implementing the Sistema Gestão Presente (SGP) were classified into four main categories to facilitate their analysis and understanding. These are: 'Programa Pé-de-Meia business rules challenges', 'Service challenges', 'Follow-up and monitoring challenges' and 'Technological challenges'. The first

[3] Simec is the Integrated System for Monitoring, Execution, and Control of the Ministry of Education (MEC), a platform that monitors and manages the federal government's budget and proposals in the area of education.

[4] The gov.br is a Federal Government portal that gathers services and information for citizens, as well as being a digital identification tool that allows access to digital public services.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

refers to the adaptations and strategies developed to adapt the Sistema Gestão Presente to particularities that arose during the implementation of the Programa Pé-de-Meia, and which helped to qualify the data on the platform. The second category, 'Service challenges', covers difficulties related to communication and technical training of the system's data operators and the activities developed to overcome them. As part of the follow-up and monitoring challenges, the tools developed for controlling and analyzing the data received by the system are described, as well as the relevance of this process for implementing the policy. The last category lists some of the challenges experienced by the systems development team in inducing the use of the SGP and the interaction of users (operators) with the platform, and the improvements implemented to address them.

4.3 Business Rules Challenges for the Programa Pé-de-Meia

During the process of implementing public policy, it is expected that some unexpected situations will lead to its redesign, to adapt to different contexts. In this sense, the initial linking of the implementation of the Sistema Gestão Presente to the Programa Pé-de-Meia helped to qualify the collection of student, enrollment and educational institution data. The strategies developed aim to deal with the challenge of covering the diversity of high school scenarios and offers in Brazil. To illustrate this point, we mention one of the situations we have experienced, which is linked to changes in the business rules of the Programa Pé-de-Meia and data collection in the Sistema Gestão Presente: the inclusion of Education for Young People and Adults (EJA)[5].

The inclusion of the "Education for Young People and Adults" (EJA) teaching modality in the Programa Pé-de-Meia panorama of beneficiaries led to the need to redesign the business rules of both the Program and the SGP. In the case of the SGP (our focus in this text), it was necessary to create strategies that encompassed (and did not harm their respective students) the various forms of offer and modality of EJA (face-to-face, semi-presential and non-presential offer). The modalities of provision directly affect the calculation of student attendance, as several educational institutions did not even collect student attendance data, and in others, attendance was only collected at a face-to-face meeting offered every one or two months.

In order to take account of these realities and ensure that EJA students were not disadvantaged by them (or that those eligible to receive the benefit stopped receiving it), a change was made to the attendance calculation carried out by the Sistema Gestão Presente, which now takes into account the workload offered by the educational institution. The formula used by the SGP to calculate the student's monthly attendance percentage is now: Present workload/Offered workload *100. This means that the student's attendance percentage will only be calculated taking into account the hours offered to them by the educational institution.

In addition to this, another particularity of the EJA that has led to changes in the Sistema Gestão Presente (both in data collection and management) involves the timing and duration of each stage/cycle in relation to regular high school. There are educational institutions where the complete EJA cycle (which corresponds to full secondary education) lasts six months, others a year, others a year and a half... With these cases in mind and the importance of collecting this data, a field was inserted to identify the total workload planned for the course in which the student is enrolled. Containing the options "First third of the workload of the EJA offer"; "Second third of the workload of the EJA offer" and "Third third of the workload of the EJA offer", this field helps to estimate which stage of secondary school the student is in.

In this way, the changes implemented in the Sistema Gestão Presente highlight the difficulties and adaptation needs that a platform that sets out to encompass all Brazilian education data goes through during its implementation period. By restructuring parameters such as the calculation of attendance and the identification of the stage taken, the system is molded to the particularities of this modality, guaranteeing greater precision in the collection and interpretation of data.

4.4 Follow-up and Monitoring Challenges

In order for us to identify the challenges and consequently plan actions to overcome them, the process as a whole needs to be monitored and followed up. In this sense, how can we design monitoring strategies in a policy that is constantly in flux, both in terms of actions and players? How can we identify the main difficulties and errors in sending data, beyond the operators' reports (even because of the difficulty in contacting some of them)?

Monitoring is an essential activity that supports decision-making, involving production, recording, monitoring and critical analysis of information, with a view to effective management and continuous improvement of the services offered to the population (Jannuzzi, 2013). On this path, the greatest (and most complex) thermometer of the assertiveness of the implementation is obtained through data: in this case, data that indicates the sending of information by operators. In the first few months of implementation, we began to develop incipient

[5] Mode of education established by Law nº 9,394/96 (Law of Directives and Bases of National Education), aimed at individuals who did not have access to or continuity of studies in elementary and high school at the appropriate age.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

tools for monitoring the sending of data, which provided information on frequencies sent by Network (state, municipal and federal). This is the basic concept for monitoring the success (and critical cases) of the implementation of the Sistema Gestão Presente, as it shows how easy or difficult it is to operate the platform and send the data it requires.

Using this data (frequency sending), it is possible to identify, in a basic and general way, which networks have already sent a high percentage of data in relation to the number of students enrolled, and those that have not sent or have sent a quantity of frequencies that represent a low percentage in relation to the whole network. Since the first months of the SGP's implementation, during the data submission windows, this daily monitoring of submissions has been carried out, which, through the figures, directs the consultants' work to the most critical cases (networks that have submitted a low percentage of data).

As the process in the system became more complex (more functions and procedures) and the data provided by the networks increased (student profile data, characteristics of the modality offered), both the consultants and the implementation coordinator felt the need to improve monitoring of the induction to use the SGP and, consequently, to send data to the system. In order to qualify this monitoring, various strategies were developed, with the different actors who demand data from the system in mind. In general, the strategies involved monitoring panels, BIs (Business Intelligence)[6] and reports.

The strategies developed can be categorized by monthly period (during the data submission window and after the window closes) and by the actors they are aimed at (consultants, implementation managers and coordinators and Ministry of Education managers). For this analysis, we will use the monthly period criterion to describe the initiatives, as illustrated in Figure 4:

Fig. 3 - Data monitoring strategies and tools developed.

Monthly period	Strategy	Target audience
Monitoring during the data submission window (15 days per month)	Daily monitoring bulletins for data sent by the Network (2 to 3 bulletins/day)	Consultants
	Data visualization tool (BI) to monitor the sending of data from the window (hourly update)	SGP and PDM managers and coordinators and MEC managers
Monitoring after the data sending window has closed	Report consolidating data from the closed window	MEC managers
	Sistema Gestão Presente data visualization tool (updates after the data submission window closes)	Managers and coordinators SGP and managers MEC

Source: prepared by the authors

As can be seen in the figure above, different strategies have been developed, each geared towards a specific demand and target audience. The daily monitoring bulletins are an essential tool for the data submission windows, as they allow consultants to keep track of the networks they are responsible for and to prioritize critical cases, identifying those with low submission rates.

In addition to this short daily summary, a visualization tool was developed for SGP managers and coordinators and MEC managers, with the aim of monitoring in “real time” (with one hour of processing). This tool brings together more qualified data on enrollments and students (active, registered and valid enrollments, enrollments per student and reclassifications and transfers) and attendance (lack of attendance information by state and daily evolution of attendance sent by administrative dependency). The data presented in the tool allows for a more in-depth analysis of critical cases and the networks that need to be activated during the window.

Strategies were also developed for monitoring consolidated data after the end of the sending periods. The tool created for monitoring the Sistema Gestão Presente by managers gathers a larger and more qualified amount of data compared to the tool for monitoring data sent during the window. In this panel, it is possible to check, in addition to student registration data, consolidated attendance and profile data for students registered in the SGP. In the case of attendance, it is possible to view the information sent by month, average attendance by state, evolution and number of attendances above 80% and below 80% and unreported attendance. On the student

[6] BI (Business Intelligence) is a set of tools and technologies used to collect, analyze, and transform data into actionable information, helping managers make more informed strategic decisions.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

profile screen, you can view information by gender, color/race and disability, as well as the number of students enrolled in regular or EJA modalities. All the data visualization tools also have filters that can be applied to all the indicators displayed on the screen: administrative dependency, UF, municipality, modality, reference month, teaching stage and organizational unit.

The last monitoring product strategically developed, this time just to provide the Ministry of Education's management with information, was the consolidated window reports. These materials, as the name suggests, compile the results of the main indicators collected during each submission period in the Sistema Gestão Presente, as well as giving feedback on the actions that were carried out in the implementation and induction axis during the window. This material also presents the critical cases - networks with the least amount of data submitted. As well as reinforcing the importance and results of the policy's implementation work, the reports support decision-making and the creation of new strategies by the MEC.

The development of these strategic products, which are widely used by their target audiences, reiterates the importance of monitoring and following up the implementation of public policies, whatever they may be, so that routes can be recalculated and results can be even more assertive. In the case of the Sistema Gestão Presente, these products are essential for qualifying the data collected and improving the data collection process itself.

4.5 Technological challenges

Many of the changes to business rules, as well as difficulties reported by operators to service consultants, lead to changes in the Sistema Gestão Presente - as well as adjustments to support documents linked to the system, such as the spreadsheets used to send data. In most cases, these changes are linked to three challenges: adapting to the different Brazilian educational contexts, the technical knowledge of the operators and improving the experience of the system's users.

To illustrate these changes, we have selected some (of the many) implemented in the 2024 cycle, focusing on improvements to the user experience, also related to the different levels of technical knowledge reported by the operators of the Education Networks. We won't go into the changes to the fields in the spreadsheets, which are the tools used to send the data (by those who don't use the API), and which are linked to changes in the business rules of the policies and their adaptation to the various high school offers in Brazil. Some of the adjustments involve the inclusion of fields to identify students in deprivation of liberty (PPL) and social name information.

The focus of this section, therefore, is on the strategies developed to deal with “everyday” challenges, which may often seem “small” - but which, when it comes to the amount of data sent by each network, can lead to major problems and, consequently, result in the disqualification of data, the lack of data and even the loss of benefits for students eligible for the Programa Pé-de-Meia. Against this backdrop, we will briefly describe two adjustments that were implemented with a focus on inducing use of the system and improving the user experience in the SGP: expanding the accepted spreadsheet file format and visualizing multiple enrollments. It is important to note that each of the changes to the system generated specific training for operators, in order to describe and demonstrate the step-by-step process and resolve doubts.

One of the biggest challenges for operators when sending data was handling the pre-formatted spreadsheets for this process. Their templates (“blank”) were downloaded directly by the system in .csv[7] format, and it only accepted uploads of files in the same format. Many operators reported difficulties in using this type of document and, in August 2024, it was implemented that spreadsheets could also be uploaded in .xls (the most common file format in Microsoft Excel programs). This change, which may be “simple” for those reading this description, was extremely important for the networks, as well as for encouraging the use of the system and broadening and facilitating the sending of data.

The second improvement developed within the scope of the Sistema Gestão Presente, with a focus on supporting its use and qualifying the data, was the ability to view students with multiple registrations, followed by the possibility of activating and inactivating registrations directly in the SGP. The SGP's data management flow faced a challenge not previously foreseen (or at least not to this extent): student transfers between different educational institutions. It is relatively common for students to transfer from one school to another during the school year, for any number of reasons.

This is another “commonplace” situation that has brought challenges for the SGP. In order for a student's transfer process to be consolidated, it is necessary for (I) the school of destination to enroll the student from the date they entered the institution and (II) the school of departure to report the transfer between institutions, based on the spreadsheets that are sent to the system. This process, however, presents mismatches and, in several cases, the student has two (or more) active enrollments in the Sistema Gestão Presente. At the start of implementation,

[7] CSV (Comma Separated Values) is a type of text file used to store data in a structured table format, separating the values with commas. These files can be created and edited in various programs, such as: Microsoft Excel, LibreOffice Calc, OpenOffice Calc, Google Sheets.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

viewing and correcting these duplicate registrations was only done via spreadsheets (by downloading and sending documents).

To help in the induction of the system, make the work of the operators less complex and more practical and mitigate the cases of multiple registrations in the SGP, new functionalities were designed, developed and implemented on the platform. In general, with this improvement, operators are able to check, directly on the front-end, which students have multiple registrations, as well as view the other institutions in which the student is enrolled.

In addition to this, another new feature has been incorporated into the SGP regarding the scope of multiple enrollments. In addition to viewing the information relating to their multiple enrollments, operators can now confirm or inactivate the enrollment directly on the front-end. Those responsible for interaction with the system on the part of the Networks can also check whether the other Network to which the enrollment is linked has also confirmed the existence and permanence of that enrollment in their Network. The two functions, which are accessed in a "Multiple enrollments" section in the SGP, are interconnected and allow the operator to review the enrollments linked to a student (CPF) and inactivate or confirm this information.

To conclude, the changes made are mainly aimed at inducing more efficient use of the Sistema Gestão Presente and improving the user experience, considering the daily challenges faced by operators. Adjustments such as expanding the accepted file format and displaying multiple enrollments are examples of how the changes seek to simplify the data entry process and make it easier to navigate the system. These adjustments, although they may seem simple at first glance, are of great importance in practice, as they have a direct impact on the quality of the data sent by the education networks and on compliance with the program's requirements. Ultimately, these changes are essential to ensure that the system is adapted to different educational contexts and to improve the effectiveness of student data management.

4. Conclusions

The implementation of the Sistema Gestão Presente, focused on integrating educational data between different levels of government, reinforces the Federal Government's commitment to the Estratégia Federal de Governo Digital (EFGD), which promotes the acceleration of the government's digital transformation, and consolidates the vision of a government that is "innovative and collaborative in its efforts to promote the digitalization of its economy and society" (OCDE, 2018, p.38). The initiative aims, among other things, to subsidize public policies aimed at educational inclusion, such as the Programa Pé-de-Meia, and to provide greater efficiency in the management of educational data at a national level. However, as has been identified throughout this study, the implementation of digital systems in a public context faces multifaceted challenges.

During the process of implementing the Sistema Gestão Presente, strategies to mitigate these challenges were designed and adopted. These strategies have a direct link to the concept of data governance, which involves creating effective practices, policies and processes to guarantee the integrity, transparency, accessibility and security of information within a public system. Data governance is a central element for the effectiveness of any information management system, especially when it involves integration between different levels of government. Through visualization tools, specific functionalities and service strategies, the Sistema Gestão Presente is moving towards more efficient data governance, which ensures that educational data is used strategically and transparently to formulate public policies. However, data governance is not limited to implementing technologies; it also requires strengthening institutional capacities and building a culture of collaboration and trust between the different actors involved. The ability to deal with the complexities of data in a government environment requires not only technological innovations, but also a deep understanding of local political and social dynamics.

Throughout the implementation, it was possible to see that the Sistema Gestão Presente, although challenging, can serve as a model for other digital transformation initiatives in the public sector, especially about data integration between different levels of government. The strategies of monitoring, personalized service and adaptation to local needs offer important lessons on how to overcome obstacles related to the decentralization of management and the diversity of realities in Brazil. The experience with the SGP also highlights the importance of continuous monitoring and effective communication between the different actors involved, from technical teams to managers and decision-makers. Ongoing training and personalized support, such as general and specific training, are key to ensuring the system's long-term effectiveness.

However, the successful implementation of the Sistema Gestão Presente depends on constant evaluation and adaptation. Although it has been possible to overcome a number of challenges, the evolution of the system and the improvement of data governance require a continuous commitment to innovation and the improvement of information management practices. The role of technology in the digital transformation of the public sector is undeniable, but it must be borne in mind that the real transformation takes place to a large extent through the integration of technology and public policies. OCDE (2018, p. 48) also reinforced the convergence between

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

technology and public policies, analyzing the Brazilian scenario: “The Brazilian programmes on e-government and digital government reflect the country's path, its main priorities and goals in different periods, and most of all, it shows Brazil's progressive policy consolidation and growing maturity in addressing key issues associated with the digitalization of the public sector”.

In the case of the Sistema Gestão Presente, this integration implies careful data management, which takes into account local specificities, information security and, above all, the social impact of the policies implemented.

References

BRASIL. Ministério da Educação. Portaria MEC nº 234, de 2 de abril de 2025. Institui o MEC Gestão Presente – Plataforma de dados da educação básica e dá outras providências. Diário Oficial da União: seção 1, Brasília, DF, ano 162, n. 64, p. 55, 3 abr. 2025. Disponível em: https://www.in.gov.br/en/web/dou/-/portaria-mec-n-234-de-2-de-abril-de-2025-621883017. Acesso em: 14 abr. 2025

DRAGO, Pedro Anibal. Pesquisa-ação - uma opção metodológica para conhecimento-mudança da realidade organizacional. Rio de Janeiro: Revista de Administração Pública. 1989.

ENAP. Contexto da Governança de Dados na Administração Pública. Fundação Escola Nacional de Administração Pública, Brasília, 2019. Disponível em: https://repositorio.enap.gov.br/bitstream/1/5008/1/M%C3%B3dulo%201%20-%20Contexto%20da%20Governan%C3%A7a%20de%20Dados%20na%20Administra%C3%A7%C3%A3o%20P%C3%BAblica.pdf. Acesso em: 31 jan. 2025.

FORSTER, M. An introduction to the theory and practice of action research in organizations. London, Tavistock Institute of Human Relations. 1971.

FRAGA, Vanessa de Souza. A participação nas mudanças de políticas públicas e o papel da sobrecarga administrativa na política de segurança social no Brasil. 2020. 2018 f. Tese (Doutorado) - Curso de Ciências da Administração, Escola de Economia e Gestão, Universidade do Minho, Braga, 2020.

HOWLETT, Michael; RAMESH, M; PERL, Anthony. Política Pública: seus ciclos e subsistemas: uma abordagem integral. Rio de Janeiro: Elsevier, 2013.

JANNUZZI, Paulo de M. Sistema de Monitoramento e Avaliação de Programas Sociais: revisitando mitos e recolocando premissas para sua maior efetividade. Revista Brasileira de Monitoramento e Avaliação, Brasília, nº 5, jan./jun. 2013, p. 4-27.

LOTTA, Gabriela. A política pública como ela é: contribuições dos estudos sobre implementação para a análise de políticas públicas. In: LOTTA, Gabriela (org.). *Teoria e análises sobre implantação de políticas públicas no Brasil*. Brasília: Enap, 2019. p. 11-39.

NOGUEIRA JUNIOR, Dario Azevedo. Governo Eletrônico: uma reflexão sobre os limites da interatividade cidadã no modelo brasileiro da gestão pública digital de difusão de informação. Revista Eptic, [S.L.], v. 21, n. 1, jan-abr. 2019.

OECD, Digital Government Review of Brazil: Towards the Digital Transformation of the Public Sector, OECD Digital Government Studies, OECD Publishing, Paris, 2018. https://doi.org/10.1787/9789264307636-en

PIRES, Roberto Rocha C. Implementando desigualdades? Introdução a uma agenda de pesquisa sobre agentes estatais, representações sociais e (re)produção de desigualdades. In: Boletim de Análise Político-Institucional, v. 13, 2017, p. 7-14.

SECCHI, Leonardo. Políticas Públicas: conceitos, esquemas de análise, casos práticos. 2 ed. São Paulo: Cengage Learning, 2015.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

What drives local governments' digital transformation in Brazil?

Lizandro Lui [a*], *Rafael Barbosa de* Aguiar [b], *Lídia Nicole dos Santos ten* Cate [c], *Samuel de Melo* Barbosa [d]

[a] School of Public Policy and Government, Getulio Vargas Foundation, Brasilia, Brazil, lizandrolui@gmail.com, ORCID 0000-0002-9276-247X.

[b] Postgraduate Program in Public Policy Management at the School of Arts, Sciences and Humanities of the University of São Paulo, São Paulo, São Paulo state, Brazil, rafaelpolpub@gmail.com, ORCID 0000-0002-2418-6845.

[c] Postgraduate Program in Public Policy, Federal University of Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil, lidianicoletencate@gmail.com, ORCID 0000-0002-9848-5370.

[d] School of Public Policy and Government, Getulio Vargas Foundation, Brasilia, Brazil, samuelbmelo1@gmail.com, ORCID 0009-0008-3146-9887.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. In the context of increasing demands for efficient and equitable public service delivery, digital transformation has become essential for local governments, particularly within federations marked by inequality. This study investigates the factors driving digital transformation in Brazilian municipalities—a country with significant regional disparities and varying administrative capacities. The objective is to identify which economic and technical-administrative variables influence the digital maturity of local governments. Using data from 4,265 municipalities collected in 2023, the study constructs a Digital Transformation Index encompassing technological infrastructure and digital service provision. Multiple linear regression models assess the relationship between digital transformation and variables such as fiscal autonomy, IT expenditures, bureaucratic quality, and mayors' educational profiles. Results indicate that municipal revenue generation and IT spending positively correlate with digital transformation, while reliance on intergovernmental transfers is negatively associated. Additionally, better-educated civil servants and mayors are more likely to lead digitally advanced municipalities. However, when accounting for regional and population size controls, many of these associations lose statistical significance, underscoring the role of broader structural disparities. The findings suggest that economic and human resource capacity are important but insufficient alone; a more coordinated national strategy is necessary to reduce regional inequalities and support local digital transformation.

Keywords. Digital Transformation, Local Governments, Brazil, Fiscal Autonomy, Education, Regional Disparities.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.961

1. Introduction

Given the increasing complexity of public problems and the evolving expectations of citizens, digital transformation is not merely an option but a necessity for local governments to ensure equitable access to essential services, improve responsiveness and accountability, and ultimately enhance public value in addressing critical societal challenges. In this sense, local governments worldwide are implementing new digital technologies in different policy domains and functions and conducting digital transformation processes (Branderhorst & Ruijer, 2024; Criado & Gil-Garcia, 2019). These new technologies are changing the landscape of public management and local authorities' abilities to create public value and deliver public services (Filgueiras et al., 2019; Mergel et al., 2019).

Digital transformation in the public sector means new ways of working with stakeholders, building new service

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

delivery frameworks and creating new relationships (Mergel et al., 2019). The focus of digital transformation shifted from internal processes and efficiency gains (e-government) to citizen-driven services, placing the citizen at the center. Adopting new technologies in governments occurs in the context of incremental changes controlled by bureaucratic agents within institutions (Filgueiras et al., 2019; Haug et al., 2024).

Regarding studies on digital transformation in local governments, literature already has important findings. Hong et al. (2022) pointed out that innovation in local governments in South Korea is driven by demand, in which public organizations respond to the needs of citizens. In addition, the study highlighted that electoral incentives motivate local governments to innovate digitally to meet local priorities, that isomorphic pressures matter, i.e., local governments tend to imitate innovative practices of neighbors, and that younger policymakers are more active in innovation. Epstein (2022), when analyzing North American cities, evaluated that the adoption of e-government services between 2014 and 2019 was different, specifically, while earlier adoption was largely driven by larger cities with more resources, by 2019, there was a broader diffusion of e-government across cities of varying sizes. The study found that over time, factors such as population size and broadband access remained significant, but economic variables like municipal wealth lost explanatory power, suggesting that access and infrastructure became more critical than fiscal capacity in determining digital service provision (Epstein, 2022). B. Fan and Pan (2023) analyzed the drivers for Chinese local government strategies and examined the effect of the interaction between IT infrastructure and other organizational resources (financial and human) on e-government performance. The authors found that the interaction between IT infrastructure and financial resources has a positive effect on e-government, while the interaction between IT infrastructure and human resources has a negative effect on e-government performance. Furthermore, they concluded that the effect of the interaction between IT infrastructure and organizational resources (financial and human) on e-government performance increases with decreasing environmental turbulence and increasing environmental complexity.

Moreover, Mergel et al. (2019) and Wilson and Mergel (2022) have pushed researchers to look at digital transformation's social, economic and political aspects from their qualitative research. Mergel et al. (2019) pointed out that external factors and pressures are the main drivers of digital transformation in governments rather than internal factors. Much work has been dedicated to understanding the drivers of digital transformation in local governments worldwide (Epstein, 2022; B. Fan & Pan, 2023; Hong et al., 2022; Mergel et al., 2019; Wilson & Mergel, 2022). Thus, there are indications that the quality of bureaucracies, external demands on government and financial resources are correlated with the process. However, only some studies examined Latin America's context in the digital transformation process (Aguerre & Bonina, 2024; Filgueiras et al., 2019). In this case, we identified a gap in the literature, given that few studies aimed to understand the drivers of digital transformation in Latin American local governments. This article addresses the following research question: What are the drivers of digital transformation in Brazilian municipalities? To address this question, this study aims to analyze the economic and technical-administrative factors associated with digital transformation in Brazilian municipalities, identifying which local government characteristics most significantly influence the adoption of digital technologies and services. Thus, we aim to identify which municipal characteristics are associated with the digital transformation process.

Brazil offers a compelling case study for digital transformation research due to its vast and diverse population within a complex federal system, which provides a rich context for observing the phenomena across different levels and allows the examination of the opportunities and challenges of digital transformation implementing initiatives. The complexities of a federal country stem from deep regional inequalities, fiscal dependencies, and varying administrative capacities across municipalities, creating significant challenges for implementing coherent public policies, especially in digital transformation (Alves & Araujo, 2024; Filgueiras et al., 2019; Grin & Abrucio, 2021; Marenco & Cate, 2021) While existing research has primarily focused on the national level (Filgueiras et al., 2019), this study delves into the experiences of local governments by examining local-level challenges and successes, filling a crucial gap in the literature, so this research contributes to understanding the factors driving digital governance in this complex federal system. This study examines the factors driving digital transformation in local governments in Brazil, considering the technical, administrative and financial inequalities between municipalities.

This paper is divided into four sections in addition to the introduction. The second section provides a background and defines the hypotheses, introducing key concepts related to digital transformation in Brazil. The third details the methodology, focusing on data selection and analysis techniques. The fourth presents the results and discussion, aiming to answer the research question and objective by clarifying the drivers of digital transformation in Brazilian municipalities. Finally, the conclusion restates the main findings, acknowledges some limitations, and offers recommendations for future research.

2. Background and Hypothesis' Definition

Brazil began with e-government initiatives in the 1960s by creating SERPRO (public data processing company) in 1964 (Filgueiras et al., 2019), and in the 1970s, another public data processing company was instituted named Dataprev, initially dedicated to the social security sector. Throughout the 1990s and 2000s, incremental progress focused on digitizing administrative processes and routines. From 2016 onwards, there was a significant

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

institutional change driven by two main factors: (1) the need to respond to the fiscal crisis with greater efficiency and cost reduction, and (2) the influence of the OECD, which advised Brazil with guidelines, case studies and standards to adopt digital transformation policies (Filgueiras et al., 2019). This process culminated in the transition to more comprehensive digital governance based on new norms and paradigms focused on providing services in a federal government platform (GOV.BR) created in 2019.

Despite Brazilian e-government initiatives, research conducted by Przeybilovicz et al. (2018) using 2014 data revealed that most municipalities had limited online services. For instance, over 90% of municipalities lacked online options for obtaining permits, enrolling children in school, or scheduling medical appointments. Furthermore, municipal websites primarily served as information portals. This scenario indicates that, a decade ago, local Brazilian governments' widespread adoption of e-government services was still a significant challenge. The Southeast/South region appeared to be the most advanced in e-government initiatives; conversely, the North and Northeast regions represented the most challenging areas for e-government implementation, revealing a significant disparity in ICT infrastructure and use, poverty, and limited access to technology. These factors hinder the development and adoption of online government services, leaving many of the population underserved (Przeybilovicz et al., 2018).

Internationally, the discussion about government as a platform began at the end of the 2000 decade (O'Reilly, 2011). Since then, a new conception of government and its role in society has emerged and changed over the last few decades. While influential in recent decades, the New Public Management (NPM) paradigm has been criticized for its limitations. Osborne et al. (2013) argued that NPM's focus on internal processes and the application of manufacturing-based theories inadequately addresses the unique characteristics of public services. Instead, they advocated for a "public service-dominant" approach. This approach emphasizes the service-oriented nature of public services, prioritizing citizen co-production, strategic orientation, marketing, and operational management. By recognizing citizens as active participants in service delivery, this approach seeks to provide a more relevant framework for contemporary public management challenges.

A crucial aspect of this revised approach is recognizing the inter-organizational nature of public service delivery. Osborne et al. (2013) highlighted the critical role of coordination and collaboration among organizations involved in service provision. This insight becomes particularly relevant in the context of digital transformation. The successful integration of ICT in the public sector hinges on overcoming significant challenges, including the technical capacity to implement ICT, the perceptions of public managers regarding transparency, efficacy, and accountability, and the persistence of data silos within public administration. These silos, exacerbated by a lack of coordination and limited political-institutional capacity for change (Wilson & Mergel, 2022), hinder the effective digital transformation of public services. As Filgueiras et al. (2019) emphasized, digital transformation necessitates robust policy coordination among various organizations to ensure coherent service delivery aligned with the priorities and objectives of each entity. This requires effective negotiation and agreement among agencies that often operate autonomously, thereby emphasizing the importance of inter-organizational collaboration for successful digital transformation in the public sector.

Given the extensive territorial inequality in Brazil, in other words, uneven distribution of resources, infrastructure, public services, and development opportunities across the country's different geographic regions and municipalities, some municipalities (mainly state capitals and large regional centers) have a greater administrative capacity linked to local government, more significant funding, and more pressure from society to digitize services. Meanwhile, most Brazilian municipalities are small (less than 20,000 inhabitants), and incorporating ICT tools has historically lagged behind (Przeybilovicz et al., 2018). Therefore, the provision of services offered by local governments via the platform is challenged, given the existing heterogeneities. In this sense, given the recent induction of the Brazilian federal government through Decree nº 12.069/2024 to the process of digital transformation of subnational entities (Brazil, 2024), one wonders what can explain the fact that some municipalities have adopted tools to offer services via the platform while others have not?

Thus, this study analyzes the relationship between the economic (H_1, H_2 and H_3) and technical-administrative (H_4 and H_5) dimensions of digital transformation in local governments in Brazil. The hypotheses underlying this research and its rationale are outlined as follows.

2.1 Fiscal autonomy and digital transformation

B. Fan and Pan (2023) argued that the interaction between IT infrastructure and organizational resources, mainly financial and human resources, significantly impacts e-government performance, specifically that financial resources positively enhance the effect of IT infrastructure. In the Brazilian case, local governments' tax revenue collection depends on the current economic structure. By law, the central and state governments transfer a fixed portion of resources to local governments (Alves & Araujo, 2024). Most of these allocations are restricted to designated purposes such as health services, education, etc., limiting their availability for digital transformation initiatives. Therefore, municipalities with thriving economic activity can collect more resources and become less dependent on state and Union

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

transfers but, for the most part, have fewer opportunities to expand the tax base. Based on it and B. Fan and Pan's (2023) proposition, it can be argued that the municipality's fiscal autonomy can affect its digital transformation capacity, taking to the first hypothesis:

H_1. Municipalities with greater fiscal autonomy from federal and state transfers exhibit higher levels of digital transformation.

2.2 Budget expenditures and digital transformation

Budget expenditures provide a key indicator of the financial resources dedicated to e-government initiatives, covering areas such as IT infrastructure, personnel training, and cybersecurity (Z. Fan et al., 2020; Reddick, 2006). The development and upkeep of such infrastructure demand significant financial resources (B. Fan & Pan, 2023; Z. Fan et al., 2020; Salim et al., 2022), inadequate funding can hinder the ability to address technical challenges, upgrade systems, and respond to evolving digital needs (Z. Fan et al., 2020; Osah & Pade-Khene, 2020; Stier, 2015). Governments may struggle to deliver efficient and effective public services without sufficient investment (Welch & Feeney, 2014). In Brazil, municipalities are responsible for financing a wide range of public policies, such as basic health care, education, and social assistance, among others. Investment in technology and digital transformation is one of the priorities that municipalities already need to address. Furthermore, more resources can be required to constrain the capacity to attract and retain skilled IT professionals, which is essential for ensuring the smooth operation of e-government systems.

In other words, governments can allocate substantial funds towards IT investments by generating adequate revenue. This enables them to embrace innovative technologies, expand the scope of e-government services, and improve overall service delivery (Z. Fan et al., 2020; Osah & Pade-Khene, 2020; Reddick, 2006; Stier, 2015). Increased financial resources empower governments to explore new opportunities, such as developing sophisticated data analytics capabilities and implementing advanced cybersecurity measures (Mukhopadhyay et al., 2019). Moreover, sufficient funding can facilitate the training and development of public servants, enhancing their digital literacy and capacity to leverage technology effectively (B. Fan & Pan, 2023). Ultimately, revenue generation empowers governments to create a more responsive, efficient, and citizen-centric e-government ecosystem. In this context, we present the second hypothesis:

H_2. Municipalities with higher revenue generation demonstrate greater levels of digital transformation.

2.3 IT expenditures and digital transformation

The successful implementation and maintenance of e-government initiatives rely on robust IT infrastructure (B. Fan & Pan, 2023); it provides the essential technological backbone that enables governments to deliver efficient and accessible public services. Regarding the technological dimension, IT infrastructure or technological capacity is a significant predictor of e-government service provision (Savoldelli et al., 2014; Welch & Feeney, 2014).

By investing in IT infrastructure, municipalities can streamline processes, reduce administrative costs, and enhance transparency and accountability (Hilhorst et al., 2022; Scholta et al., 2019). A well-developed IT infrastructure facilitates the integration of various government systems, enabling seamless data sharing and collaboration (Janssen et al., 2009). This, in turn, improves decision-making and allows for more informed policy development.

Investing in IT infrastructure empowers municipalities to embrace technological advancements and innovate in service delivery (Z. Fan et al., 2023). By adopting emerging technologies like artificial intelligence, machine learning, and blockchain, governments can automate tasks, improve service quality, and enhance citizen experiences. A strong IT infrastructure also enables municipalities to adapt to changing circumstances, such as natural disasters or economic crises. By leveraging digital tools, governments can respond quickly and effectively to challenges, ensuring business continuity and maintaining essential services (Z. Fan et al., 2023). It takes us to the following hypothesis:

H_3. Municipalities with higher IT expenditures exhibit greater levels of digital transformation.

2.4 Local government bureaucracies and digital transformation

From a Weberian perspective, we can argue that municipalities with higher bureaucratic quality – measured by the level of formal schooling of municipal bureaucrats (Grin & Abrucio, 2021; Marenco & Cate, 2021; Segatto et al., 2022) – are more likely to implement digital transformation initiatives successfully. A well-structured and efficient bureaucracy provides a solid foundation for technological advancements. By streamlining processes, improving communication, and fostering innovation, bureaucratic quality enables organizations to effectively leverage technology to enhance service delivery, citizen engagement, and overall operational efficiency.

Well-educated and well-trained public servants are essential for effective digital transformation; beyond technical skills,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

they bring analytical and problem-solving abilities needed to integrate new technologies into public services (Mergel et al., 2019; Zhu & Zhang, 2019). Continuous training keeps staff updated on evolving tools, data protection laws, and cybersecurity (Hilhorst et al., 2022). Additionally, trained bureaucrats increasingly take on roles like digital service designers, driving innovation (Melin et al., 2024). These "digital champions" help overcome internal resistance and improve project implementation (Wilson & Mergel, 2022) while their expertise reduces errors and builds citizen trust (B. Fan & Pan, 2023).The quality of the bureaucracy in the subnational context and its role in conducting public policies (including digital transformation) has been explored in Brazil and internationally (Grin & Abrucio, 2021; Melin et al., 2024). Despite the challenges in its measurement due to multiple factors, in Brazil, the Brazilian Institute of Geography and Statistics (IBGE) periodically collects information on the professional qualifications of bureaucrats in local governments. Following IBGE's proposition, years of formal study will be the proxy to measure the quality of bureaucracy.

We hypothesize that a strong workforce with expertise and training is essential for designing, implementing, and maintaining digital solutions. Municipalities can accelerate their digital transformation journey and reap the associated benefits by optimizing the interplay between bureaucratic quality, financial resources, and human capital. Based on these assertations, we present the hypothesis:

H_4. Municipalities with higher bureaucratic quality demonstrate greater levels of digital transformation.

2.5 Mayors' profiles and digital transformation

There is a consensus that older individuals are less likely to engage with digital technologies, exhibit lower trust in e-government services than younger generations, and, consequently, are less inclined to adopt e-government practices (Faber et al., 2020; Ruano De La Fuente, 2014). In this sense, it is possible to assume that younger mayors are more digitally savvy and open to innovation, making them more likely to embrace technology-driven solutions. Additionally, their higher education levels equip them with the knowledge and skills necessary to understand and navigate the complexities of digital governance (B. Fan & Pan, 2023).

Also, younger mayors are more likely to cater to the working population's needs, who often prefer digital interactions for convenience and efficiency (Budding et al., 2018). By prioritizing e-government initiatives, these mayors can enhance citizen engagement, streamline services, and improve overall governance. It is also worth noting that the influence of top-down pressures from higher levels of government can incentivize local leaders to prioritize digital transformation (Z. Fan et al., 2020; Yun & Opheim, 2010). By controlling factors such as the mayor's age, tenure, and previous experience, it is possible to isolate better the impact of youth and education on digital transformation efforts (Zhu & Zhang, 2019). In this scenario, we present the last hypothesis:

H_5. Municipalities led by younger mayors with higher levels of education exhibit greater levels of digital transformation.

3. Methods

3.1 Data Selection

The Regional Center for Studies on the Development of the Information Society (Cetic.br) is a department of the Brazilian Internet Information and Coordination Center (NIC.br), created in 2003 and linked to the Brazilian Internet Steering Committee (CGI.br) (CGI.BR, 2023). For decades, the organization, in partnership with the Brazilian Institute of Geography and Statistics, has developed research and produced data and analyses that support public policies and strategies for creating the information society, ICT use, digital transformation and internet accessibility in the country.

Since 2017, CETIC has consistently engaged all subnational governments in Brazil to generate data on technology adoption and digital transformation processes in municipal administrations. We utilized the Cetic.br database containing data from Brazilian municipalities collected in the 2023 survey. Although Brazil comprises 5,570 municipalities, the survey received responses from only 4,265 of them, constituting our sample.

The dependent variable in this study is Digital Transformation, constructed based on indicators encompassing the dimensions of Technological Infrastructure and Digital Service Provision in local governments (APPENDIX A), with data extracted from the CGI.BR – Comitê Gestor da Internet no Brasil (2023). As independent variables, we utilized indicators that measure economic and technical-administrative dimensions, as presented in Table 1. In this research, variables associated with information technology governance in city halls were measured, such as the presence of specific IT sectors, the development of strategic planning, the adoption of information security measures, the application of data protection policies and the training of civil servants on the General Personal Data Protection Act (LGPD). These elements form part of the dimension known as Technological Structure.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

On the other hand, in the Digital Public Services dimension, actions aimed at digital transformation in municipal administrations were considered, including the provision of digital services through applications for citizens, integration with the Gov.br single login, and the provision of digital solutions for issuing documents, invoices, slips, registrations and online appointments.

Tab. 1 – Overview of Regression Model Variables

Variable	Type	Description	Source	Dimension
Digital Transformation	Dependent	An index measuring the degree of technological infrastructure and digital service provision	CETIC	Technological and digital public services
IT Expenditures	Independent	Measures of how much the municipality spends on IT	Brazilian Government Accounting and Fiscal Information System (Siconf)	Economic
Intergovernmental Transfers	Independent	Measures of how dependent or autonomous the municipality is on revenues from the Union and State	System of Information on Public Budgets in Health (SIOPS)	
Municipal Revenues	Independent	Measures of how much financial resources come from own revenues	System of Information on Public Budgets in Health (SIOPS)	
Bureaucratic Qualification	Independent	Measures the percentage of the municipal bureaucracy with higher education	Gov. Munic – Laboratory of Applied Research	Technical-Administrative
Local Management	Independent	Measures the local management of the municipality	Superior Electoral Court (TSE)	

Source: From the authors.

In the economic domain, we considered Information Technology (IT) expenditures, which reflect municipal spending in this area, using data from the Brazilian Government Accounting and Fiscal Information System (Siconf), which compiles financial information from all areas of municipal public administration. We also included intergovernmental transfers, which measure the proportion of resources received by municipalities from state and federal governments and municipal revenues, with data collected from the Health Public Budgets Information System (SIOPS).

In the technical-administrative dimension, we utilized the variable of bureaucratic qualification, which measures the percentage of municipal civil servants with higher education, using information from Gov.Munic – UFRGS Applied Research Laboratory. Finally, we analyzed aspects related to the administrative management of municipal governments, including data on the gender and age of mayors collected from the Superior Electoral Court (TSE). These variables provide a comprehensive basis for understanding the factors influencing Digital Transformation in municipalities.

3.2 Analysis Technique

We constructed the dependent variable (Digital Transformation) using indicators from two main dimensions: Technological Infrastructure and Digital Service Provision in local governments. The data was extracted from the CGI.BR (2023), conducted by Cetic.br. For its construction, we employed binary factor analysis due to the binary nature of the analyzed indicators.

After correlation analysis, the selected indicators were grouped into three factors per dimension to estimate the specific weights for each variable (Medeiros et al., 2023). The process of constructing the Digital Transformation variable followed the steps: analysis of the correlation matrix; selection of the factorial method; extraction and determination of the number of factors; factor rotation; interpretation of factors; and computation of factor scores (Siqueira et al., 2015).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Binary factor analysis was chosen based on *a priori* criterion, which predefines the number of factors retained. For factor rotation, we decided on the VARIMAX method due to its ability to maximize the variance of factor loadings, making it suitable for interpreting the underlying structure of the variables. After extracting the factor loadings, we applied the obtained weights to the data of the 4,265 municipalities, assigning a score to each observation. This score resulted in a scale from 0 to 11, where lower values indicate lower Digital Transformation and higher values indicate higher Digital Transformation at the local level.

Based on the Digital Transformation variable, we used multiple linear regression to test our hypotheses. In Equation 1, $DigTransf_i$ is the index that reflects the degree of adoption of technologies and digital services in subnational governments based on Technological Infrastructure and Digital Service Provision indicators. Then, we use the determinants that drive the digital transformation process in Brazil.

Equation 1: Digital transformation index

$$DigTransf_i = \alpha + \beta\, TI_Exp_i + \gamma\, Inter_Transf_i + \delta\, Mun_Rev_i + \eta\, BurQuali_i + \theta\, Gender_i + \lambda\, Age_i + \mu\, Education_i + Region * Pop_Size$$

Our study proposes the following independent variables: TI_Exp_i, $Inter_Transf_i$, Mun_Rev_i, $BurQuali_i$, $Gender_i$, Age_i, $Education_i$, and the interaction between Region and Population size as control variables. The first three variables correspond to the economic dimension. TI_Exp_i measures the municipalities' capacity to invest in technological infrastructure. High expenditures indicate a higher priority, and resources allocated to technological modernization may be directly related to the level of Digital Transformation. The variable $Inter_Transf_i$ analyzes the proportion of resources originating from state and federal transfers, measuring the municipality's dependence on other levels of government. Finally, the variable Mun_Rev_i measures the local tax collection capacity, a crucial indicator of financial autonomy.

Regarding the technical-administrative dimension, $BurQuali_i$ measures the percentage of municipal civil servants with higher education and indicates the quality of human capital available in public administration. A more qualified bureaucracy tends to adopt and implement technologies more efficiently, favoring Digital Transformation. Finally, the variables $Gender_i$, Age_i and $Education_i$ measure the profile of the mayors and offer insights into political leadership and its openness to innovation.

To better isolate the relationship between the independent variable of interest and the dependent variable and get a more accurate and precise understanding of the proper relationship between them, we added two variables to the model to control the characteristics of the municipalities: the region in which the city/town is located (North, Northeast, Midwest, South and Southeast) and population size, the number of inhabitants in the city/town.

4. Findings and Discussion

When analyzing the level of Digital Transformation in 4,265 Brazilian municipalities in 2023, we observed that the economic dimension became a driver for the innovation process in public administration (Table 2). Alternatively, the three selected variables were statistically significant, with one exhibiting an inverse relationship and two displaying direct relationships.

There is a negative relationship between intergovernmental transfers and digital transformation; for every unit increase in intergovernmental transfers, the digital transformation (dependent variable) decreases by 0.012334 units. That is, as government transfers rise, digital transformation tends to decline, which confirms the H1, higher levels of intergovernmental transfers are associated with lower levels of digital transformation among municipalities.

We identified a positive relationship between municipal revenue generation and digital transformation; for every unit increase in municipal revenue, the digital transformation increases by 0.030738 units. Based on this, we accept H2, which states that municipalities with higher revenue generation tend to invest more in digital transformation. In other words, financial resources are essential to enable investments in technologies and digital infrastructure.

This relationship is directly associated with the level of IT expenditure at the municipality level. Also, a positive relationship was found between IT expenditures and digital transformation; for every unit increase in municipal IT expenditures, the digital transformation increases by 1.318e-08 units. In this regard, we accept H3, affirming that municipalities that allocate a portion of their expenditure to IT have a more advanced digital transformation process locally.

When considering all variables in a full model while accounting for municipal characteristics, we observed a loss of statistical significance for all the economic variables (intergovernmental transfers, municipal revenue generation and IT

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

spending). However, a positive relationship was found between region and population size; municipalities located in the Midwest region, with a population between 50,000 and 100,000 inhabitants, are positively associated with digital transformation. Similar results were found for Northeast, Southeast, and South Brazilian municipalities.

Tab. 2 – Economic dimension (descriptive statistics)

		Economic Dimension				
		Estimate	**Std. Error**	**t value**	**Pr(>|t|)**	**Full Model** (Pr(>|t|)
TI Expenditures[1]		1.318e-08	3.921e-09	3.361	0.000832 ***	0.47115
Municipal Revenues[2]		0.030738	0.003642	8.44	<2e-16 ***	0.52735
Intergovernmental[2] Transfers		-0.012334	0.001962	-6.286	3.59e-10 ***	0.27679
Region * Population[2] size						
Midwest	50001 até 100000 habitantes					0.03207 *
Northeast	50001 até 100000 habitantes					0.03794 *
Southeast	50001 até 100000 habitantes					0.00398 **
South	50001 até 100000 habitantes					0.03589 *
Number of cases		[1]624 observations	[2]4.265 observations	[2]4.265 observations	[2]4.265 observations	[2]4.265 observations

Source: From the authors.

Our analysis indicated a significant relationship between the economic variables when assessed individually. However, in the full model, this relationship loses statistical significance, suggesting a weak relationship between variables such as investment in ICT, municipal revenue collection capacity, and capacity to generate revenue (which can be understood as less financial dependence on other subnational entities). The weakening in the full model's statistical significance may be attributed to the shared variance among the predictors and the broader scope of the dependent variable, encompassing both ICT infrastructure and the provision of digital services. In this sense, although parsimoniously, we can argue that in Brazil, similarly to China, fiscal capacities are essential for the digital transformation in local governments (Z. Fan et al., 2020, 2023). However, our results do not allow for strong corroboration of the hypotheses put forward in this study.

Brazil's municipalities have undergone countless transformations over the last thirty years since the 1988 Federal Constitution gave them more significant responsibilities and administrative, political and financial autonomy. Municipalities have become the central federal unit to which the implementation and provision of public policies, especially social welfare policies, is directed. The new attributions increased both the demands for professionalization of municipal management and the need to establish democratic or popular control of public action (Segatto et al., 2022).

Nevertheless, the level of financial autonomy of Brazilian local governments is highly varied. Some municipalities, generally those with larger populations, have a greater capacity to collect taxes and make investments, while others are almost exclusively dependent on constitutional transfers from the state and federal governments (Marenco & Cate, 2021). In this sense, we identified that the Brazilian federation's inequality also affects municipalities' ability to carry out digital transformation.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The research by Przeybilovicz et al. (2018) showed that 10 years ago, ICT use and digital transformation in Brazil were very precarious. Despite South and Southeast regions presenting more ICT adoption and digital transformation initiatives due to their economic development processes, Brazilian states exhibited a high level of homogeneity, demonstrating that besides existent inequalities, there has been a growing increase in the use of technology by local governments and a greater supply of services via the platform. Therefore, the federal government's recent push, implemented by the National Digital Transformation Strategy, published in 2024, towards digital transformation is expected to stimulate increased adoption of these tools by Brazilian municipalities, ultimately narrowing regional gaps.

The state and regional inequalities demonstrated the result of a policy that, until this year, had not been coordinated nationally by the federal government. Thus, the different degrees of technological development and technology incorporation depend on each municipality's financial and technical capacities, which vary significantly among the more than 5,000 existing municipalities in Brazil. Only in 2024, with the National Digital Government Strategy, did the Brazilian Federal Government propose efforts to induce digital transformation in municipalities (Brazil, 2024), with the potential to reduce existing regional inequalities.

Focusing on the technical-administrative dimension (Table 3), only two variables regarding education (i.e., bureaucracy and mayors' qualifications) were statistically significant. This indicates that the qualifications of civil servants and mayors are positively correlated with digital transformation. Specifically, a higher proportion of civil servants with higher education levels is statistically associated with more advanced digital transformation processes; for every unit increase in education level, the dependent variable increases by 0.3548 units. In this regard, we accept H_4, which states that higher education levels are directly associated with digital transformation.

Also, municipalities led by mayors with completed university degrees tend to exhibit a significantly higher level of digital transformation than those led by mayors with only a completed elementary education. In other words, for every unit increase in education level, the dependent variable increases by 0.22957 units. However, the age and gender of the mayor are not associated with the digital transformation process. According to the findings, H_5 is partially accepted.

Tab. 3 – Technical-administrative dimension (descriptive statistics)

		Technical-administrative Dimension				
		Estimate	**Std. Error**	**t value**	**Pr(>|t|)**	**Full Model (Pr(>|t|)**
BurQuali[1]		0.3548	0.1415	2.507	0.0122 *	0.184316
GenderMale[2]		-0.01314	0.07553	-0.174	0.862	0.759449
University degree[3]		0.22957	0.09939	2.310	0.0209 *	0.405024
Age_Young_Adults		0.01571	0.08944	0.176	0.861	0.921839
Age_Elderly		0.05415	0.05992	0.904	0.366	0.913676
Region * Population size[3]						
Midwest	20001 até 50000 habitantes					0.048374 *
Northeast	100001 até 500000habitantes					0.023354 *
Number of cases		[1]4.265 observations	[2]3740 observations	[3]2368 observations		[1]4.265 observations

Source: From the authors.

When controlling municipal-level characteristics, we observed a negative association between the digital transformation process and cities in the Midwest region, with populations ranging from 20,000 to 50,000. More specifically, these municipalities demonstrate a decline of -0.6832 units in the digital transformation index. Furthermore, the reduction in the digital transformation index is more substantial for municipalities located in the Northeast region, amounting to -1.195137 units.

Our analysis indicated a significant relationship (even if faintly) between the bureaucracy quality and the mayor's university degree in digital transformation when assessed individually. However, the mayor's age, gender and age group did not show statistical significance. Yet, in the full model, this relationship loses statistical significance, suggesting that

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

there is a relationship — albeit weak — between variables. As pointed out, this weakening in the full model can also be attributed to the shared variance between the predictors and the broader scope of the dependent variable, encompassing both ICT infrastructure and the provision of digital services.

Investigations conducted in other countries have shown that age and gender can significantly influence technology adoption. For instance, studies in Korea found that younger policymakers are more likely to be active innovators (Hong et al., 2022). Similarly, research in Australia revealed that the manager's gender plays a crucial role in technology adoption (Alam et al., 2022). Alam et al. (2022) identified that female managers are more likely to leverage social networking platforms than their male counterparts. Furthermore, Onozaka and Nemoto (2023) highlighted that countries with higher female representation in the middle to senior management positions exhibit greater integration of digital technologies and more sophisticated ICT tasks performed by women.

However, our findings in Brazil did not reveal a significant impact of the mayor's age and gender on the adoption of technologies by local governments to offer platform services. This suggests that while these factors may be crucial in other contexts, their influence may vary significantly across different cultural, social, and political environments. These data reinforce the idea that in Brazil, factors associated with the bureaucracy and the mayor's formal education are more relevant to adopting digital technologies, and sociodemographic characteristics matter less – although the strength of this correlation is lost in the full model. The fact that the model adopted showed no statistical difference between men and women may be because most mayors in Brazil are men, reinforcing gender inequality in access to local political careers.

5. Conclusions and Recommendations

This study contributes to academic literature and public managers by identifying the drivers of digital transformation in local governments in Brazil. The research results converged with part of the scholarly literature, mainly on cultural aspects of digital transformation (Mergel et al., 2019). We also found that economic dimensions such as tax revenue capacity, investment in ICT, and less dependence on central and state government funding are important factors in leveraging digital transformation in the Brazilian local contexts, such as the bureaucracy and mayors' education levels. Nonetheless, the statistical significance became weakened in the full model (adopting the control variables).

There has been a change of focus in public administration theories in the last decade, where the focus has moved away from the idea of the internal efficiency of public administration and endogenous discussions in organizations to a primary focus on offering services and creating value for citizens (Osborne et al., 2013; Panagiotopoulos et al., 2019). The creation of public value through the provision of services has become one of the main mantras of digital transformation. However, we must still understand how digital transformation creates public value (Mergel et al., 2019). Our research highlighted significant advancements in many Brazilian local governments while exposing persistent inequalities. Disparities in ICT investment capacity, tax collection, and bureaucratic quality directly impact the provision of digital services. These factors, in turn, influence public value creation through service delivery. For digital transformation policy to develop effectively, policymakers need to pay attention to the characteristics of local governments.

The digital transformation in Brazil has been a dynamic and challenging process, driven by the growing need to adapt to new technologies and the pursuit of greater efficiency and competitiveness. In this context, the Brazilian regulatory framework has evolved to accompany this transformation, creating various laws to foster innovation, protect personal data, and ensure cybersecurity (Filgueiras et al., 2019). The Brazilian federal government recently redesigned its general data use and protection law, instituting new guidelines for all Brazilian public administration agencies, including local governments. Alongside this, Brazil's central government is also driving digital transformation by gradually creating and coordinating efforts so local governments, based on federal incentives, can develop strategies to offer services via platforms (Brazil, 2024).

Finally, the study's relevance relies on its being the first to analyze local governments and examine the determinants of digital innovation in the public sector in Brazil. This research significantly contributes to the existing literature by providing valuable insights into the Brazilian context (Filgueiras et al., 2019). By investigating the factors that influence the adoption of digital technologies in Brazilian municipalities, this study helps to understand the unique challenges and opportunities local governments face to modernize public services and improve service delivery to citizens. The results of this research can inform policy decisions, guide the development of targeted interventions, and contribute to the broader discourse on digital governance and public sector innovation in Brazil. Furthermore, analyzing the context of a country in the Global South adds knowledge to the international scientific community, joining forces with other researchers.

One of the main research limitations is secondary data. Despite CETIC, which is responsible for collecting data on the use of ICT and digital transformation in Brazilian municipalities, there is always a percentage of non-response to the survey. Moreover, the research yielded varying responses for each variable, as anticipated, given the use of multiple

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

databases. Secondly, we employed a quantitative approach, relying heavily on numerical data and statistical analysis and risking overemphasizing measurable variables while neglecting crucial aspects such as subjective experiences, emotions, citizen-state relationships, and cultural contexts. Consequently, this research could not qualitatively capture the primary drivers of ICT adoption and online service provision in Brazilian municipalities. Our findings indicated that economic (fiscal autonomy, tax revenue collection, ICT investments) and technical-administrative dimensions (bureaucracy and mayor's education) influenced digital transformation in Brazilian municipalities. However, further research is warranted to investigate the motivations and perceptions of local managers.

Funding or Grant

This research was funded by Foundation for Research Support of the Federal District that includes funding grants number 00193-00002202/2023-34.

Data/Software Access Statement

All the data used in this research is available at: https://www.cetic.br/pt/pesquisa/governo-eletronico/.

Contributor Statement

Lizandro Lui: Conceptualization, Funding acquisition, Project administration, Supervision, Writing – Original Draft and Writing - Review & Editing; **Rafael Barbosa de Aguiar:** Conceptualization, Writing – Original Draft and Writing - Review & Editing; **Lídia Nicole dos Santos ten Cate:** Data Curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – Original Draft and Writing - Review & Editing; **Samuel de Melo Barbosa:** Data Curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – Original Draft and Writing - Review & Editing.

Use of AI

During the preparation of this work, the authors used Grammarly in order to check grammar, spelling and writing. After using this tool/service, the authors reviewed, edited, made the content their own, validated the outcome as needed, and take full responsibility for the content of the publication

Conflict Of Interest (COI)

There is no conflict of interest.

References

Aguerre, C., & Bonina, C. (2024). Open government, civic tech and digital platforms in Latin America: A governance study of Montevideo's urban app 'Por Mi Barrio'. *Information Systems Journal*, *34*(4), 1037–1067. https://doi.org/10.1111/isj.12468

Alam, K., Ali, M. A., Erdiaw-Kwasie, M. O., Murray, P. A., & Wiesner, R. (2022). Digital Transformation among SMEs: Does Gender Matter? *Sustainability*, *14*(1), 535. https://doi.org/10.3390/su14010535

Alves, P. J. H. F., & Araujo, J. M. (2024). The effects of intergovernmental transfers on the local fiscal incentives of Brazilian municipalities. *Journal of Government and Economics*, *13*, 100104. https://doi.org/10.1016/j.jge.2024.100104

Branderhorst, E. M., & Ruijer, E. (2024). Digital leadership in local government: An empirical study of Dutch city managers. *Local Government Studies*, 1–24. https://doi.org/10.1080/03003930.2024.2363368

Budding, T., Faber, B., & Gradus, R. (2018). Assessing electronic service delivery in municipalities: Determinants and financial consequences of e-government implementation. *Local Government Studies*, *44*(5), 697–718. https://doi.org/10.1080/03003930.2018.1473768

CGI.BR – Comitê Gestor da Internet no Brasil. (2023). *Pesquisa sobre o uso das tecnologias de informação e comunicação no setor público brasileiro—TIC Governo Eletrônico 2023* [Dataset].

Criado, J. I., & Gil-Garcia, J. R. (2019). Creating public value through smart technologies and strategies: From digital services to artificial intelligence and beyond. *International Journal of Public Sector Management*, *32*(5), 438–450. https://doi.org/10.1108/IJPSM-07-2019-0178

Decreto nº 12.069, de 21 de Junho de 2024. Dispõe sobre a Estratégia Nacional de Governo Digital e a Rede Nacional de Governo Digital – Rede Gov.br e institui a Estratégia Nacional de Governo Digital para o período de 2024 a 2027., 12.069 (2024). https://www.planalto.gov.br/ccivil_03/_ato2023-2026/2024/decreto/d12069.htm

Epstein, B. (2022). Two decades of e-government diffusion among local governments in the United States. *Government Information Quarterly*, *39*(2), 101665. https://doi.org/10.1016/j.giq.2021.101665

Faber, B., Budding, T., & Gradus, R. (2020). Assessing social media use in Dutch municipalities: Political, institutional,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and socio-economic determinants. *Government Information Quarterly*, *37*(3), 101484. https://doi.org/10.1016/j.giq.2020.101484
Fan, B., & Pan, T. (2023). Does information technology–organizational resource interaction affect E-government performance? Moderating roles of environmental uncertainty. *Government Information Quarterly*, *40*(3), 101830. https://doi.org/10.1016/j.giq.2023.101830
Fan, Z., Christensen, T., & Ma, L. (2023). Policy attention and the adoption of public sector innovation. *Public Management Review*, *25*(10), 1815–1834. https://doi.org/10.1080/14719037.2022.2050283
Fan, Z., Meng, Q., & Wei, N. (2020). Fiscal slack or environmental pressures: Which matters more for technological innovation assimilation? A configurational approach. *International Public Management Journal*, *23*(3), 380–404. https://doi.org/10.1080/10967494.2019.1647318
Filgueiras, F., Flávio, C., & Palotti, P. (2019). Digital Transformation and Public Service Delivery in Brazil. *Latin American Policy*, *10*(2), 195–219. https://doi.org/10.1111/lamp.12169
Grin, E. J., & Abrucio, F. L. (2021). O elo perdido da descentralização no Brasil: A promoção das capacidades estatais municipais pelo governo federal. *Revista de Sociologia e Política*, *29*(77), e002. https://doi.org/10.1590/1678-987321297702
Haug, N., Dan, S., & Mergel, I. (2024). Digitally-induced change in the public sector: A systematic review and research agenda. *Public Management Review*, *26*(7), 1963–1987. https://doi.org/10.1080/14719037.2023.2234917
Hilhorst, C., Behrens, C., Brouwer, E., & Sneller, L. (2022). Efficiency gains in public service delivery through information technology in municipalities. *Government Information Quarterly*, *39*(4), 101724. https://doi.org/10.1016/j.giq.2022.101724
Hong, S., Kim, S. H., & Kwon, M. (2022). Determinants of digital innovation in the public sector. *Government Information Quarterly*, *39*(4), 101723. https://doi.org/10.1016/j.giq.2022.101723
Janssen, M., Chun, S. A., & Gil-Garcia, J. R. (2009). Building the next generation of digital government infrastructures. *Government Information Quarterly*, *26*(2), 233–237. https://doi.org/10.1016/j.giq.2008.12.006
Marenco, A., & Cate, L. T. (2021). Municípios são todos iguais? Decisões sobre gasto, orçamento e políticas públicas em governos locais. *Revista de Sociologia e Política*, *29*(77), e001. https://doi.org/10.1590/1678-987321297701
Medeiros, H. A. V., Figueiredo, D., Lima, M. T. A. de, Lucena, P. M. P. de, & Souza, L. S. de O. (2023). Construção de Indicadores Sintéticos para Tomada de Decisão em Governo: Um tutorial. *16º Congresso de Gestão Pública do Rio Grande do Norte*, 1–12.
Melin, U., Madsen, C. Ø., & Larsson, K. K. (2024). Five Bureaucratic Roles in the Age of Digital Transformation – Insights from Scandinavian Public Organizations. Em M. Janssen, J. Crompvoets, J. R. Gil-Garcia, H. Lee, I. Lindgren, A. Nikiforova, & G. Viale Pereira (Orgs.), *Electronic Government* (Vol. 14841, p. 99–115). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-70274-7_7
Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. *Government Information Quarterly*, *36*(4), 101385. https://doi.org/10.1016/j.giq.2019.06.002
Mukhopadhyay, S., Bouwman, H., & Jaiswal, M. P. (2019). An open platform centric approach for scalable government service delivery to the poor: The Aadhaar case. *Government Information Quarterly*, *36*(3), 437–448. https://doi.org/10.1016/j.giq.2019.05.001
Onozaka, Y., & Nemoto, K. (2023). Digital Transformation, Leadership, and Gender Equality: Are They Related? Em A. Khare & W. W. Baber (Orgs.), *Adopting and Adapting Innovation in Japan's Digital Transformation* (p. 155–173). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-0321-4_10
O'Reilly, T. (2011). Government as a Platform. *Innovations: Technology, Governance, Globalization*, *6*(1), 13–40. https://doi.org/10.1162/INOV_a_00056
Osah, J., & Pade-Khene, C. (2020). E-government strategy formulation in resource-constrained local government in South Africa. *Journal of Information Technology & Politics*, *17*(4), 426–451. https://doi.org/10.1080/19331681.2020.1715907
Osborne, S. P., Radnor, Z., & Nasi, G. (2013). A New Theory for Public Service Management? Toward a (Public) Service-Dominant Approach. *The American Review of Public Administration*, *43*(2), 135–158. https://doi.org/10.1177/0275074012466935
Panagiotopoulos, P., Klievink, B., & Cordella, A. (2019). Public value creation in digital government. *Government Information Quarterly*, *36*(4), 101421. https://doi.org/10.1016/j.giq.2019.101421
Przeybilovicz, E., Cunha, M. A., & Meirelles, F. D. S. (2018). O uso da tecnologia da informação e comunicação para caracterizar os municípios: Quem são e o que precisam para desenvolver ações de governo eletrônico e smart city. *Revista de Administração Pública*, *52*(4), 630–649. https://doi.org/10.1590/0034-7612170582
Reddick, C. G. (2006). Information Resource Managers and E-government Effectiveness: A Survey of Texas State Agencies. *Government Information Quarterly*, *23*(2), 249–266. https://doi.org/10.1016/j.giq.2005.11.006
Ruano De La Fuente, J. M. (2014). E-Government Strategies in Spanish Local Governments. *Local Government Studies*, *40*(4), 600–620. https://doi.org/10.1080/03003930.2013.787414
Salim, T. A., El Barachi, M., Mohamed, A. A. D., Halstead, S., & Babreak, N. (2022). The mediator and moderator roles of perceived cost on the relationship between organizational readiness and the intention to adopt blockchain technology. *Technology in Society*, *71*, 102108. https://doi.org/10.1016/j.techsoc.2022.102108
Savoldelli, A., Codagnone, C., & Misuraca, G. (2014). Understanding the e-government paradox: Learning from

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

literature and practice on barriers to adoption. *Government Information Quarterly*, *31*, S63–S71. https://doi.org/10.1016/j.giq.2014.01.008

Scholta, H., Mertens, W., Kowalkiewicz, M., & Becker, J. (2019). From one-stop shop to no-stop shop: An e-government stage model. *Government Information Quarterly*, *36*(1), 11–26. https://doi.org/10.1016/j.giq.2018.11.010

Segatto, C. I., Santos, F. B. P. D., Bichir, R. M., & Morandi, E. L. (2022). Inequalities and the COVID-19 pandemic in Brazil: Analyzing un-coordinated responses in social assistance and education. *Policy and Society*, *41*(2), 306–320. https://doi.org/10.1093/polsoc/puac005

Siqueira, É. S., Araujo, M. H. de, Souza, C. A. de, & Reinhard, N. (2015). Análise multivariada com dados binários e sua potencial aplicação na área de tecnologia da informação e comunicação. *Encontro de Administração da Informação - EnADI*.

Stier, S. (2015). Political determinants of e-government performance revisited: Comparing democracies and autocracies. *Government Information Quarterly*, *32*(3), 270–278. https://doi.org/10.1016/j.giq.2015.05.004

Welch, E. W., & Feeney, M. K. (2014). Technology in government: How organizational culture mediates information and communication technology outcomes. *Government Information Quarterly*, *31*(4), 506–512. https://doi.org/10.1016/j.giq.2014.07.006

Wilson, C., & Mergel, I. (2022). Overcoming barriers to digital government: Mapping the strategies of digital champions. *Government Information Quarterly*, *39*(2), 101681. https://doi.org/10.1016/j.giq.2022.101681

Yun, H. J., & Opheim, C. (2010). Building on Success: The Diffusion of e-Government in the American States. *Electronic Journal of e-Government*, *8*(1), 1–12.

Zhu, X., & Zhang, Y. (2019). Diffusion of Marketization Innovation with Administrative Centralization in a Multilevel System: Evidence from China. *Journal of Public Administration Research and Theory*, *29*(1), 133–150. https://doi.org/10.1093/jopart/muy034

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Appendix A

Tab. 3 – Description of the indicators that constitute the Digital Transformation variable

Indicator	Description	Dimension
C1	Does this municipality have a dedicated IT department or division?	Technological
C1G_A	Has this municipality formally adopted an IT master plan or strategy?	
C1G_B	Does this city hall have a formally established information security plan?	
F5A	Is there a designated individual or team responsible for data privacy and compliance with the General Data Protection Law (LGPD) within this municipality?	
F5C	Have any of the employees in the city hall's IT department or area received any training, course, or workshop offered by the city hall regarding the General Data Protection Law (LGPD)?	
I1B_1_C	Has this city government made any mobile applications developed in-house for citizen use available within the past 12 months?	
D10	Does the city government offer any online services that citizens can access using the federal government's single sign-on system, Gov.br?	
H1P_A	Does the city government's website offer a service that allows users to generate tax bills or other payment slips?	Digital Public Services
H1P_C	Does the city government's website offer a service that allows users to issue electronic invoices?	
H1P_F	Does the city government's website offer a service that allows users to issue documents such as licenses, certificates, permits, and others?	
H1P_G	Does the city government's website offer a service allowing users to register or enroll for contests, courses, and schools?	
H1P_H	Does the city government's website offer a service that allows users to schedule appointments for consultations, services, and other matters?	

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Wind of Change or Just Another Digitalization Breeze? Lessons from Municipal Digital Change Agent Initiatives

Ina Jäger [a], *Andreas* Hein [b], *Helmut* Krcmar [c]

[a] School of Information, Computation and Technology, Technical University of Munich, Munich, Germany, inajaeger@tum.de, 0009-0009-7851-4339.

[b] Institute of Information Systems and Digital Business, University of St. Gallen, St. Gallen, Switzerland, andreas.hein@unisg.ch, 0000-0001-9565-5840.

[c] School of Information, Computation and Technology, Technical University of Munich, Munich, Germany, helmut.krcmar@tum.de, 0000-0002-2754-8493.

Abstract. Digital transformation (DT) is a critical challenge for public administration, requiring municipalities to modernize services while overcoming bureaucratic inertia and workforce resistance. Hence, many German states have recently invested in municipal digital change agent (MDCA) initiatives (kommunale Digitallotseninitiativen) to facilitate and accelerate the DT process within municipalities. However, the effectiveness of such initiatives remains underexplored, as public sector constraints differ from those in private organizations, and due to their novelty. This study adopts a case study design using interviews and document analyses to examine the effectiveness and potential of MDCA initiatives. The findings indicate that the success of digital change agents is contingent on clearly defined roles, effective communication strategies, and adequate resource support. The findings highlight key drivers of success, including digital capabilities, appointing dedicated digitalization staff, fostering proactive employee initiatives, participatory leadership, proactive communication, (re)building trust, and personal benefits. However, several challenges impede MDCA's effectiveness, such as unclear role definitions, insufficient training, lack of assigned responsibilities and communication, resource scarcity, and inadequate leadership support. Structural obstacles, such as low prioritization of digitalization, absence of incentives, and resistance from tenured employees, further restrict progress. The study derives four propositions regarding the effectiveness of MDCA initiatives and DT enhancement in public administration: Clearly defining the MDCA role and responsibilities, assigning DT responsibilities to managers, increasing visibility and prioritization of DT, and introducing incentive mechanisms to foster engagement. These insights contribute to the literature on DT and change management in public administration, highlighting the need for structured frameworks and accountability measures. While MDCAs can act as catalysts for digital change, their effectiveness depends on strategic alignment, leadership commitment, and adequate resource allocation.

Keywords. Digital Transformation, Internal Change Agents, Public Administration, Municipalities, E-government

1. Introduction

Governments worldwide are changing in the light of DT, aiming to enhance process efficiency and improve public service delivery (Twizeyimana & Andersson, 2019). Municipalities play a particularly critical role in this process, as they are the first point of contact for many citizens, providing the majority of the national, state, and municipal public services. Effective digitalization can help enhance service delivery and accessibility, optimize resource allocation, and mitigate workforce shortages. Furthermore, governments face growing pressure to digitize services, increase transparency, and foster citizen engagement in response to evolving societal and technological demands (Jahn et al., 2024).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

However, public sector organizations in Germany encounter unique challenges in adopting DT (Ritchie, 2014). Legal constraints, bureaucratic inertia, and risk aversion slow progress, as a workforce accustomed to traditional processes often resist new technologies (Kussel et al., 2024; H. Markus & Meuche, 2022). Public authorities operate strictly within the boundaries of legal provisions, meaning that any change to processes has emerged from the law. If regulations do not explicitly require digital workflows, there is little motivation or incentive to implement them, as they lack the legal basis to justify financial resources from tax funds (Ritchie, 2014). Beyond legal constraints, institutional inertia and resistance to change present additional challenges. Employees accustomed to well-established administrative procedures for decades may view digitalization as a disruption rather than an improvement. Unlike private-sector organizations, where competition and efficiency pressures drive innovation, public administration operates under long-term stability principles, making change slow and complex. In addition, DT extends beyond mere technology adoption; it requires a fundamental cultural shift, which is often underestimated (Bannister & Connolly, 2014; Kuhlmann & Heuberger, 2023). Thus, implementation requires people familiar with the process to make the necessary local adjustments. To address these challenges, several German states have introduced MDCA initiatives (Kommunale Digitallotseninitiativen) to support and accelerate DT in municipalities (Fischer & Breaugh, 2024). MDCAs are internal employees who receive external training to assist their colleagues and facilitate DT (Fischer & Breaugh, 2024). However, the municipalities struggle to measure the effectiveness of such initiatives because private sector change management metrics are not easily transferable due to differing objectives (shareholder value vs. public value (Moore, 1995; Segura-Tinoco et al., 2020)) and workforce demographics and culture. For instance, in German public administration, 26% of employees and 31% of political leaders are over 55, often lacking digital education (H. Markus & Meuche, 2022).

The existing literature on DT in public administration covers various aspects of change management, strategy, and transformation progress (Kuipers et al., 2014; Tangi et al., 2021; van de Voet, 2014). However, much of this research focuses on high-level strategies and transformation outcomes (e.g., Gong et al., 2020), while the evaluation of specific measures and influencing factors remains underexplored (Buick et al., 2018; Heuberger, 2020; Kuipers et al., 2014). In contrast, change agents literature in the private sector is more developed, with numerous studies identifying success factors, impact areas, and facilitation methods (Bünnagel, 2021; Parry et al., 2014).

However, there is limited research on internal change agents in public administration, with existing studies primarily focusing on the role of managers and their influence on organizational change (Pittaway & Montazemi, 2020; Tangi et al., 2021; van de Voet, 2014). As a result, lower-hierarchy change agents, such as regular MDCAs, remain understudied despite their potential impact on DT. Kuipers et al. (2014) highlight that research often lacks detailed analyses of change processes and their outcomes in public organizations, leaving a gap in understanding how change unfolds and is sustained in governmental settings. This gap underscores the need for further empirical research into the role, effectiveness, and evaluation of internal change agents in public administration. Additionally, most public sector studies prioritize the content and context of change over the actual transformation process and its outcomes (Kuipers et al., 2014). While public sector DT is often technology-driven, cultural and social aspects – such as leadership, regulations, and workforce adaptation – are equally important but frequently overlooked (Kuhlmann & Heuberger, 2023; Mergel et al., 2019; Tangi et al., 2021). Successful DT requires organizational readiness and leadership-driven change, not just technical system upgrades. Moreover, the role of MDCAs is a relatively new and underexplored phenomenon. Most research on change agents focuses on private-sector contexts, leaving limited empirical work on their role and effectiveness in public administration, particularly in facilitating cultural and technological change (Fischer & Breaugh, 2024; Kuhlmann & Heuberger, 2023). Without such evaluations, whether these programs are effective and should be scaled further remains unclear. This gap leads to the following research question: *What factors influence the effectiveness of the municipal digital change agent initiative?*

To address the question, we conducted an exploratory case study (Yin, 2014) to investigate the effectiveness of an MDCA initiative in southern Germany. Our data collection includes 34 semi-structured interviews, analyzed through an abductive coding approach comparing success factors from the literature to the case. Additionally, we incorporated document analysis, informal discussions with the project team, and participation in initiative events for triangulation. To assess the impact of MDCAs, we compared practices and digitalization levels between departments with and without MDCAs. Furthermore, a case comparison with another municipality in southern Germany supports the robustness of the findings.

The study identified key drivers and challenges of MDCA initiatives in public administration. Effective MDCA initiatives and DT are driven by building digital capabilities, appointing dedicated digitalization staff, fostering proactive employee initiatives, encouraging participatory leadership, promoting proactive communication, building trust, and offering personal benefits. However, challenges such as unclear MDCA role definitions, unassigned responsibilities, lack of communication, resource scarcity, limited training, and insufficient leadership support hinder MDCA's effectiveness. Additionally, structural barriers like weak change incentives and low prioritization of digitalization efforts further impede progress. The study concludes with propositions and recommendations for effective MDCA initiatives.

Our study contributes to DT and change agents literature in public administration by examining the effectiveness of MDCA initiatives in a quasi-voluntary setup (Fischer & Breaugh, 2024). By identifying key drivers and challenges, we offer empirical insights into MDCA initiatives and the role of non-management level MDCAs in accelerating DT. Additionally, our findings broaden the discourse on change agents by shifting the focus from leadership roles to regular employees (Pittaway & Montazemi, 2020). The derived propositions serve as a foundation for future research to empirically validate, and the proposed recommendations can be used to set up more effective MDCA initiatives.

2. Theoretical Background

2.1 Change and Digital Transformation in Public Administration

The concept of change and change management encompasses numerous definitions, with "organizational change" being the most commonly used term. van de Ven and Poole (2014) define change in an organizational context as a transformation in form, quality, or condition that can be empirically observed over time. Organizational change involves not only adjustments to structures, systems, and processes but also psychological effects on employees (Choi, 2011). At the same time, employees can significantly influence the change process (Choi, 2011).

DT describes changes in core practices, competencies, processes, as well as (organizational) culture and mindset (Gong et al., 2020). The literature increasingly refers to a continuous change driven by digital technologies, aiming to improve or transform processes through information, computing, communication, and netwosrking technologies (Haug et al., 2024; Vial, 2019). Although governments, states, and municipalities conduct a variety of planned change initiatives, many scholars describe DT in public administration primarily as an emergent process, where incremental changes accumulate into a broader transformation (Kickert, 2010; Mergel et al., 2019). This is because DT is often viewed as a continuous process, in contrast to earlier e-government initiatives, which were characterized by a defined start and end date, a measurable outcome, and a fixed budget (Kickert, 2010; Mergel et al., 2019).

Research also associates DT in public administration with more efficient internal processes, expanded information provision, and a transformed relationship with citizens and businesses (Ndou, 2004). Additionally, bureaucratic structures pose a challenge as they can hinder the adoption of new technological innovations (Lekkas & Souitaris, 2023). Furthermore, the shortage of IT professionals and difficulties in recruiting qualified personnel complicate the implementation of such initiatives (Czernich et al., 2021). Research and practice have shown that successful DT relies on individuals familiar with the processes to implement local adjustments. At the same time, a fundamental cultural shift is necessary to better integrate digital elements into workflows and enable sustainable change (Heuberger, 2020). However, the subsequent organizational culture transformation is often overlooked in the context of DT in public administration and usually follows the technical digitization process (Tangi et al., 2021). In addition to technological aspects, social factors play a crucial role but are frequently underestimated (Bannister & Connolly, 2014; Kuhlmann & Heuberger, 2023). Thus, an increasing number of public administrations use the concept of internal change agents.

2.2 Internal Digital Change Agents

In the context of change initiatives, individuals or teams, known as change agents, can take on the initiation, promotion, or implementation of change initiatives (Caldwell, 2003). A distinction can be made between internal (employed staff) and external (external staff, e.g., consultants) change agents (Caldwell, 2003). Internal change agents address individual reactions to change (Wylie & Sturdy, 2018) or promote change (M. L. Markus & Benjamin, 1996). Studies have examined a variety of aspects of this concept, such as the influence on resistance (Battilana & Casciaro, 2013; Ford, Jeffrey D., Ford, Laurie W. & d'Amelio, 2008), acceptance and readiness benefits (Armenakis et al., 1993; Hemme et al., 2018), as well as individual workplace behavior (Parke et al., 2021). For instance, in Lewin's 3-phase model, change agents support readiness in the first phase, promote acceptance and exploration of the change in the second phase, and consolidate the progress made in the third phase (Armenakis & Bedeian, 1999; Burnes, 2004; Wylie & Sturdy, 2018). In this study, we focus on internal change agents based on Wylie and Sturdy (2018). The authors define them as individuals in permanent employment who dedicate part of their role to managing change, actively contributing to defined change projects or programs, and being part of a team or unit with a clearly assigned responsibility for implementing change. Thus, we define MDCA as trained internal employees facilitating DT within a municipal organization like a city administration. Another dimension for change agents is their role within the organization, whether in a leadership position or as regular employees (Parke et al., 2021; Specht et al., 2018). Regardless of their role, a strong network within the organization and effective change communication are key success factors (Battilana & Casciaro, 2013).

For a successful DT, processes, regulations, employees, and especially leadership must be adapted (Mergel et al., 2019). The literature emphasizes the crucial role of managers, as they exert the most significant influence within hierarchical structures (Kuipers et al., 2014; Pittaway & Montazemi, 2020). DT significantly impacts the

relationship between public managers and employees, requiring managers to emphasize relationship management, participatory leadership, and clear frameworks to effectively engage their employees (Gilli et al., 2024). Research focuses on the role and influence of leadership, identifying managerial support as a critical factor (Kuipers et al., 2014; Pittaway & Montazemi, 2020). Studies address topics such as the perception of DT (Mergel et al., 2019), challenges (Moser-Plautz, 2024), the impact of communication on employee readiness (Hameed et al., 2019), DT expertise of leaders (Pittaway & Montazemi, 2020), and the role of middle management as change agents in managing resistance (Buick et al., 2018). Buick et al. (2018) found that middle management change agents can effectively facilitate transformation and reduce resistance if adequately supported. However, the role and effectiveness of MDCAs, who are not exclusively in management positions, have been neglected in existing research.

MDCA initiatives aim to accelerate DT in cities, municipalities, and districts. They act as an interface between administration, citizens, and businesses to efficiently facilitate the DT in public administration (Fischer & Breaugh, 2024). The first approaches to such programs emerged in Germany in 2018 when the first federal states in southern Germany began deploying administrative staff as MDCAs following specialized training to support administrations in digitalizing processes and services. These programs were further developed in subsequent years and adopted by other federal states. During the COVID-19 pandemic (2020–2021), digitalization gained significant traction, further increasing the relevance of MDCAs. Many German cities implemented such programs to systematically address the challenges of DT.

2.3 Impact Areas of Internal Change Agents

The effectiveness of internal change agents in enhancing DT depends on their skills and the organizational areas they can impact. This chapter summarizes three core impact areas: employee support, resistance management and acceptance, and networking. All impact areas contribute to the workforce's acceptance of and willingness to change and are thus relevant for internal change agents such as MDCAs. While internal change agents can facilitate communication, foster readiness for change, and mitigate resistance (Buick et al., 2018), their effectiveness depends on leadership backing and sufficient resources (Fischer & Breaugh, 2024).

Impact areas are the key domains where change agents influence organizational transformation, defining where and how their actions drive change. Employee support comprises two key areas: social support and the promotion of self-efficacy. *Social support*, a central focus of change agents, includes emotional, instrumental, informational, and appreciative support (Bünnagel, 2021; Fischer & Breaugh, 2024). *Emotional support* aims to reduce fears and foster readiness for change through empathy, trust, and active listening (Endrejat et al., 2021). *Instrumental support* provides practical help, such as assistance with information systems, while *informational* support focuses on the structured sharing of explicit and tacit knowledge (Bünnagel, 2021; Fischer & Breaugh, 2024). *Appreciative support* enhances self-efficacy through constructive feedback and the recognition of achievements (Bünnagel, 2021). Promoting *self-efficacy* focuses on strengthening employees' personal traits that enhance openness to change. Self-efficacy is a key factor in successfully navigating change processes (Armenakis et al., 1993; Kuntz & Gomes, 2012). Overall, support from change agents contributes to fostering readiness for change and overcoming challenges in the transformation process.

Managing resistance is one of the core responsibilities of change agents (Angehrn & Atherton, 1999; Endrejat et al., 2021). They can create an understanding of change by highlighting its necessity and urgency (Armenakis & Fredenberger, 1997). In addition, change agents are expected to convince employees of the change and increase their willingness to embrace it by demonstrating organizational and personal benefits (Armenakis et al., 1993; Hemme et al., 2018). It is crucial for employees to recognize that the change is achievable and that they possess the skills required to implement it successfully, also known as resilience (Armenakis & Fredenberger, 1997). Clearly defined and achievable goals can further build trust in the change process (Kuntz & Gomes, 2012). Another goal of change agents is to foster a sense of accountability for the change among employees (Angehrn & Atherton, 1999). They should also confidently handle critical reactions and effectively manage conflicts (Pádár et al., 2017). Furthermore, they should address problems directly and confront underperforming employees or leaders when necessary (Furnham, 2002).

Managers play a unique role in change processes as they can impact areas beyond the influence of regular change agents, increasing the impact. Managers can influence DT at various hierarchical levels and in different ways. Lekkas and Souitaris (2023) distinguish between higher-level and lower-level managers: while senior managers initiate or approve changes, their lower-ranking counterparts are primarily responsible for operational implementation. Higher-level managers are tasked with developing visions and strategies for transformation (Fernandez & Rainey, 2006). This includes formulating a clear vision, defining goals, outlining expected outcomes, and assessing their impact on respective departments (Caldwell, 2003; Westover, 2010). Additionally, they are responsible for initiating the change process (Caldwell, 2003), ensuring the provision of adequate resources (Caldwell, 2003; Fernandez & Rainey, 2006), and overseeing progress to evaluate the success of the transformation (Angehrn & Atherton, 1999; Bünnagel, 2021). Lower-level managers play a crucial role in engaging employees at

the operational level. In addition to managing resistance (Westover, 2010), they can encourage employees to adopt new technologies (Caldwell, 2003). Gathering feedback, such as on new software, and organizing training programs are also central responsibilities (Fernandez & Rainey, 2006; Westover, 2010).

To enhance employee involvement, bottom-up initiatives are often promoted (Hansen & Nørup, 2017), and employees are integrated into decision-making processes (Angehrn & Atherton, 1999; Hansen & Nørup, 2017; Westover, 2010). Participation in implementation can further increase employees' acceptance of change initiatives (Fernandez & Rainey, 2006). While a participative leadership style improves change acceptance, a more directive leadership approach is recommended for performance-oriented implementation (Hansen & Nørup, 2017; Westover, 2010). Managers can also employ various motivational strategies. Besides traditional incentives, persuasion, rewards, and guarantees against potential disadvantages, they may also use critical feedback, pressure, or coercion (Fernandez & Rainey, 2006). Supportive measures such as psychological assistance or symbolic ceremonies can also facilitate transformation processes (Fernandez & Rainey, 2006). Managers at all levels can also influence change passively by demonstrating acceptance and commitment to transformation through their own attitudes and behaviors, thereby signaling their support for the process (Armenakis et al., 1993).

3. Method

MDCA initiatives are still a quite new approach that an increasing number of cities implement to accelerate their stagnating DT activities. The review of the literature revealed a lack of empirical evidence on the effectiveness and success of such initiatives (Kuhlmann & Heuberger, 2023; Tangi et al., 2021). When conducting the study, the literature provided little empirical evidence on the effectiveness and success of such initiatives. Therefore, we deem an exploratory case study approach suitable for the study (Yin, 2014).

3.1 Case City

For this study, we collaborated with a major city (with a population of at least 100,000 – in our case, less than 200,000) in southern Germany. The city implemented MDCAs in its municipal administration in 2019. According to their current concept, MDCAs serve as multiplicators for DT, aiming to reduce fears and concerns while motivating employees to actively contribute to its implementation. The MDCAs are part of their digital strategy, which targets DT across nearly all administrative areas, resulting in the deployment of MDCAs in almost all departments. The case city emphasized that every employee – regardless of the role or hierarchy level – is welcome to participate in the training and to qualify as MDCA.

The initiative is coordinated by the Department for Digitalization and IT Planning (Digitalization Department). The MDCAs are municipal employees who undergo three-day seminars to be trained as ambassadors for digitalization. During the training, they receive basic knowledge of DT and Change Management. The program aims to actively involve employees in the DT. The main tasks of MDCAs in the case city include informing colleagues about the city's digital activities, enhancing the understanding of DT, serving as advisors and supporters to mitigate concerns and fears, the proactive proposal of ideas to advance DT, driving cultural change by exemplifying a digital mindset, supporting organizational units in communicating their digital needs as well as implementing the digitalization strategy and actively shaping the DT. For these tasks, five working days per year are allocated for MDCAs. Additional initiatives can be pursued beyond regular working hours. Consequently, the role is quasi-voluntary.

3.2 Data Collection and Analysis

We used several information sources to collect data and enable data triangulation (Yin, 2014). Therefore, we conducted 34 semi-structured interviews, participated in an MDCA networking event day, protocoled the observations from the event and from informal meetings with the project leaders, and analyzed internal documents. The case city comprises 38 departments, ranging from the citizens' office to the city treasury and facility management. At the time of data collection in early 2024, 17 of these departments hosted 27 MDCAs, leaving 21 departments without an MDCA. To comprehensively analyze the effects of the MDCA initiative, we interviewed MDCAs, their managers, and employees from departments with MDCAs. In departments without MDCAs, we interviewed managers and employees to gather comparative insights. As summarized in Table 1, a total of 34 interviews were conducted – 28 in departments with MDCAs and 6 in departments without MDCAs, the latter reporting a high degree of digitalization. Specifically, in departments with MDCAs, we conducted 10 interviews with MDCAs, 8 with MDCAs in management positions, 4 with regular employees, and 6 with managers. In departments without MDCAs, interviews included three employees and three public managers across three departments. The sampling was balanced to account for the MDCAs' years of experience, as we anticipated that greater experience would correlate with higher impact (Myers & Newman, 2007). Interviews ranged from 24 to 77 minutes, averaging 43 minutes. The sampling process was influenced by employee availability, resulting in last-minute cancellations and adjustments, including the replacement of interviewees.

Tab. 1 – Interview Sampling (MDCA-M = Municipal Digital Change Agent-Manager, E = Employee, M = Manager).

Department	MDCA	MDCA-M	E	M
6 with MDCAs	10	8	4	6
4 without MDCAs	N/A	N/A	3	3

Based on the literature review, the informal discussions with project management, and the document analysis findings, an interview guide was developed to gain a deeper understanding of the experiences, perspectives, and attitudes of the MDCAs. It covers key topics such as resistance management, digital competencies, readiness and willingness to change, acceptance, change agent training, challenges and success factors, and the perception of the MDCA initiative and the MDCAs themselves. The interviews aimed to gather insights into the extent to which actual experiences and practices align with the concepts described in the literature and the goals pursued by the city. Semi-structured interviews were conducted to achieve comparable results while still capturing the diversity of MDCA mechanisms (Myers & Newman, 2007). During a full-day MDCA networking event, we talked to the MDCAs, participated in the discussion rounds, and summarized all impressions and observations in a joint protocol (Yin, 2014). The observations covered the agenda, self-perception, wishes, complaints, and tasks mentioned by the MDCAs, presented facts about the initiative in the case city and relevant quotes per topic. As for the document analysis, we included training documents, the digital strategy of the case city, their MDCA concept, annual reports, an internal MDCA toolbox, protocols of the meetings with the MDCA project leaders, and presentations (if available) from the networking events.

The data analysis followed an abductive coding approach based on concepts from the literature while drawing on grounded theory to identify emerging themes and patterns (Eisenhardt, 1989; Gioia et al., 2013). The analysis focused on identifying the drivers and challenges of the current MDCA initiative regarding DT for a comprehensive understanding of its implementation. We employed triangulation across all data sources to enhance reliability and validity (Yin, 2014). To enhance the robustness of our study, we incorporated insights gained through a public meeting from another city (>150,000 inhabitants) in southern Germany. The city (City-2) implemented the same MDCA initiative following the same state-led training initiative and conducted an internal evaluation.

4. Results

4.1 Drivers of Municipal Digital Change Agents and Digital Transformation in Public Administration

This section presents the drivers for MDCA initiatives and DT in public administration identified from the case study. Table 2 summarizes all drivers at the end of chapter 4. In the following interviewee citations are indicated according to Table 1 (e.g., M1 = Manager1).

Building digital capabilities. Departments without MDCAs but with a high degree of digitalization emphasized their ability to build and capture digital capabilities by strategically hiring tech-savvy employees. Thus, focusing on digital expertise in recruitment is a key driver for their digitalization success. While most employees acquired the necessary digital skills during their professional education, several managers reported identifying tech-savvy employees within their teams and intentionally assigning them digital tasks to leverage their expertise or point them out as digitally responsible (M2; M4; M5). In addition, employees in digitalized departments are reported to be well-trained in the respective systems.

Dedicated full-time digitalization equivalent. Each digitalized department had at least one team member responsible for digital topics. These employees were typically tech-savvy individuals with a strong curiosity and intrinsic interest in digitalization, demonstrating dedication and a fundamental understanding of the relevant processes. The need for such a role stems from the increasing complexity of digitalization efforts, making a decentralized approach less viable. As one interviewee explained, *"[Digitalization] has now reached such a scale and requires consolidated expertise that we decided to create the position of a 'digitalization specialist' position within our organization to centralize the competencies previously distributed across various individuals. (...) In my opinion, decentralization no longer works. It can only function centrally, with someone who holds all the threads while involving others (...)."* (M3) While most MDCAs themselves have limited capacity for DT topics directly, they view themselves as role models*: "I see it as my responsibility to make sure that I use the city's digital services, that people can see I use them, that I can handle them, and that I also look into what else can be digitalized that hasn't been digitalized yet."* (MDCA5) By demonstrating digital competence in practice, they aim to encourage broader acceptance and integration of digital processes across their departments. Although awareness of the MDCA initiative varies, several employees who know about it appreciate having a clear point of contact for digitalization-related concerns, recognizing the necessity of guidance and structured support. *"I do think it's good to have a point of contact to turn to. Because if everything gets digitalized and there's no one you can approach with questions, it would become a bit difficult. One person might be more technically skilled, (…) and understand things more easily, while another might not. I also have to consider the older colleagues."* (M5).

Proactive employee initiatives. While various facets of proactive initiative were observed, they originate from the same underlying reasons: a strong sense of responsibility and the belief that individual actions can lead to meaningful improvements in processes and workflows. Therefore, employees demonstrated attentiveness towards their colleagues and proactively offered help where needed: *"Afterward, I did realize that there was still a need for discussion – and that not everyone understood what was happening. I then scheduled another meeting once I noticed this to provide a more fundamental explanation."* (M1, MDCA-M1). Beyond assisting, employees take ownership of digital advancements, identifying opportunities for tool development or software improvements. When they recognize inefficiencies or discover better solutions from external sources, they take the initiative to assess potential benefits and address the topic with their manager. As one manager told us: "*Now we're switching to a new software. These are initiatives that come from employees who have learned that something like this works elsewhere with certain software. It fits better. Then you look at things and consider whether you can generate added value or simplify work processes."* (M2). This mindset reflects a new culture where employees actively shape their digital environment rather than passively adapting to imposed changes, ensuring that new technologies are integrated to enhance efficiency and usability.

Participatory leadership style. This describes managers who include their employees through active communication, feedback collection, and participation. There is a strong consensus that managers should actively support DT by involving employees and providing clear strategic direction. *"Ultimately, it all stands and falls with the managers – no question about it. They must ensure persistence, advocate effectively, and act as the driving force."* (M3). Managers from these departments stated that they regularly collect feedback from team members on tools and requirements for new software, invite them to beta tests, and talk about current updates and concerns at team meetings (M2; M4). In addition, some managers mentioned celebrating digitalization successes with their teams, reinforcing motivation and a positive attitude toward change. Training programs in these departments play a key role in preparing leaders for this approach, as managers and aspiring managers are systematically trained in change management and transformation methods as part of their career development. One MDCA-M also adopted a similar approach to encourage collaborative innovation: *"[I] actually try to involve people in a dialogue and encourage them to think for themselves about what could be done. (…) It's not about me sitting in an office and deciding how things should be done, but about sitting down together and figuring out how to approach it and what solutions we have."* (MDCA-M5). A participatory leadership style creates a more sustainable and employee-driven DT process by positioning leadership as an enabler rather than a directive force.

Active communication. Active communication is also part of the participatory leadership style and can be enacted by both managers and employees. Still, regular MDCAs can use proactive communication to spread information about DT and to give feedback to their colleagues and managers on how to enhance a digital mindset*: "Well, I spoke very openly. I often said, yes, you also have to deal with it, so, of course, it was department manager and his deputy. There's no other option, you have to deal with it."* (MDCA2) Departments with strong communication structures (M3; M1) report that employees feel well-informed about digitalization and system handling (M5; M2; E2). In addition, the Digitalization Department shares information on DT, e.g., by offering practical guidance on activities like setting up mobile devices, which employees and MDCAs who use the intranet find very valuable. Furthermore, MDCAs can serve as a direct communication link between employees and the Digitalization Department. In some cases, they helped identify needs, problems, and progress within their department.

(Re-)Building trust. MDCAs build trust by engaging with colleagues, pointing out the advantages of digitalization and small efficiency gains (e.g., using email instead of internal mail), and attempting to reduce fears by building trust. In this process, having the patience to identify the root causes of those fears helped to overcome them and ultimately generate acceptance. Those who were a bit anxious can be persuaded through training and support programs. However, individuals with deeply ingrained fears often develop them due to previous negative experiences with change initiatives. Hence, they first need time to rebuild trust, as illustrated by one MDCA: *"They are really extremely afraid, and in some cases, they're 30, 40, 50 years old, working for the city (…) they've had bad experiences, they lack trust, and that was crucial. I first had to build trust. It took about a year, but then it was really, really great because they knew they could rely on me. They simply lacked a foundation."* (MDCA7). Thus, MDCAs could effectively take on the role of a trusted intermediary, facilitating smoother transitions and greater acceptance of DT efforts (MDCA7; MDCA-M5). In addition, many MDCAs reported open, trusting relationships with colleagues (MDCA5; MDCA1).

Personal benefit. Employees seemed more likely to accept change in terms of DT or take over digital responsibilities when this change comes with other benefits for them, such as remote work. One interviewee from the municipal health department explained that the introduction of remote work significantly increased willingness to adopt digital tools during the COVID-19 pandemic*: "There was resistance from employees, yes, and skepticism, no question about it. The workforce (...) has a rather advanced age, let's put it that way, and perhaps a mindset that is somewhat inflexible. (...) Many employees have been here for decades (...), and they naturally struggled a lot with the transition. (...) Ultimately, there was a significant shift when the option of working from home was introduced. Then, employees showed more willingness to embrace something new."* (E2). In addition, offering individual benefits also lowers resistance and increases readiness for digital change. *"I resisted taking on the role*

of digitalization officer for a year. (...) then I finally agreed to do it voluntarily and got a day of home office in return. That's how they got me." (E1), explained an employee from the specialist administration for the building material rights department.

4.2 Challenges of Municipal Digital Change Agents Initiatives

This chapter describes the challenges we encountered while investigating the MDCA initiative. We clustered them into organizational, cultural, and structural challenges. Each group has a different level of access or leverage for the municipalities to implement resolutions. Table 2 summarizes all challenges at the end of chapter 4.

The organizational challenges are obstacles that lie within the organizational setup of the MDCA initiative. Hence, the city has the power to overcome the challenges of this group. While the power to change is high, this does not necessarily mean that the case city has sufficient resources to implement resolution changes.

MDCA Role Ambiguity. There is significant uncertainty among the MDCAs and employees about the change agents' specific tasks and responsibilities, which has been identified as the biggest challenge. The majority of the interviewees (employees, managers, and MDCAs) stated that they were not sure about the responsibilities or duties of an MDCA. One MDCA told us directly: *"[I] am an MDCA, but I don't really know exactly what the goal is at the end of the day. I was never really informed about what was expected. There isn't much information provided (...). I'm not really sure what rights or freedoms are granted in this role, even in day-to-day work."* (MDCA4) The majority perceive themselves as a person of contact. The MDCA concept of the case city includes the following responsibilities that MDCA should take on: active information dissemination, assessment of digital needs, acting as intermediaries between relevant stakeholders, proactively contributing suggestions on how organizational units can advance, serving as a local point of contact, reporting on DT progresses, regular participation in network meetings and knowledge exchange, and contribute to the implementation of the digital strategy by engaging in workshops, real-world labs, and projects. However, further than this level, the description is quite vague in terms of SMART goals or even monitoring mechanisms. We found that two factors contribute to this discrepancy: First, minimal offers (workshops, meetings, a standardized channel for suggestions, etc.) and no reporting claimed by the Digitalization Department (which we address later), and second, a lack of communication about the role. The latter was also documented in a Q&A session following up an early MDCA networking event. Thus, we suspect that this ambiguity harmfully affects the effectiveness of the MDCA. Consequently, the MDCA role is not the primary driver of action. One MDCA explained: *"I don't know if it's due to the role of being an MDCA or if the same result would have been achieved without it."* (MDCA5). The void created by the unclear definition of the MDCA's responsibilities is filled with other topics. For instance, some MDCAs reported during a network meeting that their managers had assigned their role to select a new administrative system, and they were pleased that this selection process allowed them to shape the decision according to their personal preferences. Others complained that their colleagues perceived them as low-level IT support (MDCA4). Similarly, city-2, after an internal evaluation of their program, faced very similar challenges to the case city. The ambiguous role description results in their colleagues' perception of low-level IT support. Furthermore, the factors of gender or years of experience had no notable impact on MDCA effectiveness, highlighting that intrinsic motivation rather than structured responsibilities drove the engagement in DT activities.

Insufficient training. This refers to a lack of practical knowledge among MDCAs, as they struggle to recall content, find it too abstract, and feel unprepared for DT challenges. Most MDCAs could not name any specific content from their basic training that they have applied in their role as an MDCA or demonstrated little recollection of the training content in general. Some MDCAs expressed a desire for more in-depth training and additional information to better address the questions and concerns of their colleagues. *"If you [a colleague] have this or that problem, we take a look at your processes and see if we can simplify something (...). And then [I get] very little understanding: Why? I don't have time for that, and so on. If I knew how to approach this (...), it would have stood out to me here in particular. I honestly don't know how to make it work.,"* explained MDCA7. The analysis of the training documents revealed that change management methods were covered in addition to project management topics. However, most MDCAs seem to have struggled to translate this theoretical knowledge into practice: *"The things we did (...) I found them kind of too abstract. They didn't really help me."* (MDCA6).

Lack of clear communication. This concerns *primarily* the communication on the digital strategy, stakeholder responsibilities, and the role of MDCAs within the city *administration*. Many employees are unaware of the initiative and its impact (E6). The lack of visibility limits engagement and prevents employees from recognizing the value and potential of the initiative. In addition, there are diverging perspectives on the obligation to seek and the obligation to provide information by the employees. Some believe that while digital resources and platforms already provide relevant details, MDCAs should be more active in consistently sharing and promoting it within their departments. Others argue that accessing information is a shared responsibility, emphasizing that employees should also take the initiative in seeking information on the internal platform and exploring available resources, such as internal media channels and newsletters provided by the city. MDCAs generally value their role as it often allows them to receive internal information from management earlier than others or get invited to meetings where

they are introduced to new technologies or beta testing. However, not all see it as their duty to process and share this information or meeting recaps with their colleagues. This is less about deliberately withholding information and more about the lack of responsibility and duties associated with the role. The investigation in City-2 highlights similar observations like the awareness, visibility, and recognition of the initiative.

Unclear responsibilities. We observed a significant conflict regarding the stakeholders' responsibilities in the DT's operationalization. While many employees and managers assume the Digitalization Department will initiate and lead digitalization efforts, the city's digital strategy places authority and accountability within individual divisions and departments. This was supposed to address concerns about top-down imposition, yet it creates ambiguity among all parties involved. Accordingly, several interviewees view stronger guidance from top management as essential to driving DT. Many managers, however, had a different perspective: *"(...) we are not the drivers of digitalization in the city. We are the users. We can provide suggestions, but we don't operationally drive it for ourselves."* (MDCA-M3) and later stated that the digitalization officer is in charge of operationalizing DT. On the other hand, the digitalization officer and the Digitalization Department see the higher-level and lower-level managers responsible for operationalizing the digital strategy. Regarding the MDCA initiative, according to managers, it is not the MDCA's responsibility to push forward digitization initiatives, as no resources for project management were allocated to the MDCA role. Although the execution of larger digitization projects falls under the purview of the digitization department and, thus, the digitalization officer, they cannot properly execute this task due to limited resources, as discussed later. The issue becomes even more severe when responsibilities for digitalization projects are passed back and forth until they ultimately reside in one department where the already fully occupied employees cannot manage them. For instance, MDCA has initiated the digitization of room booking processes. Shortly after, a new Building Management Office was established, but it did not want to take responsibility for the room booking digitalization project. As a result, the continuation of the initiative has fallen back to the digitization department, where progress is on hold due to limited resources. Several interviewees mentioned the mayor as head of the institution and even higher political forces such as national policymakers and the state as responsible because they were the ones allocating resources and prioritizing strategic topics such as DT (MDCA-M8; MDCA-M1; MDCA7; MDCA6; MDCA3). Most interviewees saw higher-level management in charge of initiating, driving, and prioritizing DT, while lower-level managers were expected to implement and operationalize DT efforts. Across managers and employees, there is a consensus that while DT responsibility covers multiple levels (political level, state level, mayor, etc.), each employee should actively contribute to DT within their means (MDCA-M8; MDCA-M5; MDCA-M3; MDCA1; MDCA2). However, some noted a lack of learning culture and proactive engagement to achieve this goal: *"There is too little learning culture (...) It's easier to say, 'Let someone else handle it.'"* (MDCA2). Although city-2 implemented the same quasi-voluntary approach of the initiative, their managers expected MDCA to take over responsibility for implementing digitalization projects and, like in the case city, did not perceive this responsibility as their own.

Resource scarcity. MDCAs, managers, and employees face limitations regarding time and workforce, including the Digitalization Department and the IT department. The time allocated for the MDCA activities is perceived as insufficient to effectively enhance digitalization. Since the MDCA role encompasses five working days per year, it is primarily voluntary. Hence, since employees are already fully occupied with their daily tasks, their MDCA activities are often deprioritized. *"I don't have the time for this [creating guidelines or reports]. For example, there was a request to create guidelines for meeting media, but I haven't had the time for that. Nor has anyone else. We have a high workload here.,"* explained MDCA5. City-2 reported similar observations: MDCAs face significant time constraints, with their responsibilities perceived as "on top," resulting in declining engagement. In such cases, networking meetings or training sessions are typically the first to be canceled. A higher time budget or the integration of MDCA activities into the job description would help the MDCAs to be more effective: *"And it would, of course, be helpful if specific time allocations were designated for this. In other words, being partially relieved from regular duties to have dedicated time to take on and actively carry out this task. That would help all of us tremendously"* (MDCA-M5). Similar capacity constraints forced the digitalization officer to scale back MDCA support, including temporarily suspending the Meet & Learn series, a virtual space for knowledge exchange (MDCA-M1). Furthermore, several interviewed MDCAs (MDCA10; MDCA3) did not possess their own device for participating in the online interview and had to use the only device with a camera in the department, which belongs to her supervisor. According to her manager, the shortage of technical resources and progress stems from the understaffing of the IT department: *"If the [IT department] is not well staffed, you just have to be glad if you can manage regular operations."* (MDCA-M6).

Missing structured framework. This refers to the absence of overarching offers for the MDCA initiative to be effective, such as regular networking and exchange meetings, training opportunities, or support. Although the MDCAs seem to be well-connected with their work colleagues and within their departments, they lack opportunities to exchange best practices and experiences with other MDCAs. The desire to learn from their counterparts and share experiences was raised multiple times: *"(...) I would have liked it to go a bit deeper, more like, how do you do it? I have these experiences, what are yours? So, being more in exchange."* (MDCA7). This issue originates from capacity constraints within the Digitalization Department, which oversees the initiative. Correspondingly, the MDCAs from city-2 miss offers for experience exchange and networking within the initiative.

Cultural challenges are obstacles that lie within the working culture and work demographics. Hence, the city has some power to overcome the challenges in this group. The process, however, takes much more time and effort, and the results only display in the long run.

Limited proactive engagement of MDCAs. This results from the ambiguous role of understanding the conflicting communication from the Digitalization Department (compared with the MDCA concept) and the limited accountability expected from MDCAs. According to the Digitalization Department, MDCAs are meant to play a somewhat educational role. They are intended to foster enthusiasm, influence organizational culture, and be knowledgeable about digital topics. However, the following or similar statements cast doubt on the initiative's effectiveness: In response to the question of what tasks the interviewees pursued as MDCA, they answered that they were available as a point of contact. When asked how often they are approached, they responded that they have not been contacted within the last year. Several MDCAs mentioned that they currently do not actively engage in their MDCA role within their departments (MDCA-M8; MDCA-M6; MDCA) – primarily due to time restrictions, the role ambiguity, limited intrinsic motivation, and the lack of accountability (E4). While MDCAs are generally perceived as keen to help and assist their colleagues with digital topics when approached, they seem discouraged about the limited openness of their colleagues to learn new things. *"To be honest, I don't even try to explain it to a colleague because it just goes in one ear and out the other; there's simply not much interest there."* (MDCA4). This behavior is predominantly reported for elderly personnel. Thus, younger employees might grasp the necessity of change in the light of DT faster, which we will discuss later (MDCA3).

Limited active leadership support. This refers to the passive managerial approach toward DT and MDCAs, characterized by tolerance rather than active facilitation, sometimes accompanied by managerial control concerns, organizational inertia, and a lack of a trusting feedback culture. Management support for MDCAs varies substantially across departments. Only a few interviewees, mostly MDCA managers, claimed that managers were actively involved in DT activities, often referring to their own engagement. For instance, one interviewee noted that their division management maintained an open attitude towards digitalization and covered training costs but did not mention any other active engagement (MDCA4). While the majority of MDCAs state that they do not receive support from their manager (MDCA3; MDCA3), others report that their activities as an MDCA are being tolerated or that their ideas are only checked for practicability and effort by their manager or that they have full leadership support (MDCA2; MDCA-M4). Two other managers expressed a certain reluctance towards DT by showing a lack of willingness to actively provide support (M4; M5). Managers' passivity and resistance have been frequently reported. One MDCA expressed frustration with a lack of initiative among management: *"(…) the problem is [my manager's] colleagues, the managers who work under him. I see them as the issue – they do not actively contribute, and they are not the ones shaping things. Instead, they expect to be presented with something ready-made, and then they can complain about it."* (MDCA6). This discrepancy in management engagement impacts the effectiveness of MDCAs. While some managers encourage participation and remove challenges, others exhibit skepticism, reluctance, or a fear of losing control. This notably slowed digitalization efforts and shifted the convincing responsibility onto employees (E2). This aligns with the insights from city-2, where MDCAs noted limited management support and unequal approaches from managers in releasing MDCAs from regular tasks to pursue MDCA activities.

Structural challenges are obstacles that lie within the particularities of the public sector, like their monopolistic position, incentive mechanisms, and tenure protection (Ritchie, 2014). Hence, the city has the power to overcome these challenges. The process, however, takes much more time and effort, and the results only display in the long run.

Lack of change and digitalization incentives. This refers to positive incentives like promotions or rewards and negative incentives like sanctions or disciplinary actions. In the city administration and the initiative's current set-up, there are no consequences for departments or employees who avoid digitalizing their work processes or blocking joined digitalization efforts with other departments. As a result, MDCAs and departments are left to handle the situation on their own if they encounter avoiders or strong resistance, as one MDCA remembers: *"[There are people] who simply don't want to. And if there isn't much pressure from the city, they don't feel obligated to do it either. Or if their manager doesn't explicitly tell them to, they just don't do it. There's really nothing you can do about it."* (MDCA7). According to several interviewees, a key challenge is that elderly colleagues, particularly tenured employees, lack incentives to engage in DT efforts since they face no professional consequences for refusal (MDCA3). However, this challenge is not limited to elderly colleagues. The lack of incentive is widespread across all age groups. Younger employees in the administration perceive their formal education as sufficient, displaying little interest in further developing their digital skills. (MDCA-M1). The lack of directive authority of the regular MDCAs can generate frustration because the MDCA solely relies on consistent persuasion until resignation (MDCA-M2; MDCA3; MDCA7)

Insufficient visible prioritization. This refers to the quasi-voluntary and resource-constrained set-up of MDCA initiatives, which results in structural marginalization of the MDCA role and reduces their overall effectiveness in the DT. Hence, the overall impact of the MDCAs in their current role within the case city is considered rather limited

by the majority of interviewed people (MDCA5). City-2 reported this challenge, too. Many MDCAs are not acting upon their role since it is "not a priority."

Tab. 2 – Drivers and Challenges for MDCA initiatives and DT in public administration.

Drivers	**Challenges**	
- Building digital capabilities - Dedicated full-time equivalent for digitalization - Proactive employee initiatives - Participatory leadership style - Active communication - (Re-)Building trust - Personal benefit	<u>Organizational</u> - MDCA role ambiguity - Insufficient training - Lack of clear communication - Unclear responsibilities - Resource scarcity	<u>Cultural</u> - Limited proactive engagement of MDCAs - Limited active leadership support <u>Structural</u> - Lack of change and digitalization incentives - Insufficient visible prioritization

5. Discussion

MDCA initiatives are a recent attempt to accelerate DT in public administration. While the literature on DT and change agents in public administration predominantly focuses on managerial change agents in leadership positions and managerial influence, the role and effectiveness of lower-hierarchy internal change agents, such as MDCAs, remain largely underexplored. This gap results in a lack of empirical insights into the effectiveness of such initiatives to enhance DT. This study presents insights into the effectiveness of MDCA initiatives on DT in public administration. To this end, we conducted an exploratory case study with a case city in southern Germany using interviews, informal discussions, document analysis, and insights from another south German city that implemented the same initiative. In the following, we first contextualize the observations with the literature to derive propositions, then present theoretical and practical implications and address the limitations of this study.

5.1 Propositions for Digital Transformation Initiatives in Public Administration

The effectiveness of internal change agents, particularly in the public sector, is underexplored in the literature, with existing research mainly focusing on industrial settings (Bünnagel, 2021; Parry et al., 2014). While clarity for the primary role is recognized as a factor for organizational effectiveness, its impact on employees assuming an additional role – such as MDCAs – has not been systematically examined. Our findings indicate that MDCA role ambiguity contributes to internal and external adoption issues. MDCAs from two initiatives struggled to internalize their responsibilities due to vague expectations. At the same time, colleagues and managers found it difficult to engage with them effectively, as their function within the organization remained unclear. This ambiguity results in uncertainty regarding how MDCAs should contribute to DT efforts, leading to passivity, deferred tasks, and inefficiencies in DT acceleration. In contrast to our results, Fischer and Breaugh (2024) found that MDCAs had a significant effect in their investigated city, deriving by six success factors: 1) The selection of motivated and empathetic MDCAs, 2) the provision of sufficient time resources, 3) the utilization of local expertise, 4) a focus on specific tasks to prevent overload, 5) the integration into broader digitalization strategies, and 6) the recognition and appreciation of their work. As laid out, our case city could only leverage factor 3) using local expertise and touched upon factor 1) selection of motivated MDCAs, and factor 6) appreciation of MDCAs; the remaining factors are neglected with the current set-up of the initiative and thus limit the effect of MDCAs in the case city. In our case study, the case city did not manage to implement an effective MDCA concept, leaving most MDCAs without the necessary structural support to succeed. The main reasons we identified are the MDCA role ambiguity, insufficient training, and the missing structured framework. Insights from City-2 further confirm the above findings, as they also reported unclear role descriptions and misperceptions of MDCAs as low-level IT support due to role unclarities. This leads to:

Proposition 1: Insufficient role definitions and organizational anchoring of MDCA initiatives reduce their effectiveness in accelerating DT because it leads to unclear responsibilities and limited active participation in DT efforts. (MDCA Role Clarity & Anchoring Proposition)

The case study demonstrated how the decentralization of DT responsibilities without accountability or monitoring concepts leads to decreased ownership and limited incentives for managers in DT initiatives. Responsibilities are passed back and forth until they reside on either side without consequences. We observed that public managers struggle to operationalize strategies. This is unsurprising because strategies and their operationalization were not a common and relevant task in public administrations before DT. Traditional public administration training does not emphasize the development of these competencies. This creates ambiguity regarding who is responsible for

DT at various levels, leading to a diffusion of responsibility between departments and hierarchical layers. The lack of communication within the DT exacerbates this effect. With vague responsibility structures, DT risks stagnation, as departments either defer ownership or fail to coordinate efforts effectively. This leads to:

Proposition 2: Unclear operational responsibility and respective monitoring for digital strategy in public administrations diminishes engagement and ownership of DT initiatives, leading to fragmented efforts and reduced long-term impact. (Responsibility Proposition)

Insufficient prioritization of DT efforts in public administration is often reflected not only in financial constraints but also in a significant shortage and allocation of specialized personnel, limiting the resources necessary to drive meaningful change (Fischer & Breaugh, 2024). Eggers and Bellman (2015) found that public administration is often faced with many competing priorities like political agendas, limited funding, or the lack of digital workforce skills, all of which make it harder to prioritize DT. The quasi-voluntary nature and limited visibility of the MDCA initiative contribute to the perception that DT is not a strategic priority in both cities. Additionally, time allocation for internal change agents has been a less examined factor in DT literature. Our results indicate that a quasi-voluntary set-up, without positive or negative incentives, has minimal impact on accelerating DT. Therefore, the formal allocation of resources for MDCAs is essential to ensure their effectiveness. Similar challenges have been reported in City-2, where MDCA responsibilities are frequently deprioritized due to time constraints. This leads to:

Proposition 3: A lack of strategic prioritization of DT in public administrations leads to reduced employee engagement due to perceived misalignment between organizational goals and individual motivation for change. (Prioritization Proposition)

The public sector's unique characteristics, such as monopolistic structures, distinct organizational cultures and demographics, and tenure protections, create structural barriers to DT often overlooked in change agent literature. Unlike private-sector organizations, where market competition and performance incentives drive DT, government institutions lack direct external pressures, and employees face minimal consequences for resisting change. Ritchie (2014) identifies risk aversion, bureaucratic inertia, and a lack of incentives as key factors inhibiting change in government, which enhances a culture where maintaining the status quo is preferable to engaging in innovation. Moreover, accountability for DT initiatives is often unclear, leading to diffusion of responsibility and slow adoption. Findings from our case study align with these observations, particularly in the absence of DT incentives. Employees receive no rewards for engaging in DT nor repercussions for resistance. Consequently, elderly tenured employees show little urgency to join DT activities, which may lead to stagnation. While MDCAs advocate for DT, their lack of directive authority limits their impact. To address these challenges, targeted incentive mechanisms tailored to the public sector are necessary. Options include integrating DT competencies into promotion criteria, creating structured recognition programs, or establishing clearer accountability frameworks. Based on these observations, we propose the following:

Proposition 4: The monopolistic structure and tenure protection of employees in public administration reduce the urgency for DT unless targeted incentives and accountability mechanisms are introduced. (Monopoly & Incentive Proposition)

5.2 Recommendations for MDCA Initiatives in Public Administration

This chapter summarizes actionable recommendations for municipalities that plan to implement or enhance their MDCA initiative based on the lessons from the above investigation.

Solid MDCA concept: To strengthen the effectiveness of MDCAs, a detailed concept with a clear definition of their role and responsibilities is essential. Establishing a catalog of examples or minimum tasks can provide guidance and set clear expectations. Transparent and frequent communication is also critical for successful DT and MDCA initiatives, ensuring adequate information sharing and a unified strategy (Parry et al., 2014). This should include regular internal updates on the MDCA role, tasks, and achievements, such as through newsletters or internal reports. To improve the capabilities of MDCAs, a comprehensive training program tailored for non-specialized change agents should be introduced, focusing on change and resistance management, with a particular focus on the public sector. Training materials should incorporate practical methods like role-playing exercises to enhance applicability and retention. We further recommend regular refresher sessions on emerging technologies and change practices, as many MDCAs struggled to recall or apply the learned concepts. A centrally managed initiative should oversee scheduling, networking, and training opportunities (Winners, 2020). Offering a structured framework could increase engagement and motivation among MDCAs. Furthermore, introducing a low-effort reporting mechanism (e.g., a past activities list) for the Digitalization Department would foster a sense of responsibility. Last, a continuous evaluation through annual surveys could ensure ongoing improvement of the initiative and adaptation to emerging challenges.

Clear assignment of responsibilities: This includes explicit role descriptions for managers and MDCAs, ensuring

that expectations and duties are well-defined. Managers should be held accountable for driving DT within their departments, particularly regarding the operationalization of the digital strategy. To support this, additional training for managers on how to effectively translate strategic goals into concrete actions could enhance their capacity to lead DT efforts successfully.

Visible prioritization of DT in theory and practice: Adequate resource allocation, particularly for the digitalization officer and their department, could enhance DT activities. MDCAs require dedicated time for their responsibilities rather than being expected to fulfill their role alongside their regular duties (Winners, 2020). While limited budgets restrict sufficient public administration, increased funding for the MDCAs should demonstrate a higher priority for the initiative and DT. With more funding, accountability concepts and reporting duties could be justified. In addition to this, regular communication on DT topics and emerging technologies should be aligned with the overall strategy to enhance awareness and engagement. Additionally, incentive structures should be developed within the framework of public administration to encourage participation and commitment.

Leverage organizational and cultural drivers: Leveraging organizational and cultural drivers can significantly enhance DT efforts. Organizational drivers should be prioritized, as they fall within the organization's direct control, allowing for structured implementation. At the same time, cultural drivers should be actively fostered through initiatives such as mentoring programs with successful managers or departments and competitions that encourage engagement. In particular, personal benefit has proven to be a powerful driver, offering a positive incentive for employees to adopt digital processes while mitigating resistance to change.

5.3 Implications and Future Research

This study contributes to the underexplored literature on DT and change management in public administration by examining the effectiveness of MDCA initiatives in a quasi-voluntary setup. While most research on internal change agents focuses on the private context, public administration faces distinct organizational, cultural, and structural challenges that require further theoretical exploration. By identifying key drivers and challenges of MDCA initiatives, we provide empirical insights into their role in accelerating DT and adapting change management strategies to the public administration context. Additionally, while existing research emphasizes change agents in leadership roles, our findings offer a nuanced perspective on regular employees assuming this role, broadening the theoretical discourse on hierarchical and non-hierarchical change-facilitation. The derivation of propositions provides a foundation for future research to empirically validate, refine theoretical frameworks, and develop practical strategies to enhance the effectiveness of DT initiatives in public administration. From a practical perspective, the results offer valuable guidance to cities or other public administrators who have already implemented MDCAs or are planning to do so. They can draw upon actionable drivers and recommendations that facilitate the implementation and help reduce potential inefficiencies in DT. This study comes with limitations. Following a qualitative case study approach limits the generalizability of the findings. Furthermore, the unique legal framework of German public institutions might yield additional bureaucratic hurdles to DT in public administration. Future research could focus on the quantitative evaluation of the MDCA initiatives outside of Germany and innovative accountability concepts suitable for the German public sector context.

6. Conclusion

The DT in public administration remains a complex challenge, requiring municipalities to adapt to evolving technological demands and citizen expectations while maintaining efficient service delivery. This study highlights the effectiveness of MDCA initiatives in facilitating DT efforts, particularly within a quasi-voluntary setup. Our findings reveal that the efficacy of MDCAs is highly dependent on clearly defined roles, sufficient and adequate training, and sufficient resource allocation. While MDCAs can serve as important facilitators of change, unclear responsibilities, insufficient managerial support, and a lack of strategic prioritization significantly limit their impact. Furthermore, our analysis underscores the importance of effective incentive structures and stronger organizational anchoring of MDCA initiatives to enhance their effect on DT. By identifying drivers and challenges, this study contributes to the broader discourse on change management and DT in public administration. Future research should focus on the empirical validation of our proposed theoretical insights to expand the understanding of how internal change agents can be leveraged to accelerate digitalization in government settings.

7. Acknowledgements

- **Data/Software Access Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.
- **Contributor Statement**: Ina Jäger: Conceptualization, Writing – Original Draft, Methodology, Project Administration. Andreas Hein: Writing – Review & Editing, Supervision, Project Administration, Validation. Helmut Krcmar: Resources, Validation. Additionally, we want to thank Lukas Kastenmüller and Daniel Antkowiak, who supported this research project's data collection and analysis.

- **Use of AI**: During the preparation of this work, the authors used Grammarly and ChatGPT to check the appropriateness and correctness of language and modify sentences for clarity. After using these tools, the authors reviewed, edited, made the content their own and validated the outcome as needed, and took full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Angehrn, A. A., & Atherton, J. E. M. (1999). *A Conceptual Framework for Assessing Development Programmes for Change Agents.* Centre for Advanced Learning Technologies, INSEAD.

Armenakis, A. A., & Fredenberger, W. B. (1997). Organizational change readiness practices of business turnaround change agents. *Knowledge and Process Management*, *4*(3), 143–152.

Armenakis, A. A., Harris, S. G., & Mossholder, K. W. (1993). Creating Readiness for Organizational Change. *Human Relations*, *46*(6).

Bannister, F., & Connolly, R. (2014). ICT, public values and transformative government: A framework and programme for research. *Government Information Quarterly*, *31*(1), 119–128.

Battilana, J., & Casciaro, T. (2013). Overcoming Resistance to Organizational Change: Strong Ties and Affective Cooptation. *Management Science*, *59*(4), 819–836.

Buick, F., Blackman, D., & Johnson, S. (2018). Enabling Middle Managers as Change Agents: Why Organisational Support Needs to Change. *Australian Journal of Public Administration*, *77*(2), 222–235.

Bünnagel, W. (2021). *Mitarbeiter als Change Agents*. Springer Berlin Heidelberg.

Caldwell, R. (2003). Models of Change Agency: a Fourfold Classification. *British Journal of Management*, *14*(2), 131–142.

Choi, M. (2011). Employees' attitudes toward organizational change: A literature review. *Human Resource Management*, *50*(4), 479–500.

Czernich, N., Falck, O., Pfaf, C., Ruthardt, F., & Wölfl, A. (2021). *Benchmarking Digitalisierung in Deutschland.* ifo Institut.

Eggers, W. D., & Bellman, J. (2015). *The journey to government's digital transformation* (Deloitte University Press).

Eisenhardt, K. M. (1989). Making Fast Strategic Decisions in High-Velocity Environments. *Academy of Management Journal*, *23*(3), 543–576. https://www.jstor.org/stable/pdf/256434.pdf?refreqid=excelsior%3A4db5c7dfddb91ff6f96483a94720a7b1&ab_segments=&origin=&acceptTC=1

Endrejat, P. C., Klonek, F. E., Müller-Frommeyer, L. C., & Kauffeld, S. (2021). Turning change resistance into readiness: How change agents' communication shapes recipient reactions. *European Management Journal*, *39*(5), 595–604.

Fernandez, S., & Rainey, H. G. (2006). Managing Successful Organizational Change in the Public Sector. *Public Administration Review*, *66*(2), 168–176.

Fischer, C., & Breaugh, J. (2024). Digitallotsen in der Verwaltung.

Ford, Jeffrey D., Ford, Laurie W., & d'Amelio, A. (2008). Resistance to Change: The Rest of the Story, *33*(2), 362–377.

Furnham, A. (2002). Managers as change agents. *Journal of Change Management*, *3*(1), 21–29.

Gilli, K., Lettner, N., & Guettel, W. (2024). The future of leadership: new digital skills or old analog virtues? *Journal of Business Strategy*, *45*(1), 10–16.

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research. *Organizational Research Methods*, *16*(1), 15–31.

Gong, Y., Yang, J., & Shi, X. (2020). Towards a comprehensive understanding of digital transformation in government: Analysis of flexibility and enterprise architecture. *Government Information Quarterly*, *37*(3), 101487.

Hameed, I [Imran], Khan, A. K., Sabharwal, M., Arain, G. A., & Hameed, I [Irfan] (2019). Managing Successful Change Efforts in the Public Sector: An Employee's Readiness for Change Perspective. *Review of Public Personnel Administration*, *39*(3), 398–421.

Hansen, M. B., & Nørup, I. (2017). Leading the Implementation of ICT Innovations. *Public Administration Review*, *77*(6), 851–860.

Haug, N., Dan, S., & Mergel, I. (2024). Digitally-induced change in the public sector: a systematic review and research agenda. *Public Management Review*, *26*(7), 1963–1987.

Hemme, F., Bowers, M. T., & Todd, J. S. (2018). Change readiness as fluid trajectories: a longitudinal multiple-case study. *Journal of Organizational Change Management*, *31*(5), 1153–1175.

Heuberger, M. (2020). Digitaler Organisationswandel. In T. Klenk, F. Nullmeier, & G. Wewer (Eds.), *Handbuch Digitalisierung in Staat und Verwaltung* (pp. 1–12). Springer Fachmedien Wiesbaden.

Jahn, S., Avigur-Wigand, R., Krcmar, H., Daßler, L., Jäger, I., Paul, L., & Pleger, S. (2024). *eGovernment MONITOR 2024: Nutzung und Akzeptans digitaler Verwaltungsdienstleistungen aus Sicht der*

*Bürger*innen. Die deutschen Bundesländer, Deutschland, Österreich und die Schweiz im Vergleich.* Initiative D21. https://initiatived21.de/publikationen/egovernment-monitor/2024
Kickert, W. J. (2010). Managing emergent and complex change: the case of Dutch agencification. *International Review of Administrative Sciences*, *76*(3), 489–515.
Kuhlmann, S., & Heuberger, M. (2023). Digital transformation going local: implementation, impacts and constraints from a German perspective. *Public Money & Management*, *43*(2), 147–155.
Kuipers, B. S., Higgs, M., KICKERT, W., Tummers, L., Grandina, J., & van der VOET, J. (2014). The Management of Change in Public Organizaitons: A Literature Review. *Public Administration*, *92*(1), 1–20.
Kuntz, J. R., & Gomes, J. F. (2012). Transformational change in organisations: a self-regulation approach. *Journal of Organizational Change Management*, *25*(1), 143–162.
Kussel, G., Pavleka, S., & Schmidt, C. M. (2024). *Innovationssystem Deutschland - Effizienz und Agilität der öffentlichen Verwaltung erhöhen.* acatech – Deutsche Akademie der Technikwissenschaften.
Lekkas, C.-K., & Souitaris, V. (2023). Bureaucracy Meets Digital Reality: The unfolding of urban platforms in European municipal governments. *Organization Studies*, *44*(10), 1649–1678.
Markus, H., & Meuche, T. (2022). *Auf dem Weg zur digitalen Verwaltung*. Springer Fachmedien Wiesbaden.
Markus, M. L., & Benjamin, R. I. (1996). Change Agentry - The Next IS Frontier. *MIS Quarterly*, *20*(4), 385–407.
Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. *Government Information Quarterly*, *36*(4), 101385.
Moore, M. H. (1995). Creating Public Value Strategic: Management in Government.
Moser-Plautz, B. (2024). Barriers to digital government and the COVID-19 crisis – A comparative study of federal government entities in the United States and Austria. *International Review of Administrative Sciences*, *90*(2), 402–418.
Myers, M. D., & Newman, M. (2007). The qualitative interview in IS research: Examining the craft. *Information and Organization*, *17*(1), 2–26.
Ndou, V. (2004). E – Government for Developing Countries: Opportunities and Challenges. *THE ELECTRONIC JOURNAL of INFORMATION SYSTEMS in DEVELOPING COUNTRIES*, *18*(1), 1–24.
Pádár, K., Pataki, B., & Sebestyén, Z. (2017). Bringing project and change management roles into sync. *Journal of Organizational Change Management*, *30*(5), 797–822.
Parke, M. R., Tangirala, S., & Hussain, I. (2021). Creating organizational citizens: How and when supervisor- versus peer-led role interventions change organizational citizenship behavior. *The Journal of Applied Psychology*, *106*(11), 1714–1733.
Parry, W., Kirsch, C., Carey, P., & Shaw, D. (2014). Empirical Development of a Model of Performance Drivers in Organizational Change Projects. *Journal of Change Management*, *14*(1), 99–125.
Pittaway, J. J., & Montazemi, A. R. (2020). Know-how to lead digital transformation: The case of local governments. *Government Information Quarterly*, *37*(4), 101474.
Ritchie, F. (2014). *Resistance to change in government: risk, inertia and incentives* (Economics Working Paper Series).
Segura-Tinoco, A., Holgado-Sánchez, A., Cantador, I., Cortés-Cediel, M. E., & Rodríguez Bolívar, M. P. (2020). A Conversational Agent for Argument-driven E-participation.
Specht, J., Kuonath, A., Pachler, D., Weisweiler, S., & Frey, D. (2018). How Change Agents' Motivation Facilitates Organizational Change: Pathways Through Meaning and Organizational Identification. *Journal of Change Management*, *18*(3), 198–217.
Tangi, L., Janssen, M., Benedetti, M., & Noci, G. (2021). Digital government transformation: A structural equation modelling analysis of driving and impeding factors. *International Journal of Information Management*, *60*, 102356.
Twizeyimana, J. D., & Andersson, A. (2019). The public value of E-Government – A literature review. *Government Information Quarterly*, *36*(2), 167–178.
van de Ven, A. H., & Poole, M. S. (2014). Explaining Development and Change in Organizations. *Academy of Management Review*, *20*(3).
van de Voet, J. (2014). The effectiveness and specificity of change management in a public organization: Transformational leadership and a bureaucratic organizational structure. *European Management Journal*, *32*(3), 373–382.
Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, *28*(2), 118–144.
Westover, J. H. (2010). Managing Organizational Change: Change Agent Strategies and Techniques to Successfully Managing the Dynamics of Stability and Change in Organizations. *International Journal of Management and Innovation*, *2*(1).
Winners, C. (2020). *Fit für den digitalen Wandel in Kommunen*. Springer Fachmedien Wiesbaden.
Wylie, N., & Sturdy, A. (2018). Structuring collective change agency internally. *Employee Relations*, *40*(2), 313–328.
Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th ed.). SAGE Publications, Inc.

Track 10: Generative Artificial Intelligence in Government

Track Description

Given the rapidly emerging transformations of Generative AI (GAI), the track aimed to (i) bridge research on potential theoretical underpinnings of generative AI's implications for government, as well as research on practitioners' growing experiences with generative AI in public governance; (ii) critically examine the adoption and impact of GAI in government functions, policies, and public engagement; (iii) in-depth examine associated challenges, ethical considerations, and regulatory and policy frameworks for the expanding applications of GAI in government. Collectively, the papers in this track seek to examine the implications of GAI for transparency, inclusion, accountability, and trust in government. Moreover, the track sought comparative research papers that explored emerging global governance and policy interventions as well as legal and regulatory frameworks for governing generative AI, and research papers contextually examining generative AI applications within diverse geographies, cultural settings, and societal structures.

Track Chairs

F. Salem, MBR School of Government, United Arab Emirates
G. Misuraca, Universidad Politécnica de Madrid, Spain
T. A. Pardo, University at Albany, United States of America

Contents

Analysis of automation and retraining opportunities for the Brazilian federal public service 610
Y. Lima, L. Passos, and J. M. de Souza

A Generative AI approach for creating and validating simplified versions of government documents 627
K. Alves, M. Silva, E. Santos, G. Valença, and K. Brito

Exploring generative AI effects on Korean civil servants' performance: Power and motivation 642
S. Choi, W. Sung, and J. Lee

Performance Analysis of LLMs for Abstractive Summarization of Brazilian Legislative Documents 657
D. C. G. de Lucena, E. Souza, H. O. Albuquerque, N. Félix, A. L. L. Oliveira, and A. C. P. L. F. de Carvalho

Use of AI tools in the Colombian Judiciary: Findings from Three Surveys 667
J. D. Gutiérrez and D. S. P. Mendieta

Analysis of automation and retraining opportunities for the Brazilian federal public service

Yuri Lima [a*], *Luana* Passos [b], *Jano* Moreira de Souza [a]

[a] Systems Engineering and Computer Science Program (PESC/COPPE/UFRJ), Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, yuri.lima@ufrj.br, ORCID: 0000-0002-6662-9771, 0000-0001-5080-1955.

[b] Department of Gender and Feminist Studies, Federal University of Bahia, Bahia, Brazil, ORCID: 0000-0002-5470-7349.
Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. *Context*: The speed of technological advancement has raised concerns about the impact of automation on work. Previous studies have analyzed this impact on the private sector, but there is little research focused on the Brazilian public sector, which faces additional challenges in dealing with this issue. *Objective*: To estimate the impact of automation on intermediate-level federal public positions and indicate professional retraining paths for civil servants, in the face of technological changes. *Methodology*: A 4-step approach was used, involving (1) mapping of automation technologies, (2) extraction and review of the job duties of 142 intermediate-level public positions from a government document with the support of AI models, (3) assessment of the importance level and horizon of automation of each job duty by GPT-4 Turbo and (4) suggestion of professional retraining courses for each position. *Results*: A considerable potential for automation of the analysed positions was identified, with 72% of the job duties with different automation levels in an immediate or short-term impact horizon. However, also considering the frequency and importance of each job duty, a considerable part of the positions had an impact between 0.10-0.28 points on a scale of 0 to 1. The technologies with the most occurrences in the analysis of automation impact were Machine Learning, Smart Sensors and Process Digitization Systems. In the end, 236 professional retraining courses were suggested to better prepare employees for possible technological impacts.

Keywords. automation, work, retraining, skills, Brazil
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1031

1. Introduction

The speed at which new technologies are created and disseminated has increased over time (Comin & Hobijn, 2010). In the current 4th Industrial Revolution, we have ChatGPT as a recent example of technological diffusion that occurred at an unprecedented speed. In just 5 days, ChatGPT already had more than 1 million users and, in just two months, more than 100 million monthly active users (Reuters, 2023).

Such a fast pace of advancement brings a series of concerns to any organization from a work perspective. The rapid implementation of new technologies requires preparation on the part of employers, government and workers, which, if not done, can lead to problems such as technological unemployment (Lima, Barbosa, et al., 2021). It is important to emphasize that the impacts of these new technologies may affect different population groups in distinct ways, with women and black individuals potentially being the most disadvantaged due to their weaker labor market inclusion.

Over the past decade, a significant amount of research has been devoted to exploring the impact of automation on labor. Despite the volume of articles discussing the risk of unemployment caused by automation, there was no research that considered the distinction between the public and private sectors until 2021 (Adamczyk et al., 2021). As far as the search that was carried out for this research, there are only two articles have focused on the impact of automation on the Brazilian public sector (Adamczyk et al., 2021; De Oliveira Teixeira et al., 2022). Notably, the public sector does not have the flexibility that the private sector has to deal with the impacts of automation in terms of hiring, firing, and reallocating workers (Adamczyk et al., 2021; Banco Interamericano de Desenvolvimento, 2020).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This research aims to provide a new and updated estimate of the impact of automation on public sector occupations—an effort made necessary by the current pace of technological innovation and diffusion. It also seeks to go beyond previous studies by identifying professional retraining pathways that can help federal public servants modernize their work activities. The study was conducted over the course of a four-month postdoctoral project in partnership with the Secretariat for People Management of the Ministry of Management and Innovation in Public Services. The analysis presented here is part of a broader set of initiatives led by the Ministry to deliver data-driven insights for decision-making related to the creation, merging, elimination, or enhancement of hundreds of public service careers, as well as the planning and scale of future civil service entrance examinations.

The methodology developed to achieve this goal begins by identifying the main categories of automation technologies expected to impact work in the Brazilian public sector in the coming years. It then involves the use of Claude (a generative AI model similar to ChatGPT) to extract and review the job duties of selected positions. Based on these duties, GPT-4 Turbo—the latest model from OpenAI, the developer of ChatGPT—is employed to assess the potential impact of automation on each position and to recommend professional retraining courses aligned with the required technological updates. While the use of large language models (LLMs) for research purposes is still relatively new and presents several challenges, every step of this study was carefully designed and reviewed by both the research team and the public servants supervising the project. Moreover, the results are presented with appropriate caution, and their application will be subject to human validation and complemented by other methodologies and data sources.

The remainder of this paper is organized as follows. Section 2 presents other research related to the topic of automation, particularly those related to the object of this research, automation in the public sector, and the methodology for assessing the impact of automation. Section 3 presents the methodology of the work in its four stages and highlights important differences between the present study and previous ones. Section 4 has four parts, one for each stage of the methodology, and presents the categories of technologies found during the technological mapping, the result of the extraction and review of the job duties of the selected public positions, the results of the assessment of the impact of automation on the positions and the results of the process of proposing professional retraining courses in view of the identified impact. Section 5 concludes the paper by bringing some final remarks, limitations of the work and perspectives for future work

2. Literature review

The analysis of the impact of automation gained traction in 2013, when the seminal article by Frey and Osborne was published, still as a preprint, assessing how susceptible jobs in the US were to computerization[1] (Frey & Osborne, 2017b). Since then, the article has received more than 13,000 citations and has been applied in the context of several countries around the world (Brookfield Institute, 2016; Deloitte, 2015a, 2015b; Santos et al., 2015; World Bank Group, 2016), including Brazil itself. In the Brazilian case, 60% of the workforce would have a high probability of being automated, and the same correlation between level of education and the impact of automation was observed, with the correlation between wages and the impact of automation existing, but weak (Lima, Strauch, et al., 2021).

Specifically on the impact of automation on Brazilian public sector employees and their occupations, there are two recent studies that should be mentioned (Adamczyk et al., 2021; De Oliveira Teixeira et al., 2022). The first of these studies was carried out in 2021 by researchers from PUC-RS, ENAP, IDP-DF and CNPq and had as its object of analysis federal government employees (Adamczyk et al., 2021). In this study, the Bartik Occupational Tasks (BOT) method was applied, which involves separating the differential effects of automation from the national and structural effects that lead to local employment growth, and then analyzing the frequency of words in the activities of the occupations associated with the differential effects of automation. Natural Language Processing and Machine Learning algorithms were used to extract quantitative information from the descriptions of work activities in the Brazilian Classification of Occupations (CBO). In total, 521,701 public servants distributed across 389 positions were analyzed. As a result, this first study showed that 20% of federal public servants are in occupations that are highly susceptible to automation in the next decade. Here again, it was observed that occupations related to lower levels of education and lower wage levels are more representative among those with a greater chance of being automated.

The second study was conducted in 2022 by researchers from BIOTIC and IDP, and analyzed the public sector of the Federal District (De Oliveira Teixeira et al., 2022). The methodology adopted in this study was based on another study by researchers from IPEA that considered the importance and relevance of the activities performed by each occupation (according to the O*NET occupation database in the USA) by analyzing the frequency of words related or not to automation (Kubota & Maciente, 2019). Based on the results of this study, a correlation was made between

[1]Computerization, according to the authors, would be the automation caused by Computing technologies, in particular, Machine Learning and Mobile Robotics.

the positions and duties of the executive branch of the Federal District Government and the occupations analyzed by IPEA researchers to arrive at an estimate of the impact of automation on the public servants analyzed. As a result, of the almost 100,000 civil servants who occupied the 368 positions analyzed, 5.5% were at high risk of automation, 24.1% at medium risk, and 70.4% at low risk (Kubota & Maciente, 2019). In this study, the positions that required a lower level of education were also those with the highest risk of automation.

The launch of ChatGPT by OpenAI in November 2022 and its use by more than 100 million active users as of January 2023, a record (Reuters, 2023), has made AI a versatile and user-friendly tool for workers in a wide range of sectors. The potential of this technology to impact work has led to a new wave of research on the impact of Generative AI (Chui et al., 2023; Eisfeldt et al., 2023; Eloundou et al., 2023; Gmyrek et al., 2023; Noy & Zhang, 2023), the technology category to which ChatGPT belongs. Some of this new research has brought with it an important innovation to automation studies, which is the use of Generative AI itself in the impact assessment process (Eloundou et al., 2023; Gmyrek et al., 2023).

In the first study published using this methodology, researchers from OpenAI itself analyzed the impact that technologies such as Generative Pre-trained Transformers (GPTs), that is behind ChatGPT, would have on the US workforce. The authors prompted GPT-4 to evaluate a set of occupations based on the descriptions of their activities according to the degree of exposure to GPTs at three levels: E0, in case of no exposure or worsening of the result in case of adoption of the technology; E1, direct exposure, when ChatGPT would reduce the execution time of the activity by 50%; and E3, when access to ChatGPT was not enough, but software developed based on GPTs were able to reduce the execution time of the activity by 50%. As a result, the authors paper that 80% of the US workforce would have at least 10% of their activities impacted by GPTs, while 19% of the workforce would have at least 50% of their activities impacted by this technology. An important result that contrasts with the aforementioned research, carried out before the emergence of ChatGPT, is that the effects of GPTs span all salary levels, with higher-paying jobs potentially facing greater exposure (Eloundou et al., 2023).

It is worth noting that the impacts analyzed by the studies cited do not cancel out those found in studies from the last 10 years, but rather add to the previous ones. Thus, it is becoming increasingly difficult to identify any occupation or economic sector that is immune to the impact of automation technologies of the current 4th Industrial Revolution.

Another important recent study that used ChatGPT was the one carried out by the International Labour Organization (ILO), which also sought to understand the impact of GPTs on employment, in this case, at a global level. The authors used the International Uniform Classification of Occupations (ISCO-08) as a basis to analyze the 436 occupations described therein. Before assessing the impact of GPTs themselves, the authors asked GPT-4 to generate a definition and list of 10 activities for each of the occupations and ISCO-08 codes provided. Based on this list of activities and occupations, the authors proceeded to ask GPT-4 to evaluate each one on a range from 0 to 1 according to the degree of automation of the tasks if GPT were adopted (Gmyrek et al., 2023).

In the study presented, it is identified that five categories of tasks are significantly impacted, with an impact greater than 0.75: administration and communication, customer service, data and records management and maintenance, information processing, and language and information provision services. It was found that, among the occupational groups, the "Administrative and Office Support" sector is the most affected, with 24% of tasks highly susceptible to automation and 58% with medium susceptibility. In comparison, in other occupational groups, the proportion of highly vulnerable tasks varies from 1% to 4%, and those with medium exposure do not exceed 25%. Finally, the influence of automation on employment differs significantly between countries of different income levels, due to their distinct occupational structures. In low-income nations, only 0.4% of total employment is at risk of automation, while in high-income countries, this number increases to 5.5% (Gmyrek et al., 2023).

In addition to these international studies, research conducted in Brazil provides further insight into the potential impact of automation on the country's labor market. Kubota and Maciente (2019) analyzed the susceptibility of occupations in the formal sector to automation, utilizing a methodology that classified jobs based on the degree of automatability of their tasks. Their findings indicate that 56.6% of formal employment in Brazil consists of occupations with a high or medium-high percentage of automatable tasks. This study also highlights that while some occupations traditionally considered at risk, such as bank tellers and telephone operators, have seen employment decline, others with high automation potential—such as administrative roles—continue to grow. This suggests that the diffusion of new technologies may impact not only declining occupations but also those that have played a significant role in recent job creation.

Furthermore, the study underscores the regional and sectoral differences in automation susceptibility. Urban centers, particularly metropolitan regions, tend to have a lower share of highly automatable occupations (around 36% of formal employment), whereas smaller and more economically isolated municipalities exhibit a higher concentration of automatable jobs, particularly in transportation and logistics. From a sectoral perspective, the highest risks are observed in industries such as textiles, food production, wood processing, and metallurgy, as well

as in certain service sectors like accounting, cleaning services, and logistics. This reinforces the need for policy interventions aimed at workforce reskilling and adaptation, especially in sectors and regions most vulnerable to automation-driven labor displacement.

In order to contribute to this field of research and provide data to support public policies, this research aims to analyze the impact of automation on a set of positions in the Brazilian public sector, as has been done before (Adamczyk et al., 2021; De Oliveira Teixeira et al., 2022), but using technologies such as ChatGPT, like more recent research on the subject (Eloundou et al., 2023; Gmyrek et al., 2023). In addition to defining automation levels for each position, the research presented here also seeks to indicate professional retraining paths for the positions analyzed. Further details on the methodological differences between this work and previous ones will be provided in the next Section on methodology.

3. Methodology

In order to estimate the impact of automation on public positions and indicate professional retraining courses, the methodology presented in Figure 1 was developed and used in this research. Each of these steps generated a product that can be considered a contribution of this research to the academic community and to Brazilian public management[2]. The methodology made extensive use of the most advanced and capable LLM models available at the time of execution of each step..

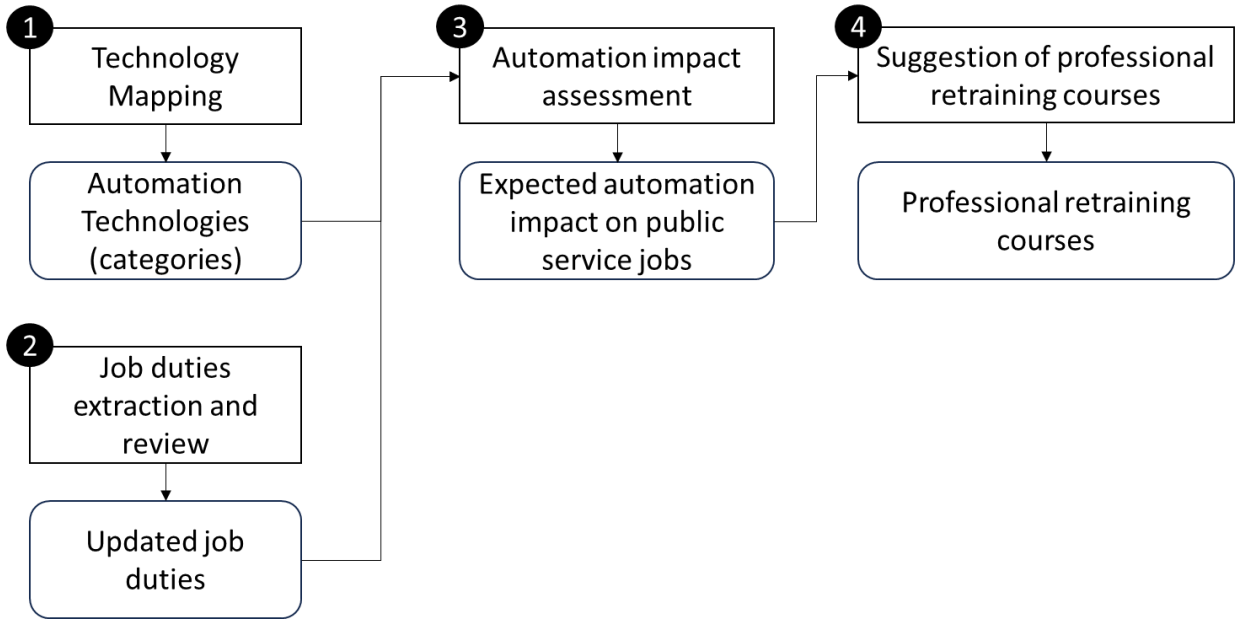


Figure 1: Summary of research methodology. Source: Created by the authors.

The assessment of the impact of automation on public jobs depends on two inputs: a list of automation technologies that are expected to impact the sector in the coming years and some type of job description that allows for a detailed analysis of the job. The first of these inputs is produced through a technology mapping based on the literature published in the last 2 years. The list of technology categories resulting from this process is then analyzed using ChatGPT 4 and Claude 2 to decide which are in fact categories of automation technologies and would have some impact on the job. Finally, ChatGPT 4 is used to provide a brief definition for each technology category and indicate 5 technologies that would be related to each one. The results of this first stage of the methodology are presented in Section 4.1.

To produce the second input required to assess the impact of automation, the job duties of the public positions to be analyzed were extracted and reviewed. As highlighted by previous research, there are a number of challenges in analyzing the positions and job duties of the Brazilian public sector given the lack of standardization in terms of code, name, and description, as indicated by previous studies (Adamczyk et al., 2021; De Oliveira Teixeira et al., 2022). In the case of the present research, an alignment of priorities was made with the Secretariat of Human Resources and the Secretariat of Labor Relations of the Ministry of Management and Innovation in Public Services (MGI) to decide which positions would be most relevant to be analyzed and which had some documentation that

[2] The prompts, codes and data produced during this research can be found at: https://drive.google.com/drive/folders/1kYqUzCRbaFB3YpfJij8KSOeiy-5thLr-?usp=sharing

gathered the job descriptions. With this, it was decided that the focus would be the analysis of intermediate-level (IL) positions and their job duties that are included in the Career Plan for Technical-Administrative Positions in Education (PCCTAE, in portuguese). The PCCTAE is a document published by the Federal Government, as part of Law No. 7.596 of 1987, that contains a list of 340 positions, of which 142 are intermediate level, and their responsibilities. It is important to note that some of these 142 positions exist in other agencies that are not in the education sector, which broadens the scope of the research.

The extraction and review of the job duties of the selected positions was done following the steps presented in Figure 2. The extraction was done using a Python code that processed the PCCTAE (pdf) file and generated a spreadsheet with the positions and their respective job duties. Then, another Python code sent the positions and job duties from the spreadsheet along with a prompt that asked the GPT-4 API to perform four activities. First, for each of the positions, GPT-4 should analyze the list of job duties provided and remove those that were considered obsolete, given that the list was written in 1987. Next, GPT-4 should expand or reduce the list of job duties for each position so that there would be a standardized number of 8 activities per position [3]. To record what GPT-4 did with the job duties for each position, it was asked to record whether each activity was: original, if the proposed job duty was the same as an activity in the original list; updated, if the proposed job duty was already on the original list, but something has been changed in the activity text; new, if the proposed job duty was created and was not on the original list. In the third activity, GPT-4 evaluated each job duty in terms of the frequency with which an average worker would perform each one, according to the scale below: rarely, once a year or less; occasionally, a few times a year, less than once a month; monthly, at least once a month, less than once a week; weekly, at least once a week, less than once a day; and daily, once or more times a day.

Finally, the last activity performed by GPT-4 was to define the degree of importance of each duty for the related position according to the scale: very low, low, medium, high and very high. The definition of frequency and degree of importance for each activity aimed to qualify the impact of automation, given that a high impact may be of little relevance for an activity that is rarely performed and of little importance for a given position. This type of classification is done by workers in catalogs of occupations and activities such as the one that exists in the USA (O*NET) and has not been used in previous studies, given the cost of producing something of this type for Brazil. However, GPT-4's ability to analyze data on occupations, proven in other previous studies, can be applied to enrich the analysis of the impact of automation by providing estimates for the frequency and degree of importance of the duties of the positions. The results of this step are presented in Section 4.2.

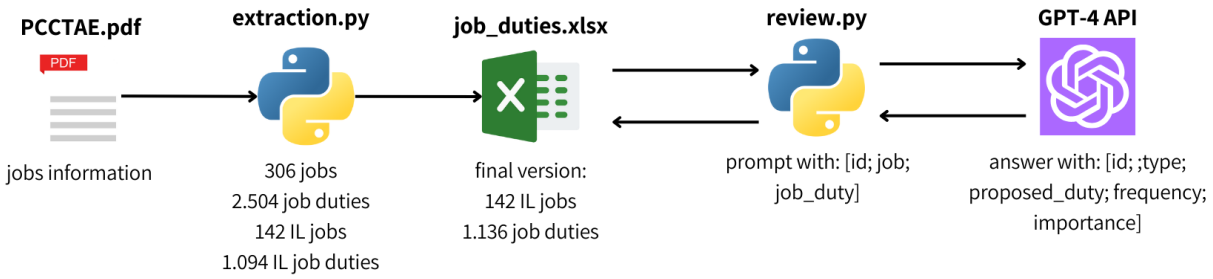


Figure 2: Details of the stage of extraction and review of public office duties. Source: Created by the authors.

Continuing with the research methodology, step 3 was the assessment of the impact of automation on the selected job roles (Figure 3). Here, a prompt (Appendix 2) for the GPT-4 Turbo API was developed with the categories of automation technologies, their descriptions, and related technologies resulting from step 1 of the methodology, and the job roles and duties resulting from step 2. In this prompt, GPT-4 Turbo was asked to respond with:

- A level of automation, according to the scale: Full (90-100%), High (70-80%), Medium (40-60%), Low (20-30%) and None (0-10%);
- Up to 3 categories of technologies and their respective technologies that would be used to automate attribution;
- An automation horizon, according to scale: immediate, available technologies could be adopted to perform the job duty; short term, in up to 2 years we would have technologies ready to replace the job duty;

[3]There is no ideal number of duties that a position should have, but the original PCCTAE list has a large variation in the number of duties, ranging from 2 to 29 duties. On average, there are 8 duties per position, and this number was adopted as being reasonable for standardizing the list.

medium term, it should take between 2 and 5 years for us to have technologies ready to replace the job duty; long term, it should take more than 5 years for us to have the technologies needed to replace the job duty.

To make it easier to understand the assessment made by GPT-4 Turbo, the prompt also asked for a justification for each of the above responses. In addition to helping to understand the logic behind GPT-4 Turbo's response, asking for a justification forces the model to "think" more carefully about its response. The results of this step are presented in Section 4.3.

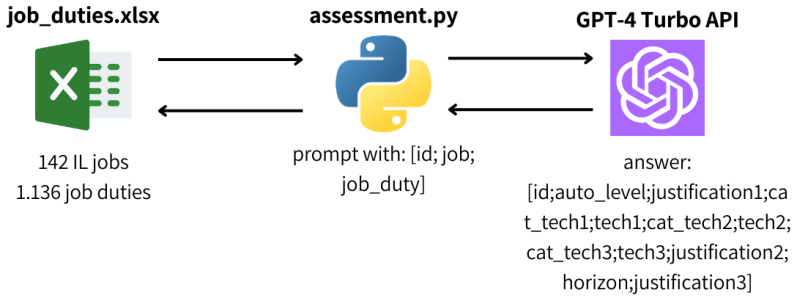


Figure 3: Details of the automation impact assessment stage. Source: Created by the authors.

The fourth and final stage of the research methodology involves suggesting courses for each position according to the duties and technologies related to each one. To do this, the GPT-4 Turbo API was once again called (Figure 4). This time, the prompt received as a response a list of courses, workload and syllabus for each position according to the duties and technologies related to each one. The results of this stage are presented in Section 4.4.

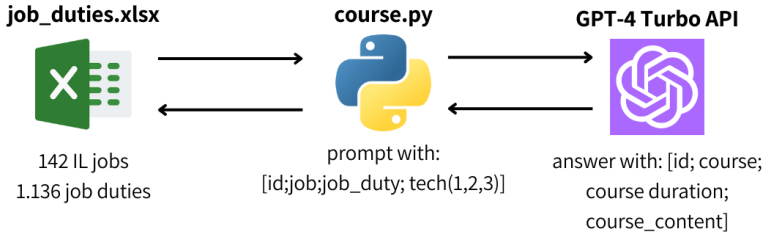


Figure 4: Details of the stage of suggesting professional retraining coursesThe use of footnotes should be avoided. Source: Created by the authors.

4. Results

This Section is structured to present the results of each of the stages of the methodology. Each of the stages generated products that are fully available in the research repository and are presented here to exemplify the results or analyze them quantitatively. Section 4.1 presents the results of the technological mapping, Section 4.2 presents the results of the extraction and review of the job duties of the positions analyzed, Section 4.3 presents the results of the technological assessment, and Section 4.4 presents the results of the suggestion of professional retraining courses.

4.1 Technological mapping

The literature review for the technology mapping was conducted based on technical papers published by organizations such as the World Economic Forum (WEF) and major consulting firms such as McKinsey, Deloitte and Gartner, which produce annual or biannual papers on technology trends. Given the differences in the names of technologies that exist from one paper to another, the list of technologies created from the mapping seeks to bring together, whenever possible, very similar technologies that have been named differently.

After listing all the technologies found in the papers, ChatGPT 4 and Claude 2 were asked to indicate which of them are automation technologies, given that some, such as Web 3, do not directly replace human labor, despite serving as a basis for the development of other technologies. Table 1 presents the result of this process.

The results were then reviewed by a human to ensure that no technology was left out and that the final list did not include technologies that did not belong to the automation technology category. As a result, encryption and cybersecurity technologies, synthetic data, and compression models that had been included by ChatGPT 4 were removed, but after stressing this with the model, the model itself recognized that it did not make sense to include

them. In addition, digital applications and platforms and data analysis were included in the list due to their potential to replace duties and streamline processes. With the final list of automation technologies, some technologies were consolidated into technology categories so that they all had the same level of granularity.

In the last step of this process, ChatGPT was asked to write a brief description and list 5 automation technologies (avoiding overlap and repetition) related to each technology category that should be considered in a study on the impact of automation on work. This led to the final list of automation technology categories which included: Data Analytics, Digital Applications and Platforms, Applied AI, 3D Printing, Internet of Things, Robots, and Extended Reality.

Table 1: Mapped technologies and evaluation results of ChatGPT 4 and Claude 2. Source: Created by the authors.

	Source						**Automation technologies**	
Technology	**WEF**	**McKinsey**	**Deloitte**	**Accenture**	**Gartner**	**FTI**	**ChatGPT 4**	**Claude 2**
Digital platforms and apps	x							
Education and workforce development technologies	x							
Big-data analytics	x		x	x			x	x
IoT and connected devices	x			x			x	x
Cloud computing (and Edge computing)	x	x	x		x		x	x
Encryption and cybersecurity / Trust architectures and digital ID	x	x	x	x	x		?	
E-commerce and digital trade	x							
Artificial Intelligence	x		x	x	x	x	x	x
Applied AI		x		x	x		x	x
Industrializing ML		x					x	x
Generative AI		x		x	x	x	x	
Self-supervised learning					x		x	
Environmental management technologies	x							
Climate-change mitigation technology	x	x				x		
Text, image and voice processing	x						x	x
Augmented and virtual reality / Immersive reality technologies / Extended reality / Metaverse	x	x	x	x		x	x	
Power storage and generation	x							
Electric and autonomous vehicles	x	x				x	x	x
Robots / and drones	x					x	x	x

Next-gen software development		x	x	x				
Web3		x	x	x		x		
Advanced connectivity		x						
Quantum technologies		x	x	x		x		
Biotechnology / Bioengineering		x				x		
Space technology		x						
Electrification and renewables		x				x		
Synthetic data					x		?	
Model compression					x		?	
3D and 4D printing and modeling	x						x	x
Nanotechnology	x							

4.2 Extraction and review of job duties

The process of extracting PCCTAE job duties resulted in a list with 142 intermediate-level positions and their 1,093 related job duties that were reviewed by GPT-4 to analyze obsolescence, given that the original document is from 1987, and to include information regarding the frequency of execution of the job duties and their importance. Table 2 shows the response given by GPT-4 for the driver position. In this case, GPT-4 kept 3 of the original job duties, updated one of them, only changing the text to simplify it, and included four new job duties to reach a total of 8, as requested in the prompt. The frequencies and degree of importance of each of the job duties were included so that it is possible to differentiate those that would have the greatest impact on the position in the event of automation.

Table 2: Example of a review of duties for the position of driver. Source: Created by the authors.

Job duty	**Type**	**Frequency**	**Degree of importance**
Use navigation system and route planning	New	Daily	Very important
Test the brakes and electrical system	Original	Monthly	Extremely important
Drive the vehicle	Original	Daily	Extremely important
Arrange for vehicle maintenance	Updated	Occasionally	Very important
Perform emergency repairs to the vehicle	Original	Rarely	Moderately important
Record mileage and fuel consumption	New	Weekly	Moderately important
Check and maintain safety equipment	New	Monthly	Extremely important
Perform daily inspections and safety checks on the vehicle	New	Daily	Very important

Figure 5 shows the distributions of type, frequency and degree of importance resulting from the review process, which resulted in 1,136 job duties. It is possible to see that GPT-4 kept just over 33% of the original job duties, either as they were already written (22%) or updated (11%), with the rest being new. Regarding the frequency distribution, 96% were considered to be performed weekly (45%) or monthly (41%), with only 0.1% of the job duties being rarely performed. Finally, the degree of importance most associated with the job duties was very important, with 52%, followed by moderate, with 30%, and extremely, with 17%. As GPT-4 reviewed the list of job duties and asked to prioritize those that were truly important, none of them received a degree of no importance and only 0.3% were considered somewhat important (low).

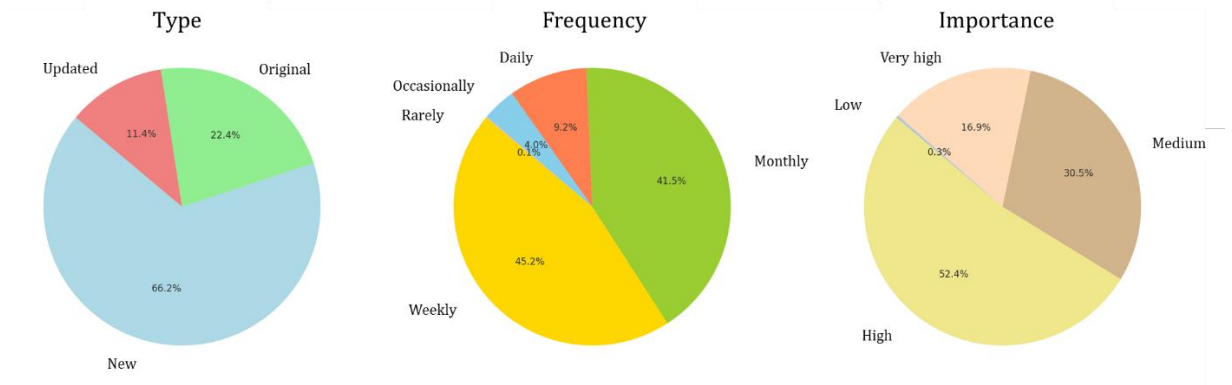


Figure 5: Type, frequency and importance distributions of revised job duties. Source: Created by the authors.

4.3 Assessment of the impact of automation

The automation impact assessment process, carried out with GPT-4 Turbo, resulted in a large amount of information regarding the level of automation, the technology and technology categories and the automation horizon for each of the 1,136 job duties, in addition to the justification for the responses given.

The example below show how the automation impact assessment was done for one job duty.

Position: Props

Job duty: Assemble, transform or duplicate scenographic or costume objects

- Automation level: Medium (40-60%)
    - Rationale: Automation can help with the assembly and duplication of objects
- Technology categories: 3D Printing and Extended Reality
- Technologies: Metal 3D Printer and Augmented Reality (AR)
    - Rationale: 3D printing for three-dimensional objects. AR for visualization and precise adjustments during creation
- Horizon: Short term (< 2 years)
    - Rationale: Advanced 3D printing and AR technologies are still under development for use in stage design

The evaluation exemplified above was made for the 1,136 job duties, with the most frequent level of automation being medium with 507 (44%) job duties, followed by high (295 or 26%) and low (291 or 25%) who had practically the same number of job duties (Figure 6). Less than 4% of the job duties were in the “none” (37) and “total” (6) levels.

Regarding the automation horizon, 817 (72%) job duties were between immediate (411) and short-term (406), 250 had a medium-term horizon and 69 had a long-term horizon (Figure 7).

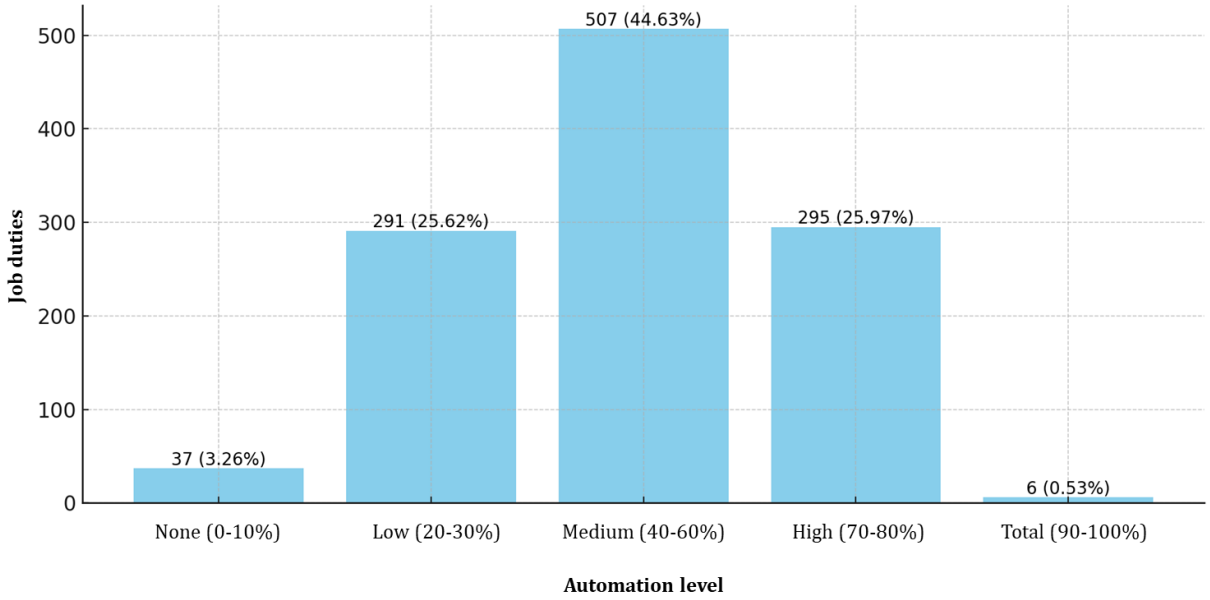


Figure 6: Job duties' automation level. Source: Created by the authors.

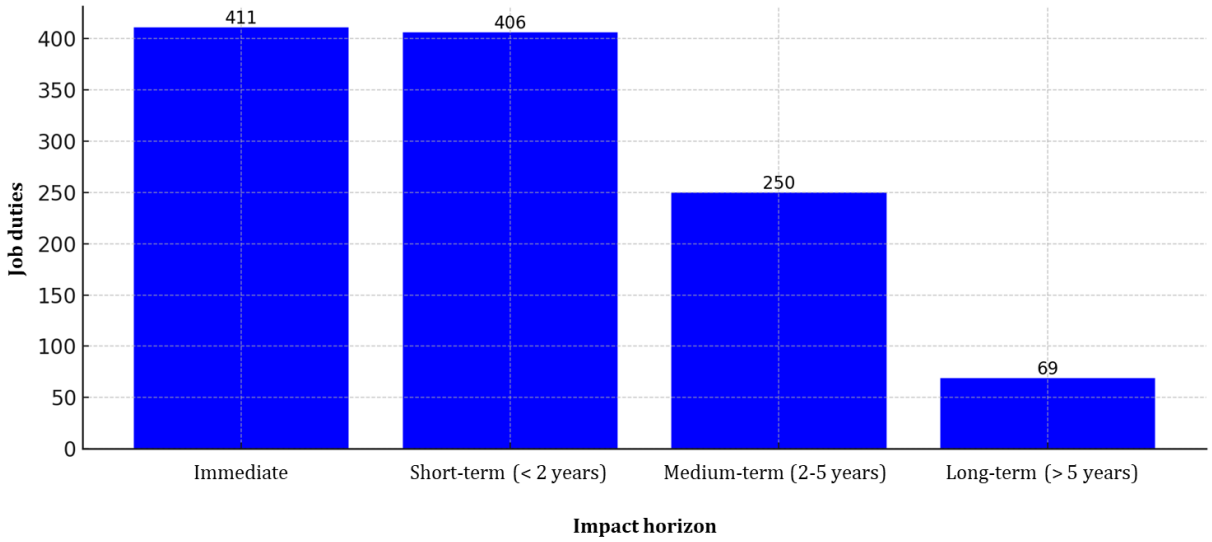


Figure 7: Technologies' impact horizon. Source: Created by the authors.

The calculation of normalized impact (In) for each position was made using the following formula:

$$In = \frac{\sum f \; x \; imp \; x \; lev_{auto} \; x \; hor}{\frac{400}{8}}$$

Being:

f the frequency of job duty

imp the degree of importance of the job duty

lev_{auto} the level of automation of the job duty

hor the horizon of attribution automation

It is important to highlight that the variable frequency of the job duty can assume the following categories and associated values: rarely (1), occasionally (2), monthly (3), weekly (4), and daily (5). Meanwhile, the variable importance of the job duty can assume these values: very low (1), low (2), medium (3), high (4) and very high (5). Automation level, in its turn, ranges from none (0) to total (4). Finally, horizon is scored from immediate (4) to long-term (1). As such, the product of these variables can reach a maximum value of 400, which justifies the division by 400 to normalize the result. Finally, the normalized sum is divided by 8, corresponding to the number of job duties evaluated per position, resulting in the average impact score for that position.

From this calculation, we have the percentage distribution presented in Figure 8, which divides the values *In* found in the assessment into 10 groups. We can see that the maximum impact we have is in the range of 0.47 to 0.52, with less than 1% of the positions, on a scale that can reach up to 1, if frequency, importance, level of automation and horizon are all at the maximum levels. The largest number of positions is in the range of 0.24-0.28, followed by the previous ranges, 0.19-0.24 and 0.15-0.19. Figure 9 and Figure 10 show the 10 positions with the highest and lowest values *In* found in the assessment.

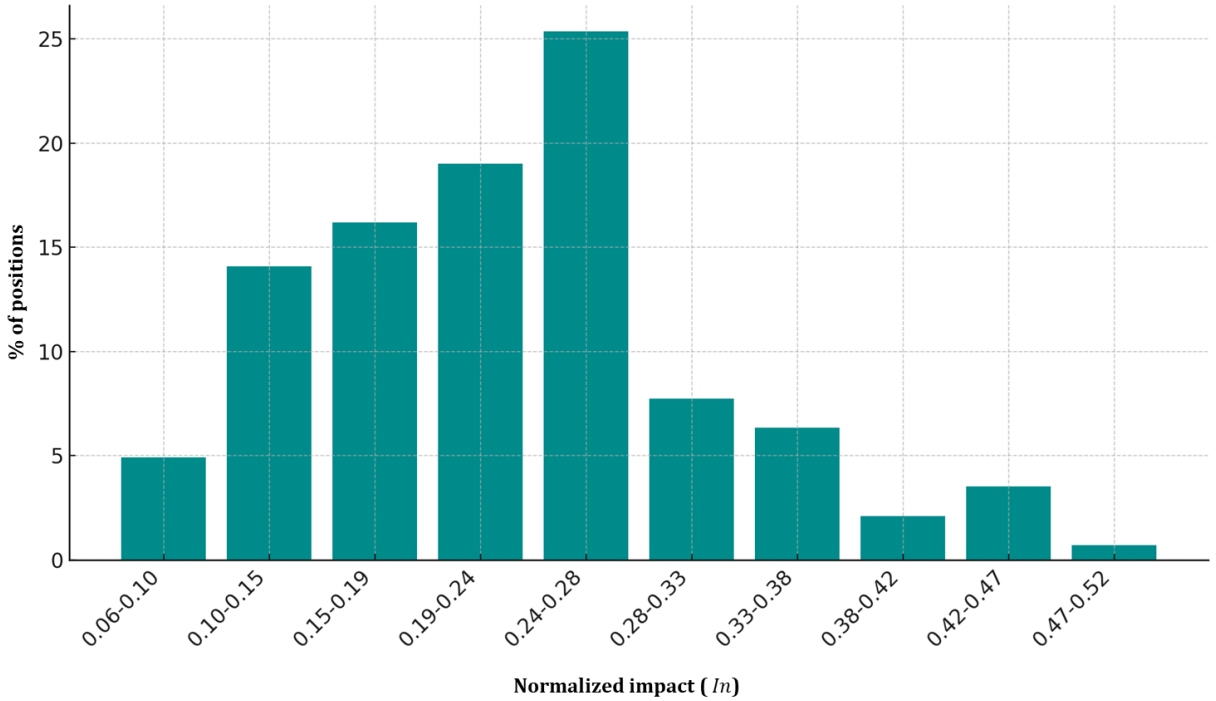


Figure 8: Percentage distribution of positions by impact range of the normalized impact. Source: Created by the authors.

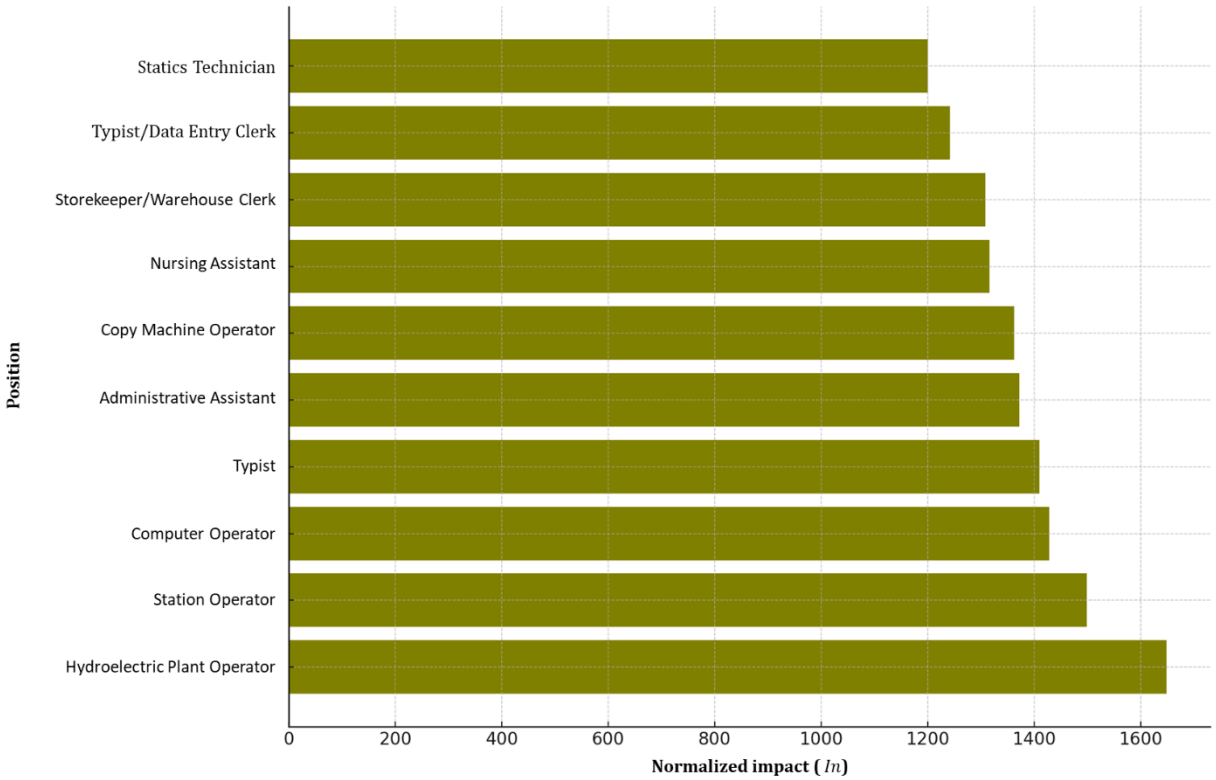


Figure 9: Top 10 positions with the highest normalized impact. Source: Created by the authors.

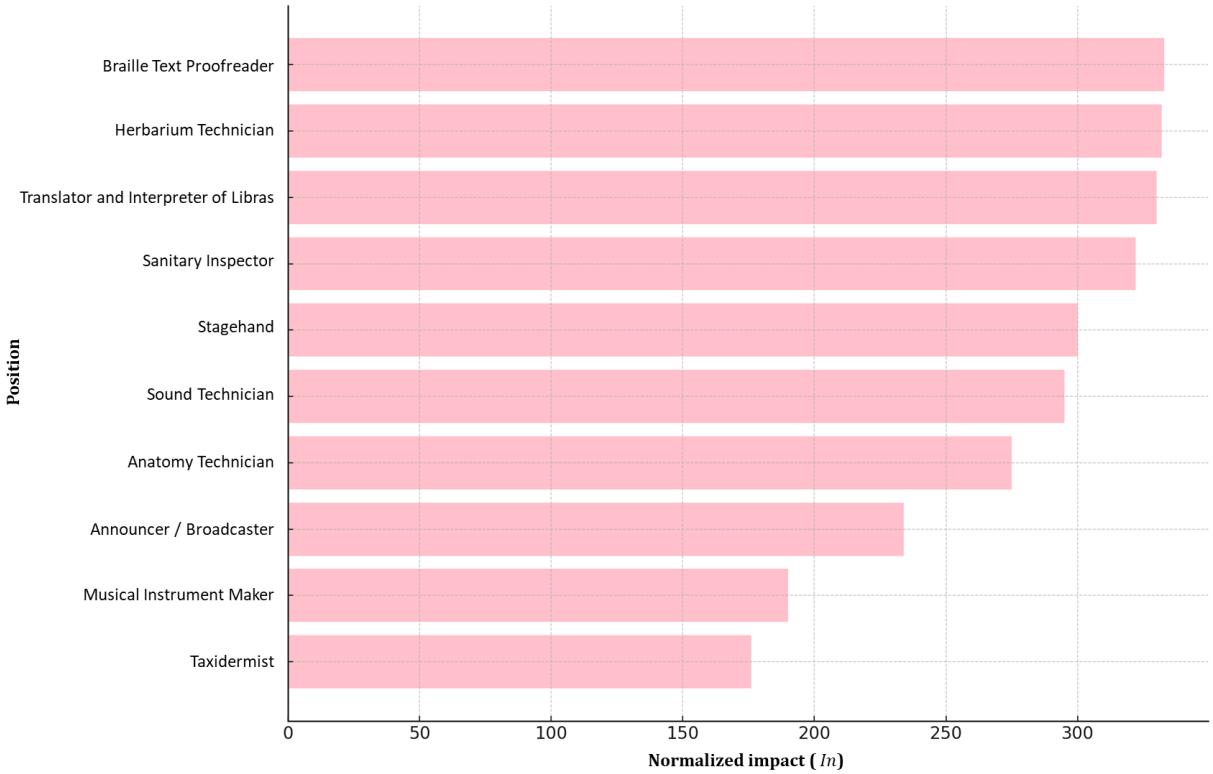


Figure 10: Top 10 positions with the lowest normalized impact. Source: Created by the authors.

Finally, the technology categories that appeared most frequently in the assessment of the impact of automation were Applied Artificial Intelligence (AAI) with 600 occurrences, Digital Applications and Platforms (APP) with 452 occurrences, and Data Analytics (DA) with 382 occurrences (Figure 11). The least cited category was 3D Printing (PRT), with only 25 occurrences. In total, GPT-4 Turbo associated 59 technologies with the 1,136 job duties evaluated (Table 3). Considering that 35 technology examples were given, 5 per category, GPT-4 Turbo needed to suggest 24 more technologies to evaluate all job duties. The list below shows the 10 most cited technologies:

1. Machine Learning: 323 occurrences
2. Smart Sensors: 169 occurrences
3. Process Digitization Systems: 163 occurrences
4. Online Communication and Collaboration Platforms: 104 occurrences
5. Business Intelligence (BI): 100 occurrences
6. Natural Language Processing (NLP): 100 occurrences
7. Data Mining: 93 occurrences
8. Big Data Analytics: 82 occurrences
9. Task and Project Management Systems: 77 occurrences
10. Robotic Process Automation (RPA): 64 occurrences

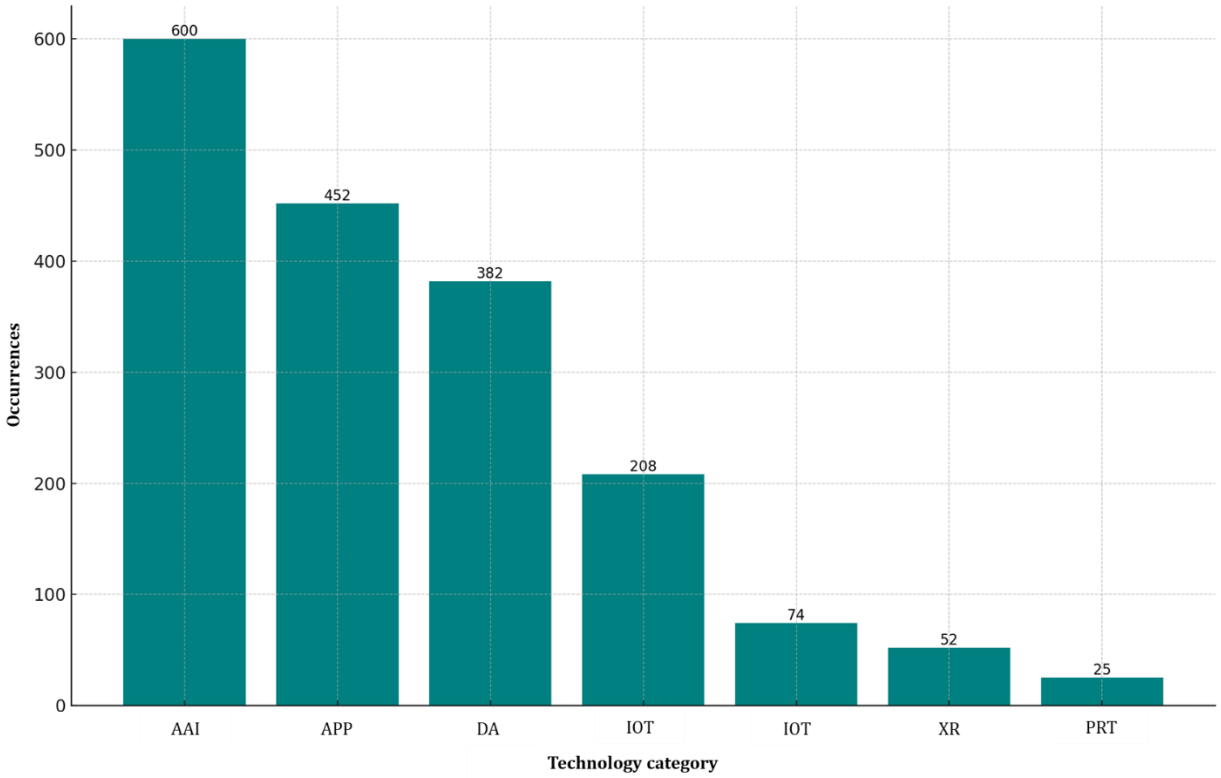


Figure 11: Frequency of technology categories with labels. Source: Created by the authors.

Table 3: List of technology categories (cat_tech) and technologies (tech) listed. Source: Created by the authors.

cat_tec	tech	cat_tec	tech
DA	Big Data Analytics	AAI	Machine Learning
DA	Business Intelligence (BI)	AAI	Natural Language Processing (NLP)
DA	Data Mining	AAI	Recommendation Systems
DA	Data Visualization	AAI	Test Automation Software
DA	Predictive Analytics	AAI	Computer Vision
DA	Data Visualization	PRT	Bioprinting
APP	CAD/CAM Software	PRT	3D Printing in Construction
APP	Online Forms	PRT	Metal 3D Printers
APP	GIS	PRT	FDM 3D Printers
APP	Laboratory Information Management Systems (LIMS)	PRT	Multi-material 3D Printers
APP	Online Communication and Collaboration Platforms	IoT	IoT Gateways
APP	E-learning Platforms	IoT	IoT Management Platforms
APP	Digital Rights Management Platforms	IoT	IoT Communication Networks
APP	Streaming Platforms	IoT	Smart Sensors
APP	Cryptography and Security Systems	IoT	Automated Control Systems
APP	Process Digitization Systems	IoT	Wearable Technology
APP	Video Editing Systems	RBO	Drones
APP	Digital Content Management Systems	RBO	Robotic Exoskeletons
APP	Document Management Systems	RBO	Autonomous Robots
APP	Event Management Systems	RBO	Collaborative Robots
APP	Information Management Systems	RBO	Cleaning Robots
APP	Sustainability Management Systems	RBO	Service Robots
APP	Task and Project Management Systems	RBO	Industrial Robots

APP	Measurement and Inspection Systems	RBO	Autonomous Vehicles
APP	Navigation Systems (GPS)	XR	Augmented Reality (AR)
APP	Information Security Systems	XR	Mixed Reality (MR)
APP	Decision Support Systems	XR	Virtual Reality (VR)
APP	Office Productivity Suites	XR	Interactive Simulations
AAI	Robotic Process Automation (RPA)	XR	VR/AR
AAI	Generative AI		

4.4 Suggestion of retraining courses

The last step of the methodology was the suggestion of retraining courses, which resulted in 236 courses for the 141 positions analyzed. Each course is accompanied by a list of topics and a suggested workload. The example presented in Table 4 for the Props position illustrates the results of this course suggestion process that was carried out with GPT-4 Turbo.

Table 4: Example of suggested courses for the position of Props Specialist. Source: Created by the authors.

Course	**Topics**	**Duration (in hours)**
3D Metal Printing Props Design and Manufacturing Course	Prop Design Fundamentals, Metal 3D Printing Materials and Techniques, Metal Post-Processing Processes for Props.	120
Instrument Conservation Course with Smart Technologies	Smart Sensors applied to Conservation, Preventive Maintenance Planning, Monitoring Methods and Conservation of Props.	60
Process Digitization Course for Prop Specialists	Introduction to Process Digitization Systems, Tools and Practical Applications, Cloud Data Management and Storage for Props Projects.	80
Course in Augmented Reality and Artificial Intelligence for Prop Design	Principles of Augmented Reality and Generative AI, Application in Artistic Design and Prop Production, Integration of AR in Artistic Production Environments.	100
Course on Communication and Collaboration in Artistic Productions with NLP	NLP Fundamentals for Team Articulation, AI-Assisted Communication Tools, Communication Strategies and Collaboration in Artistic Projects.	40
Advanced Course in Big Data Analytics for Sustainability in Props	Introduction to Big Data for Sustainable Materials Research, Data Analysis and Visualization, Sustainable Materials Implementation Strategies.	90
Computer Vision Course applied to Prop Quality	Fundamentals of Computer Vision, Automated QA Systems, Integration with Real-Time Production.	70

5. Conclusion

Assessing the impact of automation is not new in academia, including scenarios outlined for Brazil. However, few studies have addressed the specific case of automation in the public sector. The challenges in dealing with this issue in public management are even greater than those faced by the private sector and include barriers to creating or eliminating positions. In this sense, it is essential not only to frequently assess the impact of automation on public positions, given the rapid technological advances and the benefits this brings to the services provided to the population, but also to observe possibilities for professional retraining for public servants.

In this sense, the present study seeks to meet these two demands through the use of a modern methodology for assessing the impact of automation that uses Generative AI technologies such as Claude 2 and GPT-4 Turbo to evaluate a large and diverse number of positions quickly and that allows easy reproduction for other cases.

In addition to the methodology itself, the study provides some intermediate results that are contributions in themselves. The technological mapping of recent literature on emerging technologies allowed us to map, define and exemplify 7 categories of automation technologies that are important for the public sector to monitor, given their potential for implementation in a wide range of areas. The extraction and review of the job duties allowed us to create a new list of job duties for public positions that were defined in 1987. In addition, the frequency and degree of importance of the 1,136 job duties resulting from this process gave a degree of detail to the study and

enriched the definitions of the positions analyzed.

The main results of the study involved assessing the impact of automation and suggesting professional retraining courses. The assessment produced a wide range of information that allows us to understand both the level of automation of each job duty and position and a breakdown of this impact with each related technology, an automation horizon and justifications for each of these elements. The level of automation of the job duties was concentrated in the low, medium and high impact range, while the horizon is much more immediate and short term, demonstrating great potential for automation of the intermediate level positions that were analyzed. Despite this potential, when compared with the frequency, the degree of importance and the automation horizon itself, it was possible to see that the positions are concentrated in a range of 0.10-0.28 points out of a maximum of 1 and that no position exceeds 0.52 points. In terms of technologies, the ones that stood out the most were Machine Learning, Intelligent Sensors and Process Digitization Systems, with the most cited technology category being Applied Artificial Intelligence.

The suggestion of professional retraining courses was a new process for the literature in the area, but essential for dealing with automation in the public sector given the limitations of personnel management that exist in this area. 236 courses were generated with their respective syllabuses and workload.

The limitations of this study include those inherent to the technologies used, such as the hallucinations that Claude 2 and ChatGPT/GPT-4 sometimes demonstrate, and the data limitations of the training databases. The GPT-4 Turbo model represents an evolution in the face of these limitations and produced satisfactory results throughout the study, which were manually reviewed to ensure the quality of the final products. The tendency is for these models to evolve in the future and continue to surprise us with their potential for application in studies related to the impact of automation. Furthermore, the study is based on a list of duties that was developed in 1987 and updated for 2023. This process may mask a possibly greater impact of automation given that it is not known exactly what the real duties of public servants who occupy the positions analyzed are in 2023. Thus, this study, as well as any other that deals with a large number of positions or occupations, requires analyses at the individual level of the occupation or of a set of similar occupations that allow us to understand the organization of work in order to bring the analysis closer to the reality of public positions.

Future studies can expand the analysis presented here to other positions in the public sector, as well as develop methodologies that allow for a more in-depth process of suggesting retraining courses to support the creation of complete courses with a description of empirical and theoretical approaches at the forefront of science and a suggestion for the application of contextualized active methodologies. In addition, the technologies applied in this research can be used to help public servants better explore how to use automation technologies as allies in the process of delivering public services with better quality and efficiency.

Finally, as a future research agenda, the aim is to assess the impact of automation considering the criteria of gender, race, and their intersectionality. In a racist and sexist country like Brazil, where the composition of the public sector is still not representative of the population, it is essential to analyze automation through these social markers and critically examine its differentiated effects.

Acknowledgement

- **Funding:** this research was funded through the Decentralized Execution Agreement (TED) between ENAP and UnB/CDT, under the project "Data Production and Strategic Knowledge for Decision-Making in Government Management." We gratefully acknowledge their support in enabling this study.
- **Data/Software Access Statement**: all the code developed for this research and the resulting data are available at: https://drive.google.com/drive/folders/1kYqUzCRbaFB3YpfJij8KSOeiy-5thLr-?usp=sharing
- **Contributor Statement**: Conceptualization: Yuri Lima, Luana Passos, **Miriam Chaves**, Jano Moreira Souza; Methodology: Yuri Lima; Software: Yuri Lima; Data curation: Yuri Lima, **Delciene Pereira**, **Mirian Guimarães**; Visualization: Yuri Lima; Writing – Original Draft: Yuri Lima; Writing - Review & Editing: Luana Passos.
- **Use of AI**: During the preparation of this work, the authors used GPT-4 Turbo in order to analyze data. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest

References

Adamczyk, W. B., Monasterio, L., & Fochezatto, A. (2021). Automation in the future of public sector employment:

The case of Brazilian Federal Government. *Technology in Society*, *67*, 101722. https://doi.org/10.1016/j.techsoc.2021.101722

Arntz, M., Gregory, T., & Zierahn, U. (2016). *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis* (OECD Social, Employment and Migration Working Papers No. 189; Issue 189). OECD. https://doi.org/10.1787/5jlz9h56dvq7-en

Arntz, M., Gregory, T., & Zierahn, U. (2017). Revisiting the risk of automation. *Economics Letters*, *159*, 157–160. https://doi.org/10.1016/j.econlet.2017.07.001

Autor, D. H. (2015). Why Are There Still So Many Jobs? The History and Future of Workplace Automation. *Journal of Economic Perspectives*, *29*(3), Article 3. https://doi.org/10.1257/jep.29.3.3

Autor, D., & Salomons, A. (2018). Is Automation Labor Share-Displacing? Productivity Growth, Employment, and the Labor Share. *Brookings Papers on Economic Activity*, 1–87.

Banco Interamericano de Desenvolvimento. (2020). *Transformação digital e emprego público: O futuro do trabalho do governo*. Miguel Porrúa, Mariano Lafuente, Edgardo Mosqueira, Benjamin Roseth, Angela María Reyes. https://publications.iadb.org/pt/transformacao-digital-e-emprego-publico-o-futuro-do-trabalho-do-governo

Brookfield Institute. (2016). *The talented Mr. Robot: The impact of automation on Canada's workforce*. Brookfield Institute.

Chui, M., Hazan, E., Roberts, R., Singla, A., & Smaje, K. (2023). *The economic potential of generative AI*.

Chui, M., Manyika, J., & Miremadi, M. (2015). Four fundamentals of workplace automation. *McKinsey Quarterly*, 9.

Comin, D., & Hobijn, B. (2010). An Exploration of Technology Diffusion. *American Economic Review*, *100*(5), Article 5. https://doi.org/10.1257/aer.100.5.2031

De Oliveira Teixeira, K., De Guimarães E Souza, G. J., & Schneid Tessmann, M. (2022). The future of work in the Brazilian Federal District's executive branch. *Revista Do Serviço Público*, *73*(1), 9–31. https://doi.org/10.21874/rsp.v73.i1.6641

Deloitte. (2015a). *From Brawns to Brains: The Impact of Technology on Jobs in the UK*. Deloitte.

Deloitte. (2015b). *Man and Machine: Robots on the rise? The impact of automation on the Swiss job market* (p. 8). Deloitte.

Eisfeldt, A. L., Schubert, G., & Zhang, M. B. (2023). *Generative AI and Firm Values* (SSRN Scholarly Paper No. 4436627). https://doi.org/10.2139/ssrn.4436627

Eloundou, T., Manning, S., Mishkin, P., & Rock, D. (2023). *GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models* (No. arXiv:2303.10130). arXiv. https://doi.org/10.48550/arXiv.2303.10130

Frey, C. B., & Osborne, M. A. (2017a). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, *114*, 254–280. https://doi.org/10.1016/j.techfore.2016.08.019

Frey, C. B., & Osborne, M. A. (2017b). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, *114*, 254–280. https://doi.org/10.1016/j.techfore.2016.08.019

Gmyrek, P., Berg, J., & David, B. (2023). *Generative AI and Jobs: A global analysis of potential effects on job quantity and quality*. https://doi.org/10.54394/FHEM8239

Kubota, L. C., & Maciente, A. N. (2019). PROPENSÃO À AUTOMAÇÃO DAS TAREFAS OCUPACIONAIS NO BRASIL. *Radar*, *61*(Dez.).

Lima, Y., Barbosa, C. E., Dos Santos, H. S., & De Souza, J. M. (2021). Understanding Technological Unemployment: A Review of Causes, Consequences, and Solutions. *Societies*, *11*(2), 50. https://doi.org/10.3390/soc11020050

Lima, Y., Strauch, J. C. M., Esteves, M. G. P., de Souza, J. M., Chaves, M. B., & Gomes, D. T. (2021). Exploring the future impact of automation in Brazil. *Employee Relations*. https://doi.org/10.1108/ER-08-2020-0364

McKinsey Global Institute. (2017a). *A future that works: Automation, employment, and productivity*. MGI.

McKinsey Global Institute. (2017b). *Jobs lost, jobs gained: Workplace transitions in a time of automation*. MGI.

Noy, S., & Zhang, W. (2023). *Experimental evidence on the productivity effects of generative artificial intelligence*.

Reuters. (2023, December 19). *ChatGPT sets record for fastest-growing user base—Analyst note*. https://www.reuters.com/technology/chatgpt-sets-record-fastest-growing-user-base-analyst-note-2023-02-01/

Santos, I., Monroy, S., & Moreno, M. (2015). *Technological Change and Labor Market Disruptions: Evidence from the developing world*. IZA.

World Bank Group. (2016). *World Development Report 2016* (p. 359). World Bank Group.

World Economic Forum. (2018). *The Future of Jobs Report 2018*. WEF.

World Economic Forum. (2020). *Future of Jobs Report 2020*. WEF. http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

World Economic Forum. (2023). *Future of Jobs Report 2023*. WEF. http://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf

A Generative AI approach for creating and validating simplified versions of government documents.

Karine Alves[a*], *Matheus* Silva[b], *Edney* Santos[c], *George* Valença[d], *Kellyton* Brito[e].

[a] Universidade Federal Rural de Pernambuco, karine.vfalves@ufrpe.br, 0009-0004-9429-4317.

[b] Universidade Federal Rural de Pernambuco, matheus.fsilva@ufrpe.br, 0009-0003-8972-0636.

[c] Universidade Federal Rural de Pernambuco, edney.santos@ufrpe.br, 0009-0002-6784-8789.

[d] Universidade Federal Rural de Pernambuco, george.valenca@ufrpe.br, 0000-0001-9375-5354.

[e] Universidade Federal Rural de Pernambuco, kellyton.brito@ufrpe.br, 0000-0002-6883-8657.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. In the context of Brazil's re-democratization and the need for greater transparency in public administration, the 1988 Constitution established the right to access public information. However, the complexity of legal language, particularly in court documents, poses a significant barrier to understanding for the general public, especially given that only about 25% of Brazilians aged 25 or older have completed or are pursuing higher education. This study addresses this issue by leveraging generative AI models to simplify legal texts from the Court of Accounts of Pernambuco into plain language, making them more accessible to individuals with a high school education level. The research evaluates the effectiveness of two Large Language Models (GPT and Gemini) and five prompt techniques (Tree of Thought, COSTAR, Zero Shot, One Shot, and Meta Prompting) in producing simplified versions of 14 preliminary decisions. A total of 140 simplified texts were generated and evaluated using an 18-question questionnaire based on plain language principles, with scores generated by AI models and validated through human review. The results show that Gemini with the Tree of Thought technique achieved the highest average score (67.64), based on responses to the plain language questionnaire, while GPT with the COSTAR technique performed best in preserving essential information and achieving the highest readability scores (Flesch Reading Ease: 55.26). However, omissions of critical information were a common issue across all models, highlighting the need for human oversight. The study also found that GPT outperformed Gemini in evaluation accuracy, with lower Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) compared to human evaluations. Despite this, AI models tended to overestimate readability and comprehension, underscoring the importance of a hybrid approach that combines AI-generated assessments with human review. The findings demonstrate the potential of generative AI to reduce costs and improve accessibility to legal and governmental documents, while also emphasizing the need for further research to address limitations such as omissions, biases, and ethical considerations. This study contributes to the growing body of literature on AI-assisted text simplification and provides a foundation for future work in this area.

Keywords. Generative AI, Large Language Model, Plain Language, E-Government
Research paper, DOI: https://doi.org/10.59490/dgo.2025.968

1. Introduction

Simplifying public documents for better citizen understanding is a global objective (Petelin, 2010). In 1988, the text of the Brazilian Constitution was enacted. In the context of the country's re-democratization, it became

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

necessary to add subparagraph XXXIII to Article 5, aiming to allow any person to access public agency information, with the goal of increasing transparency and citizen participation in public administration—activities that bring various benefits to society(Andersen, 2009). However, it was only in 2011 that the country began to intensify actions within this agenda, joining the Open Government Partnership (OGP) and, in the same year, publishing the Access to Information Law (LAI) — Law No. 12,527 — which regulates the constitutional provision and outlines the procedures and deadlines for accessing information.

Thus, various Brazilian institutions have started publishing their information on open data online portals, making it accessible to the entire society. However, as these institutions operate in different fields, they use linguistic variations with varying levels of complexity. Among those with a high degree of linguistic complexity are the courts, making it difficult for people who are not regularly immersed in the technical context of the judiciary to understand this information (Belém, 2013). Similarly, this challenge affects a large part of the population, given that only about 25% of Brazilians aged 25 or older have completed or are pursuing higher education, while the rest have at most a high school education (Bandeira, 2024).

Therefore, recognizing this issue, some courts have started adopting the use of plain language in legal documents. However, one of the key aspects to consider when drafting a text in plain language is the target audience. If the document is intended for a more technical audience, lexical simplification may not be necessary. On the other hand, if the document is to be used both internally and by different audiences, multiple simplified versions must be created, each tailored to its respective group. As a result, the cost of producing various simplified documents becomes high for institutions.

While efforts to simplify legal texts—through manual rewriting, visual law, or controlled language systems (Belém, 2013; Martínez et al., 2024)—have existed for decades, their scalability remains limited by human resource constraints. Generative AI introduces a paradigm shift: by automating simplification, it enables institutions to produce *multiple tailored versions* of the same document (e.g., for laypersons, students, or professionals) at negligible marginal cost. This scalability aligns with the constitutional mandate of accessibility (*Constituição*, n.d.) while addressing the socioeconomic disparity in education levels (Bandeira, 2024). However, the trade-off between automation and accuracy—particularly omissions and hallucinations (Ray, 2023)—demands rigorous evaluation, as undertaken in this study.

With the launch of ChatGPT in 2022 and the rapid public adoption of the tool, both the public and private sectors saw an opportunity to solve problems using these models. However, generative AIs can produce hallucinations, that is, incorrect information in the final response (Ray, 2023). Therefore, it is necessary for the generated content to go through a revision process. So far, the literature recommends that the public sector perform human reviews before making the content available to the general public (K. Alves et al., 2024) However, the review process is expensive in environments where a lot of content is generated by AI.

In this context, the goal of this work is to simplify and evaluate documents issued by the Court of Accounts of Pernambuco. For this, 2 generative AIs were used with 5 different prompt techniques: Tree of Thought, Zero Shot, One Shot, COSTA and Meta prompting; producing a sample set of simplifications. These simplifications were evaluated by 2 different AI models. Then, the simplifications from the model and prompt combination that received the highest average score were manually reviewed by a researcher to compare with the score given by the AIs. And assess the quality of the evaluations. Thus, both the simplifications and the evaluations were assessed.

The remainder of this paper is organized as follows. Section 2 provides the related works. Section 3 outlines the methodology used to develop the experiment. Section 4 details the results obtained. Section 5 discusses the results, followed by Section 6, presenting concluding remarks and recommendations for future work.

2. Background and related works

For a better contextualization of the study, four important topics will be detailed: Plain Language in Governments, Application of Generative AI in Governments, Prompt Techniques, and finally, a review of related works.

2.1 Plain language in Government

The main element of plain language is the reader, who must be able to use the text to achieve the intended purpose (Petelin, 2010).Therefore, it is necessary for the document to be tailored to the reader, rather than expecting the reader to adapt to the document. In this way, readers can access government information and promote greater transparency in the public sector (Petelin, 2010). Recognizing the benefits, many countries have begun adopting plain language in various public information like Australia (APSC (Australian Public Service Comission), 2023), Belgium (*Heerlijk Helder | Vlaanderen.Be*, n.d.), Canada (*Plain Language*, *Accessibility*, *and Inclusive Communications*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- *Privy Council Office - Canada.Ca*, n.d.) and Norway (*Klarspråk - Språkrådet*, n.d.).

Considering the U.S. scenario, in 1978, U.S. President Jimmy Carter issued an executive order to make federal regulations clearer [Document design: a, 1980], which led the Internal Revenue Service to spend considerable time reconstructing the tax form. The movement for the use of plain language also reached other government agencies, such as in Washington State Courts (Dyer et al., 2013), which reports the need for the court to use plain language, as approximately 65% of families who go to court in Washington do not have the assistance of a lawyer.

Furthermore, in Brazil, the Fiscal Responsibility Law (LRF), in Article 48, establishes that fiscal oversight agencies must widely disclose both original and simplified versions of the following documents: plans, budgets, and budgetary guidelines laws; financial statements and their respective prior opinions; and the summarized fiscal management report. However, Article 48 does not provide clear guidelines for the construction of simplified versions of these documents. Additionally, the Brazilian Court of Accounts Members Association (ATRICON) recommended, in mid-2023, the use of plain language and visual law in the creation of their documents (*Atricon Recomenda Que Tribunais de Contas Adotem Linguagem Simples e Direito Visual – Atricon*, n.d.).

2.2 Generative AI's applications

Generative Artificial Intelligence (GenAI), particularly large language models (LLMs), has undergone rapid evolution since its inception. The foundation for modern LLMs was laid by early neural language models like Word2Vec (Mikolov et al., 2013) and ELMo (Peters et al., 2018), which introduced contextual word embeddings. A significant leap occurred with the Transformer architecture (Vaswani et al., 2017), enabling models to process sequential data more efficiently through self-attention mechanisms. This breakthrough paved the way for models like GPT (Generative Pre-trained Transformer) (Openai et al., n.d.) and BERT (Devlin et al., 2019), which demonstrated the power of pre-training on large corpora followed by fine-tuning for specific tasks.

The release of ChatGPT in 2022 marked a turning point, showcasing the capabilities of LLMs in generating human-like text and engaging in conversational interactions. Built on the GPT-3.5 and later GPT-4 architectures (OpenAI, n.d.), ChatGPT achieved widespread adoption, reaching 1 million users in just five days. The tool began being used in a virous scenarios, ranging from assisting in literature reviews (Haman & Školník, 2024)to recipe recommendations with faster, more personalized, and diverse meal options (Papastratis et al., 2024). It was also investigated how ChatGPT can contribute to the software requirements engineering process, exploring how it can assist in the activities of elicitation, validation, and documentation of requirements (Marques et al., 2024).

In the public sector, these technologies are being cautiously adopted to bridge the gap between legal systems and citizens. Brazilian courts have pioneered applications ranging from document simplification (Silva et al., 2024) to AI-powered judicial assistants like JuLIA (Araújo, 2024). Brazil's national audit institution (TCU) has implemented AI tools to streamline internal processes, including document analysis and workflow automation (*Uso de Inteligência Artificial Aprimora Processos Internos No Tribunal de Contas Da União – Notícias | Portal TCU*, n.d.), demonstrating institutional commitment to technological innovation. The Brazilian Court of Accounts of Pernambuco' initiative examined in this study represents a critical advancement in this domain, demonstrating how AI can operationalize constitutional transparency mandates at scale. However, the use of these tools must be planned to reduce risks and have mitigation plans in place should these risks occur (K. Alves et al., 2024).

2.3 Prompt Technique

A prompt is the set of instructions sent as input to generative AI models. It is through these prompts that the models generate new data. However, generative AIs are not 100% accurate; they can hallucinate, meaning they may introduce incorrect data in the final responses. However, there are ways to improve the performance of the responses obtained. By constructing the prompt well, it is possible to minimize hallucinations and get responses that are closer to what is expected, without needing to retrain the language model. Thus, in this section, we clarify the prompt techniques used in the experiment conducted in this work. The following techniques were applied: Tree of Thought, Costar, Zero Shot Prompt, One-shot Prompt, and Meta Prompting.

- **Tree of thought**: In this prompt style, the problem is sent to the model without any input examples. However, the prompt explicitly asks the model to divide the problem into subproblems and generate alternative solutions for each of them. The model will then evaluate each possible solution and select the best one (Long, 2023).
- **Costar**: Costar is a framework to support the construction of prompts. In this model, the prompt must be constructed with the following aspects: context, objective, style, tone, audience, and response. In other words, all these aspects are mapped in the prompt to contextualize the LLM and also to determine the expected response format.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **Zero Shot Prompt**: In this prompt style, the task to be performed is described in detail, without labeled training data (Sahoo et al., 2024).Thus, the model is led to use its pre-existing knowledge through a deeply described activity.
- **One-shot Prompt**: The One-shot is the prompt style that refers to using an input example for model learning (Chen et al., 2024) In other words, the model will receive an input with its respective expected result, and the input will be used for the LLM to work and achieve an output based on the example input for learning.
- **Meta prompting**: This prompt technique focuses on the structure and format of the interaction with the LLM, allowing greater control over how the model processes and presents information (Zhang et al., 2024).Therefore, there is a greater concern in describing which topics should be addressed in the response, for example.

2.3 Related Works

Although generative AI has only recently become widely known, there are already several related works on text simplification using this technology. In Ospina-Henao et al. (Ospina-Henao et al., 2024), generative AI was used to assist in simplifying technical texts for people with cognitive impairments, the elderly, and non-natives. Martinez et al. (Martínez et al., 2024) highlight the existence of guides for creating simple and easy-to-read content in plain language. However, there is no standardization between these guides, and standardization usually needs to be done manually, which is more costly.

A prominent study in the area of automatic text simplification is presented at (A. Alves et al., 2023). A total of 100 documents from the Regional Federal Court of the 5th Region (TRF5) and 100 documents from the Supreme Federal Court (STF), two major Brazilian courts, were used. The simplifications were performed using MUSS(EN), MUSS(PT), Transformers, and NMT + Attention. After simplification, the texts were evaluated using the Flesch Reading Ease (FRE) method. Only the NMT + Attention technique did not improve text readability, while the Transformers model achieved a score of 64.71, the highest readability average compared to the original text in TRF5 documents. MUSS(EN) achieved a readability score of 60, making it the best-performing model for STF documents. The study also used a human evaluation form to assess the simplified texts; however, Plain Language guidelines were not applied to determine whether the texts were effectively simplified.

Another study is being presented by Silva et al. (Silva et al., 2024). In this work, the target audience for simplification was individuals with a high school education, and prior opinions issued by the Court of Accounts of Pernambuco were used. The ChatGPT-4 was used, and the prompt technique applied was the zero-shot prompt. The simplified texts in this work contained little or no technical language while maintaining the main points of the decision. However, the work used only one Large Language Model, one prompt technique, and no simplification process was performed using plain language guides.

3. Methodology

The main objective of this work is to transform government documents, often perceived as complex by the general public, into plain language. To achieve this, we formulated the following research questions:

RQ01 – Which prompt techniques and Large Language Models most effectively translate the State Court of Accounts of Pernambuco's preliminary decisions into plain language for the audience of at least high school graduates?

RQ02 – Which Large Language Model demonstrates superior performance in evaluating the quality of AI-generated plain language texts, as measured by consistency with human judgments?

To address these questions, we structured our methodology into six complementary steps, aiming to create simplified versions of the preliminary decisions that are both satisfactory and generated automatically. The six steps are: (i) collecting the preliminary decisions; (ii) creating ten simplified versions of the decisions; (iii) automatic evaluation of simplified documents; (iv) selecting the best model; (v) human evaluation; (vi) grade alignment analysis. Figure 1 illustrates the methodology steps.

3.1 Collecting the preliminary decisions

The preliminary decisions were obtained using a system called "Decisões Simplificadas" (Translates to "Simplified Decisions") (Silva et al., 2024) which already contained the decisions. This system performed preprocessing by dividing the original preliminary decisions into logical sections, which were then stored in a database for easy retrieval and use in generating simplified versions. The scope of the preliminary decisions was limited to a specific

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

state and its capital, as it is a state-level court of accounts. The analysis focused on the most significant decisions for the state and its capital, starting from year 2016, totaling 14 documents.

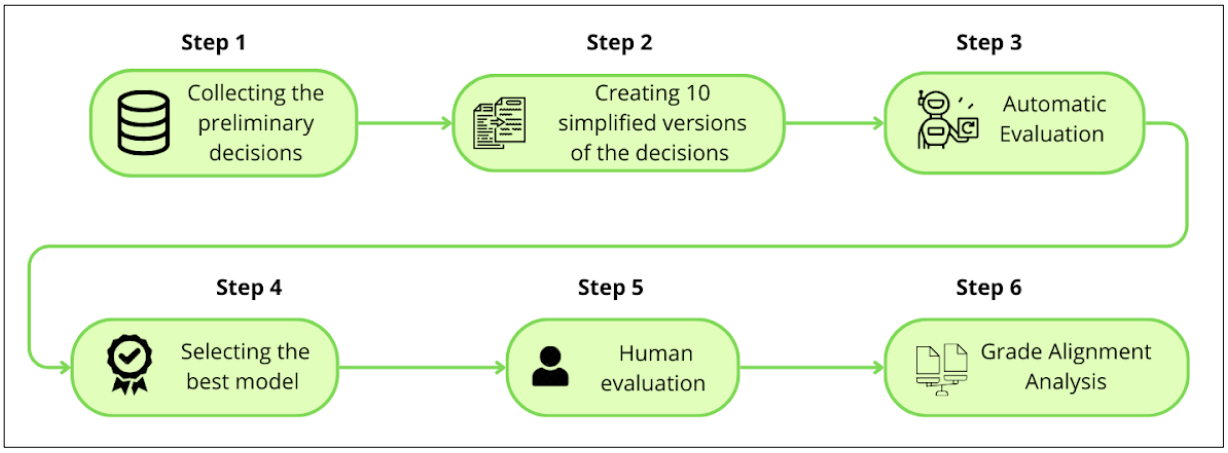


Fig. 1 – Methodology Diagram

3.2 Create ten simplified versions of the decision

Then, we chose five prompt techniques—zero-shot, one-shot, COSTAR, meta-prompting, and tree of thoughts—were selected for their varying approaches to contextual understanding and generative capabilities. The respective prompts are available in figures 2, 3, 4, 5 and 6. The prompts and all original texts were in Portuguese, the working language of the Court of Accounts.

```
Role:
You are a language expert specializing in plain and clear language.
Task:
Your task is to translate documents into plain language. To do this, you must follow the guidelines below, maintaining the most
important information and the structure of the text, while considering the target audience for whom the simplification is intended. You
should not summarize or condense texts; only translate them into plain language. Do not use markdown.
Target Audience:
General public, with a high school education, who want to know the results of municipal account judgments.
Guidelines:
Follow this algorithm:
1. Identify what needs to be said.
2. Identify what can be excluded.
3. Define the information architecture.
4. Structure the sentences.
5. Review the choice of words.
Use the order of importance in the content of the text:
• Essential content
• Important content
• Complementary content
• Accessory content
Information Architecture:
• Start the text with the most important point for the reader.
• Use lists or tables to organize information when necessary.
• Present only one idea per paragraph.
Sentence Construction:
• Be objective.
• Prefer active voice.
• Use sentences in direct order (subject + verb + complement).
• Avoid sentences interrupted by commas.
• Use affirmative sentences.
Word Choice:
• Explain technical terms and jargon.
• Use words common to the target audience.
• Avoid uncommon foreign words.
• Explain acronyms.
Text:
{&TEXTHERE&}
```

Fig. 2 – Zero Shot Prompt

Regarding the Large Language Models, Google's Gemini 1.5 flash and OpenAI's GPT 4o mini were selected. The decision to use these tools was based on their popularity and endorsement, which facilitate the process of simplification. To automate the process of generating each text, Python scripts were used to connect with the database containing the original preliminary decision texts. The GPT and Gemini APIs were then used to send the prompts, applying the chosen prompt technique along with the original text. The response from the API, containing the plain language version, was stored in a table within the same database.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

```
Role:
You are a language expert specializing in plain and clear language.

Task:
Your task is to translate preliminary opinions into plain language. To do this, you must follow the guidelines below, maintaining the
most important information and the structure of the text, while considering the target audience for whom the simplification is
intended. You should not summarize or condense texts; only translate them into plain language. Maintain the general structure of the
text. Do not use markdown.

Target Audience:
General public, with a high school education, who want to know the results of municipal account judgments.

Guidelines:
Follow this algorithm:

1.      Identify what needs to be said.

2.      Identify what can be excluded.

3.      Define the information architecture.

4.      Structure the sentences.

5.      Review the choice of words.

Use the order of importance in the content of the text:

·        Essential content

·        Important content

·        Complementary content

·        Accessory content

Information Architecture:

·        Start the text with the most important point for the reader.

·        Use lists or tables to organize information when necessary.

·        Present only one idea per paragraph.

Sentence Construction:

·        Be objective.

·        Prefer active voice.

·        Use sentences in direct order (subject + verb + complement).

·        Avoid sentences interrupted by commas.

·        Use affirmative sentences.

Word Choice:

·        Explain technical terms and jargon.

·        Use words common to the target audience.

·        Avoid uncommon foreign words.

·        Explain acronyms.

Examples:
To illustrate the change in technical terms, see the following examples:
Original:
"The present Technical Opinion aims to analyze the request for Suspension of Bidding Process (doc. 1), requested by the company WT –
TECHNOLOGY, MANAGEMENT AND ENERGY S.A, a legal entity under private law, registered with the CNPJ/MF under no. 08.624.525/0001-00,
headquartered at Rua Carneiro Leão, no. 203, Brás, CEP. 03040-000, São Paulo/SP, duly represented by its partner Mr. THIAGO HENRIQUE
PESSOA, Brazilian, holder of Identity Card RG no. 25.927.596-7 and CPF/MF no. 220.858.618-22."

Simplified:
"This opinion analyzes the request for suspension of Bidding Process No. 004/2021 (doc. 1), requested by the company WT – Technology,
Management, and Energy S.A.
The bidding process is being conducted by the Public Intermunicipal Consortium of Agreste Pernambucano and Borders (CONIAPE), with the
following objective:
Price registration for engineering services related to the management of the public lighting system (doc. 7).

CONIAPE initiated the bidding process (doc. 7) in 2021. In November of the same year, the company WT was disqualified for not meeting
the technical qualification requirement specified in item 5.2 of the bidding notice.
On January 2, 2022, the company WT requested (doc. 1) the Court of Accounts to immediately suspend the bidding process. They claimed
that the Technical Archive Certificates (CAT) presented for their qualification exceeded the requirements of the notice.
The Municipal Works Audit Office/North (GAON) was asked to issue an opinion on the regularity of the notice and the documentation
presented by the company, as well as to assess the possibility of suspending the precautionary measure."

Text:
{&TEXTHERE&}
```

Fig. 3 – One Shot Prompt

3.3 Automatic Evaluation:

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In this step, the quality of the generated simplified versions was evaluated using two complementary approaches. First, an 18-question questionnaire, primarily based on Patricia Roedel's plain language guidebook (Roedel, 2024), was developed to assess adherence to plain language principles. This questionnaire included specific guidelines for simplification as well as broader questions about readability and comprehension. The original text, simplified text, and questionnaire were sent to the same large language models, which generated a score between 0 and 100 for each simplified version based on the plain language criteria. The questionnaire and the questions' weights is available at table 1.

```
Context:
You are a language expert specializing in plain and clear language. To ensure greater understanding by the general public, people with
a high school education, of the preliminary opinions of the Court of Accounts of the State of Pernambuco, the texts must be translated
into plain language.
Objective (O):
Your task is to translate voting documents into plain language so that the text of such documents is clear, easy to understand, but
maintains the meaning of the text. Initially, you should identify sentences and words that are difficult to read and then modify them,
following the style below:
Style (S):
Follow the guidelines below, maintaining the most important information and the structure of the text, while considering the target
audience for whom the simplification is intended. You should not summarize or condense texts; only translate them into plain language.
The text should follow this style:
1. Information Architecture:
- Start the text with the most important point for the reader.
- Use lists or tables to organize information when necessary.
- Present only one idea per paragraph.
2. Sentence Construction:
- Be objective.
- Prefer active voice.
- Use sentences in direct order (subject + verb + complement).
- Avoid sentences interrupted by commas.
- Use affirmative sentences.
3. Word Choice:
- Explain technical terms and jargon.
- Use words common to the target audience.
- Avoid uncommon foreign words.
- Explain acronyms.
Tone (T): The final text must retain all the information and the same structure as the original text but should be in plain language,
with the specified guidelines. Do not remove any information; keep everything and do not summarize.
Audience (A): The target audience for this text is the general public, who want access to a plain language version of a preliminary
opinion document, which indicates whether the accounts of a municipality, judged by the Court of Accounts of the State of Pernambuco,
were approved or not.
Response (R): The format must follow the plain language guidelines. Do not use markdown.
Text:
{&TEXTHERE&}
```

Fig. 4 – CoStar Prompt

In addition to the questionnaire-based evaluation, we assessed the readability of each simplified text using two standardized metrics: the Flesch Reading Ease (FRE) and Flesch-Kincaid Grade Level (FKGL).

The Flesch Reading Ease score, calculated using Portuguese-adapted formulas that account for the language's specific phonetic and syntactic characteristics, measures text accessibility on a scale from 0 to 100. Higher scores indicate greater readability, with scores above 50 generally considered appropriate for audiences with basic literacy skills. This metric considers both average sentence length and average syllables per word.

```
Task: Translate the following text with complex language into a simpler version, using the guidelines provided below.
Original Text: {&TEXTHERE&}
Translation Guidelines:
1. Information Architecture:
- Start the text with the most important point for the reader.
- Use lists or tables to organize information when necessary.
- Present only one idea per paragraph.
2. Sentence Construction:
- Be objective and direct.
- Prefer active voice and use sentences in direct order (subject + verb + complement).
- Avoid sentences interrupted by commas and prioritize affirmative sentences.
3. Word Choice:
- Explain technical terms and jargon.
- Use words common to the target audience.
- Avoid uncommon foreign words and explain acronyms.
Target Audience: The target audience for this simplification is the general public, with a high school education, who want to know the
results of municipal account judgments by the Court of Accounts of the State of Pernambuco.
Expected Response Structure: Return ONLY the text translated into plain language.
```

Fig. 5 – Meta Prompting

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

```
Scenario: Imagine three experts collaborating to translate a text of votes from the Court of Accounts of the State of Pernambuco into
plain and clear language, so it can be widely understood, following specific guidelines.
Guidelines:
Information Architecture:
- Start the text with the most important point for the reader.
- Use lists or tables to organize information when necessary.
- Present only one idea per paragraph.
Sentence Construction:
- Be objective.
- Prefer active voice.
- Use sentences in direct order (subject + verb + complement).
- Avoid sentences interrupted by commas.
- Use affirmative sentences.
Word Choice:
- Explain technical terms and jargon.
- Use words common to the target audience.
- Avoid uncommon foreign words.
- Explain acronyms.
Expert 1: Focuses on the structure of the text, ensuring it starts with the most important point and uses lists or tables when
necessary.
Expert 2: Focuses on sentence construction, ensuring sentences are objective, in direct order, and use active voice.
Expert 3: Focuses on word choice, replacing jargon with clear explanations, avoiding foreign words, and explaining acronyms.
Process: The process will follow these steps:
1. Each expert proposes an initial translation or refinement based on their area of focus.
2. Everyone evaluates the suggestions of the other experts and makes adjustments.
3. After several iterations, they arrive at a final version that is simple and clear.
Text to be translated: {&TEXTHERE&}
Additional Instructions: Start with the first iteration of the translation, following these guidelines. Each expert should write a
proposal in their area, and the group, with their expertise in plain language, will evaluate and refine the text before moving on to
the next step. The target audience for this simplification is the general public, with a high school education, who want to know the
results and process of municipal account judgments.
Required Final Format: This is not a summary or simplification but a full translation of the text into plain language. Send only the
final text, which must contain all the information from the original text. No markdown.
```

Fig. 6 – Tree of Thought

The Flesch-Kincaid Grade Level metric converts the FRE score into the corresponding U.S. educational grade level needed to comprehend the text. Lower scores represent simpler texts that require less formal education to understand. For our target audience of high school graduates (typically corresponding to grade 12), we aimed for FKGL scores at or below this threshold. These Portuguese-adapted versions of the tests maintain the original metrics' validity while accounting for linguistic features specific to Portuguese, such as its typically longer words and more complex verb conjugations compared to English.

The combination of these two approaches—questionnaire scores and readability metrics—allowed for a comprehensive evaluation of the simplified texts. The questionnaire scores were used to determine how well the simplified versions adhered to plain language principles, while the readability metrics provided objective measures of text complexity. Together, these evaluations helped identify the best-performing model.

3.4 Selecting the best model:

Scores were calculated using a weighted average, with each question assigned a specific weight, based on the importance of each question. Particular emphasis was placed on assessing whether the large language model omitted information or generated hallucinations, ensuring the output was a true simplification rather than a summary (questions q1 and q2). Besides, higher weights were also given on questions 17 and 18, Using the LLM-generated scores for each simplified version, the next step was to determine the best-performing model by identifying the combination of prompt technique and Large Language Model that achieved the highest average grade. Alongside this, the Flesch Reading Ease and Flesch-Kincaid Grade Level metrics were calculated to verify whether the simplified versions were indeed easier to read compared to the original texts. While these readability metrics were not used to select the best model, they provided additional validation that the simplified texts were more accessible to a broader audience.

3.5 Human evaluation:

The original version of the document, the simplified version, and the questionnaire were sent to human evaluators, who assessed the 14 text samples from the prompt-model combinations that achieved the best average performance. Although the human evaluators were not language specialists, they received instructions on how to conduct the evaluations, including guidelines on the principles of plain language, its objectives, and its definition. These evaluations were limited to the simplified versions produced by the selected best-performing model. To quantify the differences between human and LLM grades, tests on Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE), metrics widely used in the evaluation of AI models were conducted. These metrics were chosen as they provide clear insights into the consistency and accuracy of the LLM evaluations compared to human assessments.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 – Evaluation Questionnaire

No.	question	weight
q1	Does the simplified text omit any information from the original text?	5
q2	Does the simplified text include any information that is not in the original text?	5
q3	Does the text present the most important information first?	1
q4	Does the text structure the information using lists, tables, graphs, etc.?	1
q5	Does the text convey only one idea per paragraph?	1
q6	Does the text use the minimum number of words?	1
q7	Does the text use the active voice?	1
q8	Does the text use direct word order?	1
q9	Does the text avoid sentences with intercalated clauses separated by commas?	1
q10	Does the text use words that are generally familiar to the target audience?	1
q11	Does the text translate technical terms and jargon?	1
q12	Does the text use precise words?	1
q13	Does the text spell out acronyms in full?	1
q14	Does the text avoid foreign words without common usage?	1
q15	Does the text avoid nominalizing verbs?	1
q16	Does the text use any pejorative terms?	1
q17	Has the simplification compromised the full understanding of the content?	3
q18	Is the simplified text appropriate for the target audience's level of knowledge?	3

4. Results

In the following section, we present the results achieved, discussing the most relevant aspects of the implemented methodology and the findings obtained during its development.

4.1 Research Question 01

For Research Question 01, "Which prompt techniques and Large Language Models most effectively translate the State Court of Accounts of Pernambuco's preliminary decisions into plain language for the audience of at least high school graduates?", it was crucial to identify the best-performing prompt technique and large language model for translating text into a plain language version. To develop this, it was necessary to understand the overall performance of each combination of prompt techniques and large language model. Each preliminary decision was sent to GPT 4o mini and Gemini 1.5 flash, using five different prompts for evaluation. The evaluation process then generated automatic scores, as described in the methodology section.

With the automatic scoring system, we evaluated different combinations of prompt techniques and large language models (LLMs) to determine the most effective approaches, as summarized in Table 2. The results show that Gemini achieved the highest score (67.64) using the "Tree of Thought" technique, followed closely by its performance with "COSTAR" (67.36). GPT's strongest results came from the same "Tree of Thought" approach (67.21), slightly outperforming its "COSTAR" score (66.07). Notably, Gemini consistently scored higher than GPT across most techniques, with the exception of "Tree of Thought," where GPT was nearly on par. The weakest performance came from GPT using "Meta Prompting" (62.79), which scored lower than even GPT's "Zero Shot" baseline (63.71). Overall, structured techniques like "Tree of Thought" and "COSTAR" delivered the best results for both models, suggesting that methodical, multi-step prompting strategies yield superior performance compared to simpler approaches like zero-shot or one-shot prompting.

Table 3 illustrates the omission rate, additional info rate, comprehension compromised rate, and audience suitability rate from each combination of prompt technique and LLM. These rates were based on the questionnaire responses to Questions 1, 2, 17, and 18, where the values are expressed as percentages. As shown, GPT with the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

COSTAR and Zero Shot (90%) technique had the lowest omission rate, even though this means that from all of the documents, 90% had something missing. This was closely followed by Gemini with the Tree of Thought technique, which also performed well. Most models struggled to follow the instructions to avoid omitting information, with most exhibiting an omission rate of 100%, indicating either missing information or significant data loss. On a positive note, none of the models added information that was not present in the original text, indicating they did not hallucinate.

Tab. 2 – Average Score of each model

Average Score	LLM	Prompt Technique
67,64	gemini	Tree Of Thought
67,36	gemini	COSTAR
67,21	gpt	Tree Of Thought
66,71	gemini	One Shot
66,07	gemini	Meta Prompting
66,07	gpt	COSTAR
65,71	gemini	Zero Shot
63,71	gpt	Zero Shot
62,79	gpt	Meta Prompting
60,71	gpt	One Shot

Regarding the comprehension compromised rate, GPT led with the Tree of Thought at 37%, followed by Gemini with One Shot at 45%, and Gemini with Tree of Thought at 50%, maintaining a good average across the rates. For audience suitability, all models performed well, except for Gemini using the COSTAR prompt.

Tab. 3 – Omission, additional info, comprehension compromised and audience suitability rate by model

LLM	Prompt Technique	Omission Rate	Additional Info Rate	Comprehension Compromised Rate	Audience Suitability Rate
gemini	Tree Of Thought	91%	0%	50%	100%
gpt	Tree Of Thought	100%	0%	37%	100%
gemini	Meta Prompting	100%	0%	54%	100%
gpt	Meta Prompting	100%	0%	59%	100%
gpt	COSTAR	90%	0%	63%	100%
gemini	Zero shot	100%	0%	50%	100%
gpt	Zero shot	90%	0%	59%	100%
gemini	One Shot	100%	0%	45%	100%
gpt	One Shot	100%	0%	59%	100%
gemini	COSTAR	100%	0%	50%	90%

Table 4 presents readability scores for different prompt techniques and the two different models utilized, compared with the original texts. The readability metrics were the Flesch Reading Ease (FRE), which has higher scores for easier to read texts, and Flesch-Kincaid Grade Level (FKGL), that has lower scores for easier to read texts. The original text has very low readability (FRE: 11.13) and a high FKGL score (22.71), indicating that it is highly complex and likely inaccessible to a general audience, which confirmed the need for simplification to enhance accessibility. GPT + COSTAR achieved the best readability score (FRE: 55.26, FKGL: 8.82), which was approximately five times the original FRE metric, going from 'very difficult' score to just below the plain language standard,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

making it the most effective at simplifying the text. Tree of Thought, by the metrics, underperformed compared to other techniques, especially with Gemini, which was contrary to the other conclusions.

Tab. 4 – Flesch and Flesch-Kincaid for each model

Prompt technique	LLM	FRE average	FKGL Average
Original text		11.13	22.71
COSTAR	gpt	55.26	8.82
Meta Prompting	gpt	54.97	8.40
Zero shot	gpt	53.62	8.75
One Shot	gpt	51.86	9.22
Tree Of Thought	gpt	50.79	9.39
COSTAR	gemini	44.66	11.43
One Shot	gemini	40.51	11.11
Meta Prompting	gemini	40.40	11.43
Tree Of Thought	gemini	39.40	13.10
Zero shot	gemini	36.29	12.68

Overall, based on all metrics from the tables 2, 3, and 4 the best-performing combination for simplified text generation was Gemini with Tree of Thought, which had the highest average score, created the best simplified version for four of the preliminary decisions, kept a good average across the rates, even though it had a non-satisfactory result in the readability metrics. This model was followed by GPT with COSTAR, which created the best scored simplified version, lowest omission rate, and the second highest average score.

4.2 Research Question 02

To address Research Question 02—"Which Large Language Model demonstrates superior performance in evaluating the quality of AI-generated plain language texts, as measured by consistency with human judgments?"—we conducted a comparative analysis between AI-generated evaluations and human assessments. This evaluation aimed to determine the reliability of large language models in assessing the quality of simplified preliminary decisions.

As described in the methodology section, the evaluation process involved human raters grading the simplified versions produced by the best-performing prompt technique and LLM combination (Gemini with Tree of Thought). The human evaluations were then compared with the AI-generated scores from both Gemini and GPT to quantify discrepancies. To measure the degree of deviation between human and AI-generated scores, we employed Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE).

Tab. 5 – MAE and MAPE for each model

LLM	MAE	MAPE
Gemini	22.14	32.34%
GPT	16.79	25.76%
Average	19.03	28.5%

The results indicate that GPT provided scores that were closer to human evaluations than Gemini. GPT's lower MAE and MAPE suggest a more reliable alignment with human judgment, making it a stronger candidate for evaluating plain language texts. In contrast, Gemini's higher MAE and MAPE suggest a greater deviation from human ratings, meaning its evaluation system might not be as precise for this specific task.

A notable finding is that the AI-generated scores consistently overestimated readability and clarity, suggesting that

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

large language models may havea bias toward assuming their outputs are clearer than they actually are for human readers. Additionally, while Gemini outperformed GPT in text simplification, it performed worse in evaluation, raising concerns about its effectiveness as an assessment tool.

Another important observation is the variability of AI evaluations across different texts. While some simplified versions received similar scores from both AI and human evaluators, others showed significant discrepancies. This suggests that AI evaluations may struggle with certain linguistic features, such as legal terminology, sentence complexity, or implicit contextual meaning.

5. Discussion

This study demonstrates that Large Language Models can *operationalize* plain language principles at scale, a task previously hindered by labor-intensive manual processes (Petelin, 2010). Where traditional simplification relies on linguists or legal experts to draft single versions, AI models like Gemini and GPT generate context-aware variants in seconds, as evidenced by our 140 simplified texts. This efficiency could transform public institutions' capacity to comply with transparency laws (e.g., Brazil's LAI) while reducing costs. However, our findings reveal a critical gap: AI's tendency to omit details (Table 3) mirrors the 'summary effect' observed in early machine translation (A. Alves et al., 2023), underscoring that *scalability does not equate to reliability*. Hybrid workflows—combining AI's speed with human oversight for legal precision—emerge as the optimal path forward.

Haman & Školník (2024) demonstrated GPT's potential for complex texts, which we extend to legal simplification. Alves et al. (2023) improved readability using models like Transformers and MUSS, but our study goes further by incorporating plain language principles, human evaluation, and a hybrid approach to ensure both readability and information retention. These comparisons highlight our study's novelty in enhancing public access to legal information while addressing prior limitations.

As for ethical and legal considerations, the deployment of AI for legal text simplification raises critical challenges regarding accountability (e.g., determining liability for errors in AI-generated documents), risks of misinformation from model hallucinations or omissions, and potential erosion of public trust in official records. These concerns are particularly acute in legal contexts where precision is paramount, as highlighted by AI safety literature (Ray, 2023) and emerging regulations like the EU AI Act's high-risk classification for public-sector AI. While Brazil's evolving AI governance framework acknowledges transparency needs (K. Alves et al., 2024), specific safeguards for legal applications—such as mandatory human review of AI outputs, audit trails, and public education about AI-processed documents—must be prioritized to balance accessibility with legal integrity.

However, despite promising results, some challenges can be highlighted. GPT outperformed Gemini in accuracy, suggesting its reliability for preliminary assessments. However, discrepancies between human and AI scores indicate that a hybrid approach—combining AI with human review—is most effective. Despite structured prompts, omissions were common, showing that critical information loss remains a risk. Another limitation noted is the small sample size, which may be sufficient for a preliminary analysis, however may not capture the full complexity of legal languages across diverse contexts.

Moreover, human evaluation was limited to 14 simplified versions due to resource constraints and conducted by non-specialists, potentially introducing bias. While evaluators were trained in plain language principles, their lack of legal expertise could affect judgments about information retention and clarity. Incorporating feedback from both legal professionals and target audience representatives (e.g., high school graduates) would strengthen future evaluations. Additionally, the cost of proprietary models like Gemini and GPT is a limitation, and future studies could explore open-source models for cost-effective solutions. Lastly, models evolve and new models are being created constantly, as in the case of the very recent DeepSeek (DeepSeek-AI et al., 2025), launched on the week of the submission of this paper. Thus, methodologies like the one presented in this study, mostly based on the prompt rather than exactly on the basis model, are important to be pursued.

While this study focused on proprietary models (GPT-4 and Gemini), open-source alternatives like Mistral and LLaMA offer potential cost-effective solutions, though their performance on legal text simplification remains untested. Domain-specific improvements could be achieved through fine-tuning on Brazilian legal corpora or Retrieval-Augmented Generation (RAG) architectures to reduce omissions of critical legal concepts. The superior evaluation accuracy of GPT over Gemini (Table 5) may stem from architectural differences—GPT's reinforcement learning from human feedback (RLHF) appears better optimized for consistency with human judgments, whereas Gemini's strength in creative generation may compromise evaluation precision. Future work should investigate whether these performance gaps persist when models are specifically adapted to legal Portuguese and constrained by RAG systems.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Finally, the study focused on Portuguese-to-plain-Portuguese simplification, which poses unique challenges due to grammatical structures (e.g., complex verb conjugations) and untranslatable legal terms. While readability metrics were adapted for Portuguese, further research is needed to address cultural and linguistic nuances that AI models may overlook. These limitations highlight the need for hybrid human-AI workflows to ensure both accessibility and precision.

Future research should investigate AI consistency over time, incorporate qualitative methods like expert interviews, and develop hybrid evaluation frameworks combining AI and human judgment. Exploring domain-specific AI models, prompt engineering, and ethical implications, such as biases in multilingual contexts, could further refine AI's role in text evaluation. This study lays the groundwork for developing robust, fair, and adaptable AI-assisted evaluation frameworks.

6. Concluding Remarks

Enhancing the clarity of public documents to improve citizen comprehension is a global goa., moreover in the context of Brazil's redemocratization and the need for greater transparency in public administration, the 1988 Constitution established the right to access public information. However, the complexity of legal language, particularly in court documents, poses a significant barrier to understanding for the general public. This study aimed to address this issue by leveraging large language models to simplify legal texts from the Court of Accounts of Pernambuco into plain language, making them more accessible to individuals with a high school education level. The research sought to identify the most effective combination of prompt techniques and AI models for this task, while also evaluating the reliability of AI-based assessments of simplified texts.

The methodology involved generating 140 simplified versions of 14 preliminary decisions using two large language models (GPT and Gemini) and five prompt techniques (Tree of Thought, COSTAR, Zero Shot, One Shot, and Meta Prompting). These simplifications were evaluated using an 18-question questionnaire based on plain language principles, with scores generated by AI models and validated through human review. The study also analyzed readability metrics, omission rates, and audience suitability to assess the quality of the simplified texts.

For RQ01, which focused on identifying the most effective prompt techniques and AI models for simplifying legal texts, the results showed that Gemini with the Tree of Thought technique achieved the highest average score (67.64) based on responses to the plain language questionnaire, and produced the best simplified versions for four of the 14 decisions. However, GPT with the COSTAR technique also performed well, particularly in preserving essential information and achieving the highest readability scores (Flesch Reading Ease: 55.26), which was just below the plain language standard. Despite these successes, omissions of critical information were a common issue across all models, indicating the need for human oversight to ensure the integrity of the simplified texts.

For RQ02, which examined the effectiveness of AI models in evaluating plain language texts, the findings revealed that GPT outperformed Gemini in evaluation accuracy, with lower Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) compared to human evaluations. However, AI models tended to overestimate readability and comprehension, suggesting that while they can provide rapid preliminary assessments, human review remains essential for ensuring the quality and accuracy of simplified texts.

The study also highlighted the practical implications of using Large Language Models for text simplification in the public sector. By automating parts of the simplification process, governments can reduce costs and improve accessibility to legal and administrative documents. However, the findings emphasize the importance of a hybrid approach, combining AI-generated simplifications with human review to address limitations such as omissions and readability overestimations. This approach can enhance transparency and citizen participation in public administration, aligning with the goals of the Access to Information Law (LAI) and the Open Government Partnership (OGP).

The main contributions of this work include: (i) identifying the most effective prompt techniques and AI models for simplifying legal texts, (ii) demonstrating the potential and limitations of AI-based evaluations for plain language transformations, and (iii) proposing a hybrid evaluation framework that integrates AI-generated assessments with human oversight. These findings provide a foundation for future research on AI-assisted text simplification and evaluation in the public sector.

For future work, we recommend: (i) exploring domain-specific fine-tuning of open-source AI models to improve performance and reduce costs, (ii) conducting longitudinal studies to assess the consistency of AI evaluations over time, (iii) incorporating qualitative research methods to gain deeper insights into the strengths and limitations of AI-driven evaluations, and (iv) investigating the ethical and cultural implications of AI-based text simplification to ensure inclusivity and fairness. By addressing these areas, future research can develop more robust and reliable

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

tools for plain language transformation, ultimately enhancing public access to legal and administrative information.

References

Alves, A., Miranda, P., Mello, R., & Nascimento, A. (2023). *Automatic Simplification of Legal Texts in Portuguese Using Machine Learning*. https://doi.org/10.3233/FAIA230975

Alves, K., Santos, E., Silva, M. F., Chaves, A. C., Fernandes, J. A., Valenca, G., & Brito, K. (2024). Towards the regulation of Large Language Models (LLMs) and Generative AI use in the Brazilian Government: the case of a State Court of Accounts. *Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance*, 28–35. https://doi.org/10.1145/3680127.3680219

Andersen, T. B. (2009). E-Government as an anti-corruption strategy. *Information Economics and Policy*, *21*(3), 201–210. https://doi.org/10.1016/j.infoecopol.2008.11.003

APSC (Australian Public Service Comission). (2023). *Australian Government Style Manual*. https://www.stylemanual.gov.au/

Araújo, R. (2024, November 18). *JuLIA Explica: novo módulo da IA do TJ-PI simplifica o acesso a informações processuais | Tribunal de Justiça do Piauí*. https://www.tjpi.jus.br/portaltjpi/tjpi/noticias-tjpi/julia-explica-novo-modulo-da-ia-do-tj-pi-simplifica-o-acesso-a-informacoes-processuais/

Atricon recomenda que Tribunais de Contas adotem linguagem simples e direito visual – Atricon. (n.d.). Retrieved April 5, 2025, from https://atricon.org.br/atricon-recomenda-que-tribunais-de-contas-adotem-linguagem-simples-e-direito-visual/

Bandeira, G. (2024, March 22). *54,5% dos brasileiros têm formação básica completa, diz IBGE*. https://www.poder360.com.br/educacao/545-dos-brasileiros-tem-formacao-basica-completa-diz-pnad/

Belém, M. (2013). A simplificação da linguagem jur\’\idica como meio de aproximação do cidadão à justiça. *Revista Jur\’\idica Da Seção Judiciária de Pernambuco*, *6*, 313–320.

Chen, B., Zhang, Z., Langrené, N., & Zhu, S. (2024). *Unleashing the potential of prompt engineering in Large Language Models: a comprehensive review*. https://arxiv.org/abs/2310.14735

Constituição. (n.d.). Retrieved April 15, 2025, from https://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm

DeepSeek-AI, Guo, D., Yang, D., Zhang, H., Song, J., Zhang, R., Xu, R., Zhu, Q., Ma, S., Wang, P., Bi, X., Zhang, X., Yu, X., Wu, Y., Wu, Z. F., Gou, Z., Shao, Z., Li, Z., Gao, Z., … Zhang, Z. (2025). *DeepSeek-R1: Incentivizing Reasoning Capability in LLMs via Reinforcement Learning*. https://arxiv.org/abs/2501.12948

Devlin, J., Chang, M.-W., Lee, K., Google, K. T., & Language, A. I. (2019). BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding. *Proceedings of the 2019 Conference of the North*, 4171–4186. https://doi.org/10.18653/V1/N19-1423

Dyer, C., Fairbanks, J., Greiner, M., Barron, K., Skreen, J., Cerrillo-Ramirez, J., Lee, A., & Hinsee, B. (2013). Improving Access to Justice: Plain Language Family Law Court Forms in Washington State. *Seattle Journal for Social Justice*, *11*(3). https://digitalcommons.law.seattleu.edu/sjsj/vol11/iss3/10

Haman, M., & Školník, M. (2024). Using ChatGPT to conduct a literature review. *Accountability in Research*, *31*(8), 1244–1246. https://doi.org/10.1080/08989621.2023.2185514

Heerlijk Helder | Vlaanderen.be. (n.d.). Retrieved January 30, 2025, from https://www.vlaanderen.be/intern/werkplek/ondersteuning/heerlijk-helder

Klarspråk - Språkrådet. (n.d.). Retrieved January 30, 2025, from https://sprakradet.no/klarsprak/

Long, J. (2023). *Large Language Model Guided Tree-of-Thought*. https://arxiv.org/abs/2305.08291

Marques, N., Silva, R. R., & Bernardino, J. (2024). Using ChatGPT in Software Requirements Engineering: A Comprehensive Review. *Future Internet*, *16*(6), 180. https://doi.org/10.3390/fi16060180

Martínez, P., Ramos, A., & Moreno, L. (2024). Exploring Large Language Models to generate Easy to Read content. *Frontiers in Computer Science*, *6*. https://doi.org/10.3389/fcomp.2024.1394705

Mikolov, T., Chen, K., Corrado, G., & Dean, J. (2013). Efficient Estimation of Word Representations in

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Vector Space. *1st International Conference on Learning Representations, ICLR 2013 - Workshop Track Proceedings*. https://arxiv.org/abs/1301.3781v3

OpenAI. (n.d.). *GPT-4 Technical Report*.

Openai, A. R., Openai, K. N., Openai, T. S., & Openai, I. S. (n.d.). *Improving Language Understanding by Generative Pre-Training*. Retrieved April 15, 2025, from https://gluebenchmark.com/leaderboard

Ospina-Henao, V., Flórez, S. L., Núñez, V. J. M., Lamas, Ó. L., & De la Prieta, F. (2024). *Generative AI: Simplifying Text for Cognitive Impairments and Non-native Speakers* (pp. 33–44). https://doi.org/10.1007/978-3-031-73538-7_4

Papastratis, I., Konstantinidis, D., Daras, P., & Dimitropoulos, K. (2024). AI nutrition recommendation using a deep generative model and ChatGPT. *Scientific Reports*, *14*(1), 14620. https://doi.org/10.1038/s41598-024-65438-x

Petelin, R. (2010). Considering plain language: issues and initiatives. *Corporate Communications: An International Journal*, *15*(2), 205–216. https://doi.org/10.1108/13563281011037964

Peters, M., Neumann, M., Iyyer, M., Gardner, M., Clark, C., Lee, K., & Zettlemoyer, L. (2018). Deep Contextualized Word Representations. *Proceedings of the 2018 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long Papers)*, 2227–2237. https://doi.org/10.18653/v1/N18-1202

Plain language, accessibility, and inclusive communications - Privy Council Office - Canada.ca. (n.d.). Retrieved January 30, 2025, from https://www.canada.ca/en/treasury-board-secretariat/topics/government-communications/communications-community-office/communications-101-boot-camp-canadian-public-servants/plain-language-accessibility-inclusive-communications.html

Ray, P. P. (2023). ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope. *Internet of Things and Cyber-Physical Systems*, *3*, 121–154. https://doi.org/10.1016/j.iotcps.2023.04.003

Roedel, P. (2024). *Manual de Linguagem Simples* (Edições Câmara, Ed.).

Sahoo, P., Singh, A. K., Saha, S., Jain, V., Mondal, S., & Chadha, A. (2024). *A Systematic Survey of Prompt Engineering in Large Language Models: Techniques and Applications*. https://arxiv.org/abs/2402.07927

Silva, M., Santos, E., Alves, K., Silva, H., Pedrosa, F., Valença, G., & Brito, K. (2024). Using Generative AI for Simplifying Official Documents in the Public Accounts Domain. *Anais Do XII Workshop de Computação Aplicada Em Governo Eletrônico (WCGE 2024)*, 246–253. https://doi.org/10.5753/wcge.2024.2915

Uso de inteligência artificial aprimora processos internos no Tribunal de Contas da União – Notícias | Portal TCU. (n.d.). Retrieved April 16, 2025, from https://portal.tcu.gov.br/imprensa/noticias/uso-de-inteligencia-artificial-aprimora-processos-internos-no-tribunal-de-contas-da-uniao

Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., Kaiser, Ł., & Polosukhin, I. (2017). Attention Is All You Need. *Advances in Neural Information Processing Systems*, *2017-December*, 5999–6009. https://arxiv.org/abs/1706.03762v7

Zhang, Y., Yuan, Y., & Yao, A. C.-C. (2024). *Meta Prompting for AI Systems*. https://arxiv.org/abs/2311.11482

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Exploring generative AI effects on Korean civil servants' performance: Power and motivation

Sukwon Choi [a*], *Wookjoon* Sung [b], *Jooho* Lee [c]

[a] PhD Student, College of Public Affairs and Community Service, University of Nebraska at Omaha, Omaha, Nebraska, USA, sukwonchoi@unomaha.edu, 0009-0006-7943-9113

[b] Associate Professor, Graduate School of Public Policy and Information Technology, Seoul National University of Science and Technology, Seoul, South Korea, wjsung@seoultech.ac.kr

[c] Professor, School of Public Administration, University of Nebraska at Omaha, Omaha, Nebraska, USA, jooholee@unomaha.edu, 0000-0001-8425-3491

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. This study explores the factors influencing civil servants' perceptions of generative AI-assisted work performance, focusing on extrinsic and intrinsic motivations and the moderating role of organizational power, as measured by government level and organizational rank. Artificial Intelligence (AI) has emerged as one of the most influential technologies, driving transformation in both government and society. Generative AI, as a subfield of AI, has gained recognition for its capabilities to automate routine tasks, enhance decision-making, and improve work productivity. However, little is known about who perceives the positive effects of these tools on performance and why. Drawing on the notion that motivations affect work performance and the reinforcement politics model, this study analyzes survey data from 1,608 Korean civil servants collected by the Korean Institute of Public Administration (KIPA) in April 2023, when generative AI was still in its early stages of development. The survey targeted civil servants from central, provincial, and local governments to gauge their perspectives on generative AI-assisted work performance. This study employed partial least squares structural equation modeling (PLS-SEM), an appropriate method for predictive modeling and identifying key driving factors in complex relationships to investigate the connection between two types of motivation and perceived work performance. The findings reveal that extrinsic and intrinsic motivations positively influence perceived work performance, with intrinsic motivation having a more substantial effect. Also, extrinsic motivation significantly enhances intrinsic motivation, highlighting the dynamic interaction between the two constructs. However, the moderating effects of government level and organizational rank on the relationship between motivations and perceived work performance were not statistically significant. These results underscore the critical role of individual motivation in shaping perceptions of generative AI tools while suggesting that organizational power may play a less significant role in this context than previously anticipated. Theoretically, this study provides empirical evidence supporting the idea that motivations affect work performance by demonstrating the effectiveness of generative AI tools in public administration while challenging the reinforcement politics model. It challenges the foundational assumption of the model that organizational power makes a significant impact on the adoption and effectiveness of generative AI tools.

Keywords. Generative Artificial Intelligence, ChatGPT, Reinforcement Theory, Extrinsic Motivation, Intrinsic Motivation, Civil Servant
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1032

1. Introduction

Artificial Intelligence (AI) refers to "a cluster of technologies that enables machines to learn and autonomously solve cognitive problems without human intervention" (Madan & Ashok, 2022). AI has emerged as one of the most significant technologies, facilitating digital transformation in government and society. We expect it to significantly

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

transform the work environment, driving efficiency and innovation across various sectors (Boyd & Wilson, 2017). Generative AI, a subfield of AI, is "a computational technique capable of producing new and meaningful content, such as text, images, audio, video, and even computer code, from training data" (Feuerriegel et al., 2023). This technology serves as a transformative force that can potentially drive significant change. It replicates complex data distributions to generate outputs that closely resemble or surpass the quality of real-world data (Banh & Strobel, 2023; Lehmann & Buschek, 2020; Tomczak, 2024). Generative AI tools have been widely and rapidly diffused. Since its release in November 2022, ChatGPT has reached over 200 million weekly active users by August 2024, doubling its user base from the previous year. Its subscription-based service, ChatGPT Plus, serves approximately 10 million users (Backlinko, 2024).

Advocates claim that generative AI tools facilitate task performance by efficiently handling routine or resource-intensive activities (e.g., drafting and reviewing documents, analyzing data to identify patterns, and automating repetitive tasks like filing, scheduling, or data entry) (Brynjolfsson et al., 2023). These advantages allow individuals to focus on more highly valued activities—a benefit particularly significant for civil servants, who spend up to 30% of their time on paperwork and administrative duties (Gmyrek et al., 2023; Viechnicki & Eggers, 2017). Conversely, critics raise concerns about ethical and legal challenges, including the risk of producing inaccurate, biased, or irrelevant outputs, which could hinder their reliability and task performance (Bloch-Wehba, 2021; Bender et al., 2021). Despite these controversies and its early stages of development, some public administration scholars and government professionals have paid significant attention to its impact on the government (Wirtz et al., 2018; Salah et al., 2023). However, little is known about who perceives the positive effects of these tools on work performance and why, particularly in the context of the public sector.

Empirical studies on generative AI tools in public administration have been limited in recent years. Most research (Noonpakdee, 2024) primarily focuses on adoption as the technology remains in its early stages of development (Al Naqbi et al., 2024; Bright et al., 2024). These studies provide valuable insights into the government's adoption of technology. However, there is a limited understanding of how individuals, particularly government employees, perceive the benefits of their work performance and the factors that influence these perceptions. To address this gap, this study examines how civil servants' organizational power and extrinsic and intrinsic motivations influence their perceptions of generative AI-assisted work performance. It is important to note that adopting generative AI tools—without exploring their effectiveness—may not ensure meaningful implementation in the public sector. We draw on extrinsic and intrinsic motivations and the reinforcement politics model, as these frameworks provide complementary perspectives on how individual and organizational factors shape perceptions of work performance. By employing the partial least squares structural equation modeling (PLS-SEM), we analyze survey data from civil servants collected by the Korea Institute of Public Administration (KIPA) in April 2023, when generative AI tools were still in their early development stages. This survey targeted civil servants from the central, provincial, and local governments to evaluate their perspectives on generative AI-assisted work performance. By analyzing these relationships, this study provides theoretical insights into the adoption of generative AI and its impact on public administration and practical implications for effective implementation. These findings will assist policymakers and government officials in understanding the conditions under which generative AI tools enhance work performance.

The paper is organized as follows: Section 2 presents a literature review that examines generative AI tools and their impact on public administration. Section 3 outlines the theoretical framework, drawing on the two types of motivations and the reinforcement politics model to establish the foundation for the study's conceptual model and hypotheses. Section 4 represents the theoretical model and nine hypotheses. Section 5 describes the data collected by KIPA and details the dependent, independent, moderator, and control variables. Section 6 draws the results of the PLS-SEM, underscoring the significant effects of two types of motivations on perceived work performance and the non-significant moderating role of organizational power. Section 7 interprets the findings based on the results and discusses their theoretical and practical implications. Section 8 summarizes the core findings and recommends effectively implementing generative AI tools into public administration.

2. LITERATURE REVIEW

2.1 Generative AI Tools

AI encompasses a range of technologies that enable machines to learn and autonomously solve cognitive problems without human intervention (Madan & Ashok, 2022). It drives innovation across various sectors by using machine and deep learning to analyze data, identify patterns, and enhance decision-making independently (Brynjolfsson & Mitchell, 2017; Brynjolfsson et al., 2023). The McKinsey Global Institute predicts that AI will significantly improve productivity, leading to transformative shifts in workplace efficiency (Gaurav et al., 2018). Generative AI, a subfield of AI, refers to computational methods that can create new and meaningful content—like text, images, or audio—by learning patterns from existing training data (Feuerriegel et al., 2023). This technology acts as a transformative force that can drive significant change. The technology replicates complex data distributions to produce outputs that closely resemble or surpass real-world data quality (Lehmann & Buschek, 2020; Tomczak, 2024). By modeling high-dimensional probability distributions, it creates seemingly new samples that reflect the underlying structure

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of the original data (Ruthotto & Haber, 2021; Tomczak, 2024; Weisz et al., 2023). Unlike traditional AI systems that map input features to output labels, generative AI focuses on understanding data structures to generate new and meaningful content (Jebara, 2004).

Generative AI stands out because of its unique characteristics, setting it apart from many historical technological advancements, like the internet, which have primarily been driven by government-led initiatives (Goldman Sachs Global Institute, 2023). Conversely, its development and growth are dominated by a few tech companies, including OpenAI, Alphabet (Google), and Microsoft, which control digital platforms (Birch & Bronson, 2022). Traditional AI has become ubiquitous in powering advertising algorithms, content recommendations, and social media targeting, typically functioning behind the scenes on platforms like Apple's Siri, yet generative AI has brought its capabilities to the forefront, making its influence more visible and directly impactful. In their intermediary roles, Generative AI tools also resemble social media platforms, such as Facebook and X, connecting users with service providers within a platform economy driven by network effects (Wörsdörfer, 2022). As users and service providers increase, these platforms become increasingly attractive, fostering monopolistic dynamics and consolidating technological power structures (Jullien & Sand-Zantman, 2021; Sharon & Gellert, 2024). By February 2024, 23% of adults in the United States reportedly used OpenAI's ChatGPT, up from 18% in July 2023 (Backlinko, 2024). This indicates the rapid adoption and increasing reliance on generative AI tools, even in the workplace. The reliance has resulted in markets dominated by a handful of firms that wield unparalleled power and resources. These firms further centralize their authority and operate beyond the reach of traditional government-led governance. The changes in power dynamics raise critical questions about accountability (Khanal et al., 2024).

Moreover, many businesses are increasingly implementing generative AI tools in their workplaces, leveraging their ability to enhance productivity by combining human beings with machine computational power. The tools facilitate task automation, streamline workflows, and support decision-making (Nakavachara et al., 2024; Rana et al., 2024). Empirical studies (Budhwar et al., 2023; Goldstein, 2023; Fauzi et al., 2023; Kumar, 2024; Peng et al., 2023) have shown the significant impact of generative AI tools on work performance. For instance, Brynjolfsson et al. (2023) found that generative AI tools enhanced employee productivity by 14%, while Noy and Zhang (2023) reported a 40% decrease in task completion time for writing-intensive work. Similarly, Dell'Acqua et al. (2023) demonstrated that consultants from the Boston Consulting Group, a profession known for demanding workload, completed tasks 25% faster with generative AI tools, showcasing their efficiency in high-intensity environments. Even job seekers have benefited from AI-driven automation in resume writing and portfolio creation, which has increased efficiency and reduced costs (Malhotra et al., 2021). Despite certain drawbacks (De Cremer et al., 2023; Morshidi et al., 2023), most literature has underscored generative AI's performance benefits across sectors. However, there is a limited understanding of who perceives the positive effects of these tools on their work performance and why, particularly in the context of the public sector. To address the gap, this study explores how civil servants' organizational power, and their two types of motivations influence their perceptions of generative AI-assisted work performance.

2.2 Generative AI Tools in Public Administration

AI has advanced unprecedentedly, transforming various industries, reshaping daily life for citizens, and redefining interactions with emerging technologies like generative AI. These tools analyze patterns in existing datasets and generate seemingly new and meaningful content (Dasborough, 2023; Hadi et al., 2023). This rapid evolution drives significant changes in working environments, where generative AI enhances performance by automating routine tasks and facilitating idea generation (Androniceanu, 2024; Castro & New, 2016; Hoffmann et al., 2024; Wirtz et al., 2018). While the private sector has effectively leveraged these tools to streamline operations, reduce staffing needs, and lower costs (Rana et al., 2024), the government faces distinct challenges as it prioritizes the public interest and ensures equitable access to services over efficiency-driven outcomes (Council of the European Union, 2023).

Accountability and equity, foundational principles of public administration, present opportunities and challenges in adopting and implementing generative AI (Erkkilä, 2020). These tools enhance decision-making by efficiently processing large datasets, identifying patterns humans may overlook, and automating routine tasks such as filing, scheduling, or data entry. This enables civil servants to relieve themselves of simple administrative burdens, such as drafting and reviewing documents, and focus more on highly valued activities and strategic priorities, fostering greater accountability and responsiveness to citizens' needs (Salah et al., 2023). However, their "black box" nature and lack of transparency in reasoning raise significant accountability concerns, as even software developers do not fully comprehend how these algorithms function (Bloch-Wehba, 2021; Radford et al., 2019). Equity challenges also emerge due to biases embedded in the training datasets of generative AI tools, often derived from culturally narrow, predominantly English internet sources. Such biases hinder fairness and exacerbate systemic disparities, affecting marginalized groups disproportionately (Bender et al., 2021; Faisal et al., 2021; Schramowski et al., 2023).

Despite challenges such as algorithmic bias, data privacy risks, and environmental concerns related to high energy consumption, generative AI has gained widespread adoption in the public sector, especially among civil servants, due to its ability to enhance efficiency and foster innovation (Bright et al., 2024). Civil servants, who allocate up to 30% of their time to paperwork and administrative duties, can utilize automation to focus more on higher-value

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

activities and strategic priorities (Gmyrek et al., 2023; Viechnicki & Eggers, 2017). Like its transformative effect on other industries, generative AI has the potential to reshape public-sector operations, fundamentally redefining the roles and responsibilities of civil servants (Criado et al., 2020). The Boston Consulting Group (2024) also indicates that this technology could result in annual productivity improvements estimated at $1.75 trillion globally across all levels of government by 2033. Moreover, generative AI assists in policy development, decision-making, public service delivery, and citizen engagement, significantly transforming public administration and redefining the roles of civil servants (Salah et al., 2023). As governments encounter increasing pressure to transition to a digital society, the potential of generative AI is becoming clear in its ability to boost administrative efficiency, promote equitable and impactful public services, and provide vital support to less experienced and entry-level workers (Bright et al., 2024; Brynjolfsson et al., 2023).

Empirical studies on generative AI tools in public administration have been limited in recent years. Most research (Noonpakdee, 2024) focuses on adoption as the technology remains in its early development stages (Al Naqbi et al., 2024; Bright et al., 2024). These studies provide valuable insights into the government's adoption of technology. However, there is a limited understanding of how individuals perceive the benefits of their work performance and the factors that shape these perceptions. To address the gap, this study examines how civil servants' organizational power, and two types of motivations influence their perceptions of generative AI-assisted work performance. It is important to note that simply adopting generative AI tools—without exploring its effectiveness—may not ensure meaningful implementation in the public sector. Therefore, we draw on the extrinsic and intrinsic motivations and the reinforcement politics model as these frameworks provide complementary perspectives on how individual and organizational factors shape perceptions of work performance.

3. THEORETICAL FRAMEWORK

3.1 Motivation in Work Performance

Motivation in the workplace is crucial for clarifying differences in an employee's work performance. Motivation is an internal force that energizes, directs, and sustains behavior over time (Diefendorff & Chandler, 2011). Intrinsic motivation stems from a genuine interest in or enjoyment of an activity. It is linked to high-quality performance and improved employee well-being, even when applied to specific tasks (Ryan & Deci, 2000). Hawthorne studies (Mayo, 1949; Landsberger, 1968) suggested that work conditions can influence productivity, drawing attention to organizational psychological and social dynamics. These findings facilitated the development of core theories like Maslow's Hierarchy of Needs (1943), suggesting that employees are motivated to fulfill a sequence of needs, and Herzberg's Two-Factor Theory (1959), which differentiated between hygiene factors that prevent dissatisfaction and motivators that promote satisfaction. While these theories have faced methodological critiques (Hackman & Oldham, 1976), they laid the groundwork for understanding how external and internal motivations interact in the workplace. While motivation theories often emphasize intrinsic factors, extrinsic rewards are still important—particularly for attracting and retaining talent. Extrinsic motivation, influenced by external reward or pressure, is often effective in achieving short-term goals and meeting organizational expectations. A reward system combining material and psychological incentives has been shown to enhance employee satisfaction and performance, aligning each value and task goal (Gagné & Deci, 2005).

Maslow's Hierarchy of needs suggests that once fundamental needs are satisfied, psychological needs become more powerful motivators in the workplace than basic physiological ones. Employees pursue fulfillment by striving for higher-level needs like esteem and self-actualization. Similarly, Herzberg (1959) suggested that although monetary compensation can initially motivate employees, its effectiveness diminishes over time, redirecting the motivational focus toward psychological and social factors. In this context, McGregor (2002) reinforced this perspective through Theory Y, which emphasizes intrinsic motivations in contrast to the extrinsic motivations highlighted in Theory X. Nevertheless, extrinsic motivation remains a fundamental motivational tool for motivating employees, particularly in attracting and retaining talent, and it is embedded in many performance-based incentive systems (Taylor, 1919; Bishop, 1987). Some scholars often study two types of motivations to understand their impact on employee work performance (Moran et al., 2012).

Recent empirical studies (Baard et al., 2004; Rhoades & Eisenberger, 2002; Moran et al., 2012; Van den Broeck et al., 2016) have emphasized the key role of motivation in improving workplace performance. Motivation is generally divided into extrinsic and intrinsic types, with each playing a unique role in employee engagement and productivity (Deci et al., 2001). Intrinsic motivators, such as knowledge, accomplishment, and stimulation, significantly enhance employee engagement and task performance (Weinberg & Gould, 2023; Amabile et al., 1994). Similarly, Chintalloo and Mahadeo (2013) and Khan et al. (2014) observed that two types of motivations drive higher work performance, while Abdullatif (2016) mentioned that extrinsic factors provide a foundation for motivation and intrinsic factors, intrinsic motivation positively influencing employee performance. Although motivation has been widely studied concerning workplace performance across sectors, limited research has investigated who perceives the benefits of adopting emerging technologies, why, and what factors shape this perception—especially within the public sector. To address this gap, this study explores how civil servants' organizational power and motivational factors influence

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

their perceptions of generative AI-assisted work performance. Furthermore, given the structural characteristics of public organizations—often more bureaucratic and centralized than their private-sector counterparts and focused on public interest (Perry & Rainey, 1988)—this study provides valuable insights into how two types of motivations influence employee performance in the context of advanced technology adoption.

3.2 Reinforcement Politics Model

Reinforcement politics model (Kraemer & Dedrick, 1997; Kraemer & King, 1986; Kraemer & King, 2006) provides a framework for understanding how the impact of computing technologies—such as mainframe computers in the 1980s and early 1990s and later e-government technologies—was significantly shaped by individuals in positions of power within government organization. Organizational power, defined as the authority to make decisions within a hierarchical structure (Pinsonneault & Kraemer, 1993), enables these individuals to influence the adoption and implementation of technologies in ways that reinforce existing power dynamics (Pinsonneault & Kraemer, 1997). Technologies play a key role in shaping how control over information is exercised, with information becoming a critical resource of power in decision-making. While information is not inherently powerful, those with access to and control of it can influence decisions and maintain authority in bureaucratic structures (Kraemer & King, 1986). Emerging technologies have the potential to either centralize or decentralize access to information, yet their actual use often reflects and reinforces pre-existing hierarchies. Furthermore, the allocation of critical resources, such as budgets and technical infrastructure, is typically managed by senior civil servants, further consolidating the power.

According to the reinforcement politics model, civil servants with organizational power are more likely to perceive greater benefits from supporting the adoption of generative AI tools. However, during the early stages of adopting and diffusing emerging technologies within government organizations, these individuals might face uncertainties surrounding implementation. Such uncertainties challenge the assumption that technological innovations serve the interests of those in power or reinforce existing hierarchies (Lee, 2008). Emerging technologies can disrupt established workflows, raise concerns about operational reliability, and complicate the process of decision-making. Bureaucrats used to traditional systems may resist adoption due to concerns about transparency, effectiveness, or the potential erosion of their authority. This resistance is often driven by a desire to maintain institutional stability, particularly when technological governance frameworks are designed to protect the interests of those already in power. In contrast, individuals with less organizational power may regard emerging technologies as opportunities to challenge the status quo. By acquiring specialized expertise and leveraging emerging tools to influence decision-making processes, individuals can reposition themselves as valuable contributors, potentially shifting the balance of authority and redefining organizational roles.

In recent years, several empirical studies (Burkhardt & Brass, 1990; Heintze & Bretschneider, 2000; Jasperson et al., 2002) have examined the political dynamics surrounding technology adoption, emphasizing that the success of emerging technologies depends not only on their technical features but also on organizational power structures and individuals' adaptability to change. Kraemer and King (1986) suggested that computing technologies will likely reinforce existing organizational arrangements: individuals favoring centralization use information technologies to strengthen control, while those advocating for decentralization employ them to promote autonomy. Similarly, Chelmis and Prasanna (2013) suggested that managers are more effective than peer pressure in encouraging the adoption of emerging microblogging platforms among their employees. However, Lee (2008) observed that lower-ranking civil servants in Korea were among the early adopters of electronic approval systems (EAS), suggesting that resistance to technological innovation—particularly in its early developmental stages—often originates from entrenched power hierarchies and concerns over potential threats to established roles. Lee's study also noted that high-ranking officials in the central government adopted such technologies more readily than their counterparts in local government. While much of the existing literature argues that adopting information technology influences organizational dynamics, relatively little research has investigated who perceives these tools as beneficial to their work performance and why, especially within the public sector. Heintze and Bretschneider (2000) are among the few scholars who suggest that the adoption of information technology may have a limited impact on organizational dynamics but can directly improve performance. To address this gap, this study examines how the organizational power of civil servants, alongside their extrinsic and intrinsic motivations, shapes their perceptions of generative AI-assisted work performance.

4. THEORETICAL MODEL & HYPOTHESIS

In Figure 1, the conceptual model demonstrates the relationships between two types of motivations and perceived work performance, with organizational power, as indicated by government level and organizational rank—acting as moderating factors. H1 assumes a relationship between extrinsic motivation and perceived work performance, whereas H3 posits that extrinsic motivation influences intrinsic motivation. Both extrinsic and intrinsic motivation were hypothesized to independently affect perceived performance (H1 and H2, respectively). The moderating role of organizational power was examined at the government level (H5a and H6a) and organizational rank (H5b and H6b), which may either strengthen or weaken these motivational effects. Additionally, H4a and H4b investigated the direct effects of government level and organizational rank on perceived work performance. Collectively, this

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

model provides a comprehensive framework for understanding how two types of motivations and organizational power dynamics influence perceived work performance.

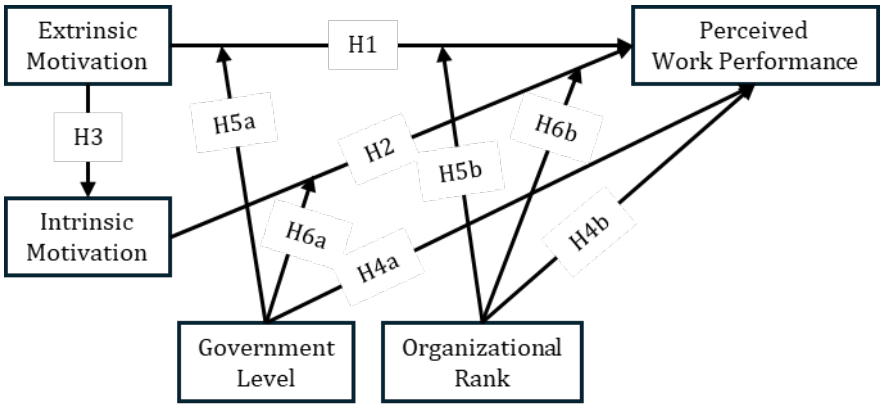


Fig. 1 – Research Model

H1: Civil servants with stronger extrinsic motivation are more likely to perceive improved work performance when utilizing generative AI tools than those with weaker extrinsic motivation

H2: Civil servants with stronger intrinsic motivation are more likely to perceive improved work performance when utilizing generative AI tools than those with weaker intrinsic motivation

H3: Civil servants' extrinsic motivation positively influences their intrinsic motivation when utilizing generative AI tools

H4a: Civil servants at higher levels of government are more likely to perceive improved work performance when utilizing generative AI tools than those at lower levels

H4b: Civil servants in higher organizational ranks are more likely to perceive improved work performance when utilizing generative AI tools than those in lower organizational ranks

H5a: Government level moderates the relationship between extrinsic motivation and perceived work performance when utilizing generative AI tools, such that the positive relationship is stronger for civil servants at higher levels of government

H5b: Organizational rank moderates the relationship between extrinsic motivation and perceived work performance when utilizing generative AI tools, such that the positive relationship is stronger for civil servants in higher organizational ranks

H6a: Government level moderates the relationship between intrinsic motivation and perceived work performance when utilizing generative AI tools, such that the positive relationship is stronger for civil servants at higher levels of government

H6b: Organizational rank moderates the relationship between intrinsic motivation and perceived work performance when utilizing generative AI tools, such that the positive relationship is stronger for civil servants in higher organizational ranks

5. METHODOLOGY

5.1 Data

This study utilized survey data collected by KIPA in April 2023 to test nine hypotheses. The survey targeted Korean civil servants from central, provincial, and local governments to explore their perceptions of generative AI-assisted work performance. The questionnaire consisted of five sections: (1) general perceptions of generative AI, (2) user experiences in work-related contexts, (3) perspectives of non-users, (4) views on adopting generative AI tools in government affairs, and (5) demographic information. The survey was not explicitly designed for the study; only a subset of relevant items was analyzed. Each questionnaire was translated from Korean to English using ChatGPT.

A total of 1,608 responses were collected using a Computer-Assisted Web Interviewing (CAWI) system between April 21 and April 27, 2023, when generative AI was still in its early stages of development. The participants were

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

recruited by various channels, including an official cooperation letter from the Ministry of the Interior and Safety (MOIS), banners, and online panels, ensuring voluntary participation. The survey was conducted by Next Research and commissioned by KIPA. Among the respondents, 545 were from the central government, 416 from provincial governments, and 647 from local governments. The respondents included civil servants from a wide range of roles, ranging from rank three (senior officials) to rank nine (entry-level positions) within the Korean civil service system, with lower rank numbers indicating higher positions. At the time of the survey, generative AI tools were optional, with decisions left to individual discretion. Table 1 represents the demographic characteristics of the participants, such as gender, age, government level, and organizational rank.

Tab. 1 – Demographic Characteristics of the Participants

Demographics	*Category*	*Subjects (N = 1,608)*	
		Frequency	*Percentage*
Gender	Male	801	49.8
	Female	807	50.2
Age	20s	211	13.1
	30s	601	37.4
	40s	500	31.1
	50s	287	17.8
	60s and above	9	0.6
Government Level	Central	545	33.9
	Provincial	416	25.9
	Local	647	40.2
Organizational Rank	Rank 3 or above	6	0.4
	Rank 4	33	2.1
	Rank 5	165	10.3
	Rank 6	359	22.3
	Rank 7	487	30.3
	Rank 8	304	18.9
	Rank 9	254	15.8

5.2 Measurement

Dependent Variable

The study's dependent variable is perceived work performance, a latent construct evaluated utilizing the PLS-SEM method. Perceived work performance reflects employees' subjective evaluations of productivity, effectiveness, and quality of contribution (Deci & Ryan, 1985; Ryan & Deci, 2000). Initially, an item inquired where respondents had utilized generative AI tools in their work; however, it was excluded because of low Cronbach's alpha and composite reliability. Instead, it was measured using an item that evaluated how participants perceived the effectiveness of generative AI tools across five dimensions: reducing workload, improving work efficiency, generating new ideas, enhancing the quality of work outputs, and increasing client or stakeholder satisfaction. The item used a five-point Likert scale: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. This approach offered a more robust measurement of participants' perceptions of work performance.

Independent Variable

The independent variables consist of two types of motivations: extrinsic and intrinsic. Extrinsic motivation, driven by external rewards or pressures, effectively achieves short-term goals and meets organizational expectations. In contrast, intrinsic motivation, derived from internal satisfaction and genuine interest in tasks, promotes creativity, problem-solving, and long-term commitment (Gagné & Deci, 2005). Extrinsic motivation was measured across two dimensions: superior directives and expectations of improved performance evaluations. However, the former was excluded due to low Cronbach's alpha and composite reliability. Therefore, extrinsic motivation was only assessed using the expectations of improved performance evaluations. Intrinsic motivation was also measured across two dimensions: capturing enjoyment and interest in using generative AI tools at work. As with the dependent variable, participants' responses were recorded on a five-point Likert scale. This refined approach ensured a more reliable

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

assessment of the independent variables.

Moderator

The moderators represent the government levels and organizational ranks. Organizational power, or the authority to make decisions within a hierarchy, is commonly measured through the levels of government and organizational rank (Pinsonneault & Kraemer, 1993). Initially, organizational power was conceptualized as a single moderator; it was divided into two constructs after Cronbach's alpha and composite reliability fell below acceptable thresholds, indicating insufficient reliability. Government level was coded as central government (1), provincial government (2), and local government (3), demonstrating a hierarchy from higher to lower governance levels. Organizational rank reflects the civil system hierarchy in Korea, with ranks ranging from nine (1) to three or above (7), indicating a progression from lower to higher ranks. This study ensured the reliability and validity of organizational power as a moderating variable by treating government level and organizational rank as distinct constructs.

Control Variable

The control variables are gender and age. Gender was determined based on participants' responses. The item was pre-coded in the dataset as male (1) or female (2). Age was reported by respondents and categorized into groups on an ordinal scale: 20s (2), 30s (3), 40s (4), 50s (5), and 60s and above (6), indicating a progression from younger to older. This coding improved clarity and consistency in analyzing demographic controls.

5.3 Estimation Model

This study utilized the PLS-SEM model using Smart PLS 4.0 software (Ringle et al., 2015). This model is especially effective for predictive models and identifying key driving factors in complex relationships (Hair et al., 2011). This study utilized a sample of civil servants from central, provincial, and local governments to examine perceptions of generative AI-assisted work performance. These perceptions are influenced by extrinsic and intrinsic motivations, with organizational power measured by government level and organizational rank as moderating factors. In Korea, emerging technologies have historically been promoted and implemented mainly by the central government, while provincial and local governments tend to adopt these technologies at later stages (Lee, 2008). This gap highlights the potential role of organizational power in influencing civil servants' motivation to utilize generative AI tools. To analyze these dynamics, PLS was used to evaluate the relationships between motivation types and perceived work performance while considering the moderating effects of organizational power.

6. RESULTS

6.1 Measurement Model

Cronbach's alpha and composite reliability (CR) were calculated to assess reliability, and both values exceeded the recommended threshold of 0.7, as suggested by Hair et al. (2019) (Table 2). Factor loadings were well above 0.708, and the Average Variance Extracted (AVE) exceeded 0.5, indicating strong convergent validity (Bagozzi et al., 1991; Hair & Alamer, 2022). Discriminant validity was evaluated using two established criteria. First, the square root of the AVE for each construct was greater than its correlations with other constructs, satisfying Fornell and Larcker's (1981) criteria (Table 3). Additionally, the Heterotrait-Monotrait (HTMT) ratio of correlations was analyzed, with all constructs falling below the recommended threshold of 0.85 (Henseler et al., 2015) (Table 4). The results tested the measurement model's reliability and validity.

Tab. 2 – Reliability and Validity

Construct	*Item*	*Mean*	*Standard deviation*	*Factor loading*	*Cronbach's alpha*	*CR (rho_a)*	*CR (rho_c)*	*AVE*
Extrinsic Motivation	Q9-2	2.676	.599	1				
Intrinsic Motivation	Q9-3	3.788	.459	.913	.827	.837	.920	.852
	Q9-4	3.891	.406	.933				
Government Level	SQ4	2.063	.859	1				
Organizational Rank	Q22	3.000	1.303	1				

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Gender	Q21	.502	.500	1				
Age	SQ1	3.553	.949	1				
Work Performance	Q7-1	3.679	.450	.832	.882	.886	.914	.681
	Q7-2	3.825	.428	.822				
	Q7-3	3.692	.434	.745				
	Q7-4	3.708	.430	.867				
	Q7-5	3.565	.453	.855				

Tab. 3 – Fornell-Larcker Scale Results

	Constructs	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1	Extrinsic Motivation	1						
2	Intrinsic Motivation	.179	.923					
3	Government Level	-.008	.005	1				
4	Organizational Rank	-.036	-.036	-.227	1			
5	Gender	-.013	-.007	.126	-.139	1		
6	Age	-.012	-.031	-.064	.597	-.184	1	
7	Work Performance	.231	.440	.028	-.043	-.068	-.032	.825

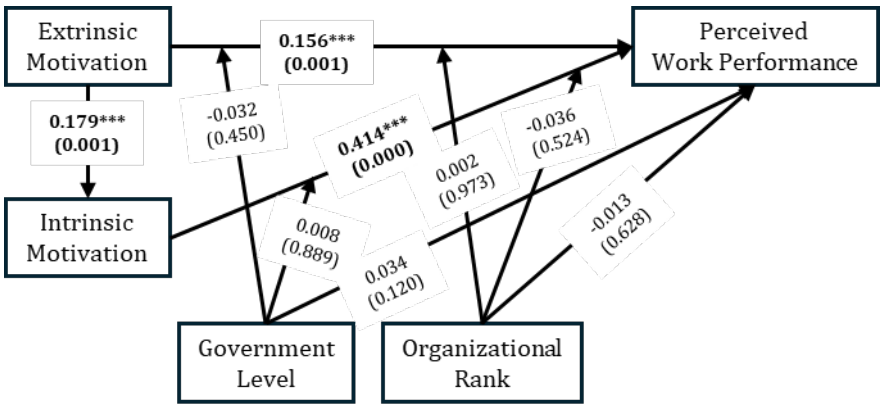
Tab. 4 – HTMT Ratio

	Constructs	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1	Extrinsic Motivation							
2	Intrinsic Motivation	.201						
3	Government Level	.008	.005					
4	Organizational Rank	.036	.038	.227				
5	Gender	.013	.007	.126	.139			
6	Age	.012	.033	.064	.597	.184		
7	Work Performance	.246	.510	.031	.046	.073	.034	

6.2 Structural Model

A bootstrap resampling method with 1,608 resamples was employed to evaluate the structural models. The results indicate that extrinsic motivation significantly positively affects perceived work performance ($\beta = .155$, $p < .05$), supporting H1. In addition, extrinsic motivation positively affects intrinsic motivation ($\beta = .179$, $p < .05$), supporting H3. Intrinsic motivation significantly influences perceived work performance ($\beta = .414$, $p < .05$), supporting H2. In contrast, government level ($\beta = .034$, $p > .05$) and organizational rank ($\beta = -.013$, $p > .05$) do not significantly affect perceived work performance, indicating that H4a and H4b are not supported. Furthermore, the moderating effects of government level and organizational rank on the relationship between extrinsic motivation and perceived work performance are not statistically significant (H5a: $\beta = -.032$, $p > .05$; H5b: $\beta = .002$, $p > .05$). Also, their moderating effects on the relationship between intrinsic motivation and perceived work performance are not significant (H6a: $\beta = .008$, $p > .05$; H6b: $\beta = -.036$, $p > .05$). Lastly, the model accounted for 23% of the variance in perceived workplace performance. Figure 2 presents a structural model summarizing the PLS-SEM results.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



*p<.1. **p<.05. ***p<.01.

Fig. 2 – PLS-SEM Results

7. DISCUSSION

7.1 Theoretical Implications

This study provides empirical evidence supporting the idea that motivation affects work performance by showing the effectiveness of generative AI tools in public administration but challenging the reinforcement politics model regarding organizational power dynamics in technology adoption. This underscores the essential role of intrinsic motivation among civil servants in enhancing their perceived work performance when utilizing generative AI tools. Civil servants who enjoy these tools are likelier to perceive enhanced productivity and efficiency. Additionally, the positive relationship between the two types of motivation suggests that external incentives, such as recognition or improved evaluations, can enhance intrinsic motivation under certain conditions. However, this study challenges the basic assumption of the reinforcement politics model that organizational power dynamics significantly impact the adoption and effectiveness of new technologies. Contrary to expectations, organizational power did not directly impact perceived work performance or strengthen the relationship between two types of motivation and perceived work performance. This discrepancy may arise from how generative AI tools and computing technologies were developed. Information technologies have primarily been driven by government-led initiatives, which have made them compatible with government affairs (Goldman Sachs Global Institute, 2023). In contrast, generative AI has been primarily developed and advanced by a few major tech companies (Birch & Bronson, 2022). Furthermore, since the data was collected when the generative AI tool was still in its early development stages, its compatibility with government functions may not have been fully recognized.

7.2 Practical Implications

This study underscores the practical implications for the government as it aims to adopt and implement generative AI tools in the workplace. To enhance civil servants' intrinsic motivation, the government is introducing training programs demonstrating how these tools can streamline workflows, improve decision-making, and facilitate work productivity. Drawing on Singapore and Iceland, fostering an environment that encourages curiosity, innovation, and active participation is essential for maximizing the benefits and value of these technologies. The public sector faces high employee turnover, with many civil servants shifting to the private sector for more competitive salaries (Ciobanu & Androniceanu, 2015). The Korean civil service system has historically been rigid and based on seniority. Despite recent efforts to incorporate performance-based approaches, it still lags the private sector (Kim, 2005; Kim, 2014). Given this structure, automating administrative tasks with generative AI tools can help civil servants focus more on high-value activities and strategic priorities (Viechnicki & Eggers, 2017). Kim and Chung (2021) suggests that information technologies such as big data and cloud computing have had little impact on improving efficiency at the organizational level within Korean government institutions. However, this study emphasizes the need for a supportive infrastructure that facilitates the adoption of generative AI tools, as motivation—particularly extrinsic incentives—plays a crucial role in shaping individual perceptions of work performance. To leverage these tools in addressing public sector challenges, the government implements thoughtfully designed incentives encouraging adoption among civil servants. Moreover, aligning these incentives with external rewards, professional aspirations, and public service value is vital for ensuring long-term adoption and meaningful impact.

7.3 Limitations and Future Research

This study had several limitations. It relied solely on cross-sectional data collected through the CAWI system, which may introduce self-selection bias due to open participation via a publicly accessible government agency website. While utilizing a government platform helps mitigate this risk—since it is less accessible than commercial search engines like Google and Bing—there remains the possibility that individuals who are not government employees may misrepresent themselves as civil servants. Moreover, the data were collected in April 2023, when generative

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

AI was still in its early development stages. Consequently, the findings may not align with the current technological landscape or accurately reflect the evolving capabilities of generative AI. Methodologically, this study encountered limitations in its measurement model, as some latent variables were represented by fewer than the recommended three indicators, potentially affecting the robustness and reliability of the measurements. However, since the data were collected by KIPA rather than specifically for this study, it relied on a limited number of indicators for certain constructs due to data constraints. To address the issues, we employ PLS-SEM, which is well-suited for models with fewer indicators and complex relationships. By maximizing explained variance and enabling flexible modeling of latent constructs, PLS-SEM helped mitigate measurement limitations and enhance the validity of the results (Hair et al., 2017). Lastly, this study only focused on the Korean public sector, which may restrict the applicability of its findings to other contexts.

Future research should adopt a longitudinal approach to track changes over time to address the above limitations, providing a comprehensive understanding of how perceptions of generative AI-assisted work performance evolve. Expanding the scope beyond Korea by conducting comparative studies in various cultural and institutional settings could further enhance the applicability of the findings. Such studies would provide deeper insights into potential motivations and variations in organizational power dynamics, enabling a better understanding of how generative AI influences public sector performance across different governance structures and policy environments. Finally, additional indicators for each latent variable in future models would enhance the measurement's precision and reliability, leading to more robust and generalizable conclusions.

8. CONCLUSION

This study examines the factors influencing civil servants' perceptions of generative AI-assisted work performance, focusing on two types of motivations and the moderating effects of organizational power. The findings reveal that both types of motivation positively influence perceived work performance, with intrinsic motivation having a more significant impact. Furthermore, extrinsic motivation significantly enhances intrinsic motivation, underscoring the dynamic interplay between these two motivational constructs. However, contrary to expectations, organizational power—assessed by government levels and organizational ranks—did not significantly moderate the relationship between motivations and work performance. This indicates that traditional power structures have less influence on government adoption and its effects than earlier technological advancements.

Theoretically, this study empirically supports the idea that motivation affects work performance by demonstrating the effectiveness of generative AI tools in public administration while challenging the reinforcement politics model regarding organizational power dynamics in technology adoption. Intrinsic motivation plays a crucial role in civil servants' perceived work performance when utilizing generative AI tools, and external incentives can significantly enhance intrinsic motivation. However, organizational power did not directly impact perceived work performance. Practically, the government should boost motivation through training programs that promote curiosity, creativity, and problem-solving, fostering an innovation-friendly environment while using automation to enable greater focus on high-value activities and strategic priorities. Additionally, aligning external incentives with public service values and professional aspirations is essential for ensuring long-term adoption and maximizing the impact of generative AI in the public sector.

Despite its contributions, this study has several limitations. It relies on cross-sectional data collected via the CAWI system, which may introduce self-selection bias since a government website facilitated participation. While using a government platform mitigates their risk, non-civil servants still can misrepresent their identities. Additionally, data were collected in April 2023, when generative AI was still in its early development stages, meaning that the findings may not reflect its current capabilities. Methodologically, some latent variables were measured with fewer than the recommended three indicators due to data constraints; however, PLS-SEM was used to address this issue and enhance model validity. The study focuses on the Korean public sector, which limits its generalizability to other contexts. Future research should utilize a longitudinal approach to monitor the evolving perceptions of AI-assisted work performance, broaden its scope to encompass various cultural and institutional settings, and integrate more indicators to enhance measurement precision and model reliability.

Acknowledgement

- **Funding or Grant** (if applicable)**:** N/A
- **Data/Software Access Statement** (if applicable): N/A
- **Contributor Statement***: The authors contributed to this work as follows: Wookjoon Sung was responsible for conceptualization and theoretical framing. Sukwon Choi managed the data, conducted the analysis, and contributed to both the methodology's design and the interpretation of results. Jooho Lee collaborated on interpreting results and focused on refining the manuscript by enhancing clarity, coherence, and structure through writing and revisions. All authors reviewed and approved the final manuscript.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **Use of AI***: During the preparation of this work, Sukwon Choi utilized ChatGPT to assist with editing, proofreading, and grammar refinement. This tool was used solely to enhance the clarity and readability of the manuscript without generating original ideas or contributing to the research content. Following its use, Wookjoon Sung and Jooho Lee carefully reviewed and revised the final text to ensure its accuracy, coherence, and originality. The authors take full responsibility for the integrity and quality of the published work.
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Abdullatif, T. N., bt Johari, H., & bt Adnan, Z. (2016). The influence of extrinsic motivation on innovative work behaviour with moderating role of quality culture. *Journal of Business and Social Review in Emerging Economies*, *2*(1), 79-86. https://doi.org/10.26710/jbsee.v2i1.21

Al Naqbi, H., Bahroun, Z., & Ahmed, V. (2024). Enhancing work productivity through generative artificial intelligence: A comprehensive literature review. *Sustainability*, *16*(3), 1166. https://doi.org/10.3390/su16031166

Amabile, T. M., Hill, K. G., Hennessey, B. A., & Tighe, E. M. (1994). The Work Preference Inventory: Assessing intrinsic and extrinsic motivational orientations. *Journal of Personality and Social Psychology, 66*(5), 950–967. https://doi.org/10.1037/0022-3514.66.5.950

Androniceanu, A. (2024). Generative artificial intelligence, present and perspectives in public administration. *Administration & Public Management Review*, (43). https://doi.org/10.24818/amp/2024.43-06

Baard, P. P., Deci, E. L., & Ryan, R. M. (2004). Intrinsic need satisfaction: a motivational basis of performance and well-being in two work settings 1. *Journal of Applied Social Psychology*, *34*(10), 2045-2068. https://doi.org/10.1111/j.1559-1816.2004.tb02690.x

Backlinko. (2024). ChatGPT stats: Usage, adoption trends, and key facts. Retrieved November 28, 2024, from https://backlinko.com/chatgpt-stats

Bagozzi, R. P., Yi, Y., & Phillips, L. W. (1991). Assessing construct validity in organizational research. *Administrative Science Quarterly*, 421-458. https://doi.org/10.2307/2393203

Banh, L., & Strobel, G. (2023). Generative artificial intelligence. *Electronic Markets*, *33*(1), 63. https://doi.org/10.1007/s12525-023-00680-1

Bender, E. M., Gebru, T., McMillan-Major, A., & Shmitchell, S. (2021, March). On the dangers of stochastic parrots: Can language models be too big? 🦜 . In *Proceedings of the 2021 ACM conference on fairness, accountability, and transparency* (pp. 610-623). https://doi.org/10.1145/3442188.3445922

Birch, K., & Bronson, K. (2022). Big tech. *Science as Culture*, *31*(1), 1-14. https://doi.org/10.1080/09505431.2022.2036118

Bishop, J. (1987). The recognition and reward of employee performance. *Journal of Labor Economics*, *5*(4, Part 2), S36-S56. https://doi.org/10.1086/298164

Bloch-Wehba, H. (2021). Transparency's AI problem. Knight First Amendment Institute. Retrieved December 31, 2024, from https://knightcolumbia.org/content/transparencys-ai-problem

Boston Consulting Group, (2024). Generative AI for the Public Sector: The Journey to Scale. Retrieved January 8, 2025, from https://www.bcg.com/publications/2024/gen-ai-journey-to-scale-in-government

Boyd, M., & Wilson, N. (2017). Rapid developments in artificial intelligence: How might the New Zealand government respond?. *Policy Quarterly*, *13*(4). https://doi.org/10.26686/pq.v13i4.4619

Bright, J., Enock, F. E., Esnaashari, S., Francis, J., Hashem, Y., & Morgan, D. (2024). Generative AI is already widespread in the public sector. *arXiv preprint arXiv:2401.01291*. https://doi.org/10.48550/arXiv.2401.01291

Brynjolfsson, E., & Mitchell, T. (2017). What can machine learning do? Workforce implications. *Science*, *358*(6370), 1530-1534. https://doi.org/10.1126/science.aap8062

Brynjolfsson, E., Li, D., & Raymond, L. (2023). Generative AI at Work. *National Bureau of Economic Research Working Paper No. 31161.* https://doi.org/10.3386/w31161

Budhwar, P., Chowdhury, S., Wood, G., Aguinis, H., Bamber, G. J., Beltran, J. R., ... & Varma, A. (2023). Human resource management in the age of generative artificial intelligence: Perspectives and research directions on ChatGPT. *Human Resource Management Journal*, *33*(3), 606-659. https://doi.org/10.1111/1748-8583.12524

Burkhardt, M. E., & Brass, D. J. (1990). Changing patterns or patterns of change: The effects of a change in technology on social network structure and power. *Administrative Science Quarterly*, 104-127. https://doi.org/10.2307/2393552

Castro, D., & New, J. (2016). The promise of artificial intelligence. *Center for Data Innovation*, *115*(10), 32-35. Retrieved June 8, 2018, from http://www2.datainnovation.org/2016-promise-of-ai.pdf

Chelmis, C., & Prasanna, V. K. (2013, August). The role of organization hierarchy in technology adoption at the workplace. In *Proceedings of the 2013 IEEE/ACM international conference on advances in social networks analysis and mining* (pp. 8-15). https://doi.org/10.1145/2492517.2492566

Chintalloo, S., & Mahadeo, J. (2013, July). Effect of motivation on employees' work performance at Ireland Blyth

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Limited. In *Proceedings of 8th Annual London Business Research Conference Imperial College, London, UK* (Vol. 8, p. 9).
Ciobanu, A., & Androniceanu, A. (2015). Civil servants motivation and work performance in Romanian public institutions. *Procedia Economics and Finance*, *30*, 164-174. https://doi.org/10.1016/S2212-5671(15)01280-0
Council of the European Union. (2023). ChatGPT in the public sector: Overhyped or overlooked? Brussels: General Secretariat of the Council. Retrieved December 31, 2024, from https://www.consilium.europa.eu/
Criado, J. I., Valero, J., & Villodre, J. (2020). Algorithmic transparency and bureaucratic discretion: The case of SALER early warning system. *Information Polity*, *25*(4), 449-470. https://doi.org/10.3233/IP-200260
Dasborough, M. T. (2023). Awe-inspiring advancements in AI: The impact of ChatGPT on the field of Organizational Behavior. *Journal of Organizational Behavior (John Wiley & Sons, Inc.)*, *44*(2). https://doi.org/10.1002/job.2695
De Cremer, D., Bianzino, N. M., & Falk, B. (2023). How generative AI could disrupt creative work. *Harvard Business Review*, *13*.
Deci, E. L., & Ryan, R. M. (2013). *Intrinsic motivation and self-determination in human behavior*. Springer Science & Business Media. https://doi.org/10.1007/978-1-4899-2271-7
Deci, E. L., Ryan, R. M., Gagné, M., Leone, D. R., Usunov, J., & Kornazheva, B. P. (2001). Need satisfaction, motivation, and well-being in the work organizations of a former eastern bloc country: A cross-cultural study of self-determination. *Personality and Social Psychology Bulletin*, *27*(8), 930-942. https://doi.org/10.1177/0146167201278002
Dell'Acqua, F., McFowland III, E., Mollick, E. R., Lifshitz-Assaf, H., Kellogg, K., Rajendran, S., ... & Lakhani, K. R. (2023). Navigating the jagged technological frontier: Field experimental evidence of the effects of AI on knowledge worker productivity and quality. *Harvard Business School Technology & Operations Mgt. Unit Working Paper*, (24-013). https://doi.org/10.2139/ssrn.4573321
Diefendorff, J. M., & Chandler, M. M. (2011). Motivating employees. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology, Vol. 3. Maintaining, expanding, and contracting the organization* (pp. 65–135). American Psychological Association. https://doi.org/10.1037/12171-003
Erkkilä, T. (2020). Transparency in public administration. In *Oxford research encyclopedia of politics*. https://doi.org/10.1093/acrefore/9780190228637.013.1404
Faisal, F., Wang, Y., & Anastasopoulos, A. (2021). Dataset geography: Mapping language data to language users. *arXiv preprint arXiv:2112.03497*. https://doi.org/10.48550/arXiv.2112.03497
Fauzi, F., Tuhuteru, L., Sampe, F., Ausat, A. M. A., & Hatta, H. R. (2023). Analysing the role of ChatGPT in improving student productivity in higher education. *Journal on Education*, *5*(4), 14886-14891. https://doi.org/10.31004/joe.v5i4.2563
Feuerriegel, S., Hartmann, J., Janiesch, C., & Zschech, P. (2024). Generative ai. *Business & Information Systems Engineering*, *66*(1), 111-126. https://doi.org/10.1007/s12599-023-00834-7
Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39-50. https://doi.org/10.1177/002224378101800104
Gagné, M., & Deci, E. L. (2005). Self-determination theory and work motivation. *Journal of Organizational Behavior*, *26*(4), 331-362. https://doi.org/10.1002/job.322
Gaurav, B., Queirolo, A., & Santhanam, N. (2018). Artificial intelligence: The time to act is now. McKinsey & Company. Retrieved December 31, 2024, from https://www.mckinsey.com/industries/advanced-electronics/our-insights/artificial-intelligence-the-time-to-act-is-now
Gmyrek, P., Berg, J., & Bescond, D. (2023). Generative AI and jobs: A global analysis of potential effects on job quantity and quality. *ILO working paper*, *96*. *https://doi.org/10.54394/FHEM8239*
Goldman Sachs Global Institute. (2023). The generative world order: AI, geopolitics, and power. Retrieved December 31, 2024, from https://www.goldmansachs.com/insights/articles/the-generative-world-order-ai-geopolitics-and-power
Goldstein, J. (2023). New IBM study reveals how AI is changing work and what HR leaders should do about it. Retrieved from December 29, 2024, from https://www.ibm.com/blog/new-ibm-study-reveals-how-ai-is-changing-work-and-what-hr-leaders-should-do-about-it/
Hackman, J. R., & Oldham, G. R. (1976). Motivation through the design of work: Test of a theory. *Organizational Behavior and Human Performance*, *16*(2), 250-279. https://doi.org/10.1016/0030-5073(76)90016-7
Hadi, M. U., Qureshi, R., Shah, A., Irfan, M., Zafar, A., Shaikh, M. B., ... & Mirjalili, S. (2023). A survey on large language models: Applications, challenges, limitations, and practical usage. *Authorea Preprints*, *3*. https://doi.org/10.36227/techrxiv.23589741.v1
Hair Jr, J. F., Matthews, L. M., Matthews, R. L., & Sarstedt, M. (2017). PLS-SEM or CB-SEM: updated guidelines on which method to use. *International Journal of Multivariate Data Analysis*, *1*(2), 107-123. https://doi.org/10.1504/IJMDA.2017.087624
Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice*, *19*(2), 139-152. https://doi.org/10.2753/MTP1069-6679190202
Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

SEM. *European Business Review*, *31*(1), 2-24. https://doi.org/10.1108/EBR-11-2018-0203
Hair, J., & Alamer, A. (2022). Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language and education research: Guidelines using an applied example. *Research Methods in Applied Linguistics*, *1*(3), 100027. https://doi.org/10.1016/j.rmal.2022.100027
Heintze, T., & Bretschneider, S. (2000). Information technology and restructuring in public organizations: Does adoption of information technology affect organizational structures, communications, and decision making?. *Journal of Public Administration Research and Theory*, *10*(4), 801-830. https://doi.org/10.1093/oxfordjournals.jpart.a024292
Herzberg, F. (1959). The motivation to work. *John Wiley & Sons*.
Hoffmann, M., Boysel, S., Nagle, F., Peng, S., & Xu, K. (2024). *Generative AI and the Nature of Work* (CESifo Working Paper No. 11479). CESifo. https://www.cesifo.org/en/publications/2024/working-paper/generative-ai-and-nature-work
Jebara, T. (2004). Generative versus discriminative learning. In *Machine learning: Discriminative and generative* (pp. 17-60). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4419-9011-2_2
Jon (Sean) Jasperson, Carte, T. A., Saunders, C. S., Butler, B. S., Croes, H. J., & Zheng, W. (2002). Power and information technology research: A meta triangulation review. *MIS Quarterly*, 397-459. https://doi.org/10.2307/4132315
Jullien, B., & Sand-Zantman, W. (2021). The economics of platforms: A theory guide for competition policy. *Information Economics and Policy*, *54*, 100880. https://doi.org/10.1016/j.infoecopol.2020.100880
Khanal, S., Zhang, H., & Taeihagh, A. (2024). Why and how is the power of Big Tech increasing in the policy process? The case of generative AI. *Policy and Society*, puae012. https://doi.org/10.1093/polsoc/puae012
Kim, M., & Chung, S. (2021). Analysis of the utilization of digital technology on organization performance of the government: Focusing on public officials' perception. *Korean Society and Public Administration*, 32(2), 85–111. https://doi.org/10.53865/KSPA.2021.08.32.2.85
Kraemer, K. L., & Dedrick, J. (1997). Computing and public organizations. *Journal of Public Administration Research and Theory*, *7*(1), 89-112. https://doi.org/10.1093/oxfordjournals.jpart.a024344
Kraemer, K. L., & King, J. L. (1986). Computing and public organizations. *Public Administration Review*, 488-496. https://doi.org/10.2307/975570
Kraemer, K., & King, J. L. (2006). Information technology and administrative reform: Will e-government be different?. *International Journal of Electronic Government Research (IJEGR)*, *2*(1), 1-20. https://doi.org/10.4018/jegr.2006010101
Kumar, T. V. (2024). Developments and uses of generative artificial intelligence and present experimental data on the impact on productivity applying artificial intelligence that is generative. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, 12(10), 2382–2388. https://doi.org/10.15662/IJAREEIE.2022.1210015
Landsberger, H. A. (1968). Counseling in an Organization: A Sequel to the Hawthorne Researches.
Latif, F., Jalal, W., Anjum, R., & Rizwan, M. (2014). The impact of rewards & corporate social responsibility (CSR) on employee motivation. *International Journal of Human Resource Studies ISSN 2162-3058 2014*, *4*(3), 70-86. https://doi.org/10.5296/ijhrs.v4i3.5875
Lee, J. (2008). Determinants of government bureaucrats' new PMIS adoption: The role of organizational power, IT capability, administrative role, and attitude. *The American Review of Public Administration*, *38*(2), 180-202. https://doi.org/10.1177/0275074007304386
Lehmann, F., & Buschek, D. (2020). Examining autocompletion as a basic concept for interaction with generative AI. *i-com*, 19(3), 251–264. https://doi.org/10.1515/icom-2020-0025
Madan, R., & Ashok, M. (2022). A public values perspective on the application of Artificial Intelligence in government practices: A Synthesis of case studies. In *Handbook of research on artificial intelligence in government practices and processes* (pp. 162-189). IGI Global Scientific Publishing. https://doi.org/10.4018/978-1-7998-9609-8.ch010
Malhotra, A., Sharma, A., Sharma, D., & Ahmed, F. (2021). Résumé builder over rejuvenated AI features in website development. In M. A. Khan, S. Gairola, B. Jha, & P. Praveen (Eds.), *Smart Computing* (pp. 519–525). CRC Press. https://doi.org/10.1201/9781003167488-62
Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50(4), 370–396.
Mayo, E. (1949). Hawthorne and the Western Electric Company. *The social problems of an industrial civilization*, 1-7.
McGregor, D. M. (2002). 19 THEORY X AND Y. *The Motivation Handbook*, 142.
Moran, C. M., Diefendorff, J. M., Kim, T. Y., & Liu, Z. Q. (2012). A profile approach to self-determination theory motivations at work. *Journal of Vocational Behavior*, *81*(3), 354-363. https://doi.org/10.1016/j.jvb.2012.09.002
Morshidi, A., Zakaria, N. S., Idris, R. Z., Ridzuan, M. I. M., & Yusoff, S. M. (2023). Generative Artificial Intelligence and Risk at Work: An Inevitable Consequence?. *Asian Journal of Research in Education and Social Sciences*, *5*(4), 329-343. https://doi.org/10.55057/ajress.2023.5.4.33
Nakavachara, V., Potipiti, T., & Chaiwat, T. (2024). Experimenting with Generative AI: Does ChatGPT Really

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Increase Everyone's Productivity?. *arXiv preprint arXiv:2403.01770*. https://doi.org/10.48550/arXiv.2403.01770
Noonpakdee, W. (2024). User Adoption of Generative AI for Government Information Services in Thailand. *Rajapark Journal*, *18*(60), 1-20.
Noy, S., & Zhang, W. (2023). Experimental evidence on the productivity effects of generative artificial intelligence. *Science*, *381*(6654), 187-192. https://doi.org/10.1126/science.adh2586
Peng, S., Kalliamvakou, E., Cihon, P., & Demirer, M. (2023). The impact of ai on developer productivity: Evidence from github copilot. *arXiv preprint arXiv:2302.06590*. https://doi.org/10.48550/arXiv.2302.06590
Perry, J. L., & Rainey, H. G. (1988). The public-private distinction in organization theory: A critique and research strategy. *Academy of management review*, *13*(2), 182-201. https://doi.org/10.5465/amr.1988.4306858
Pinsonneault, A., & Kraemer, K. L. (1993). The impact of information technology on middle managers. *Mis Quarterly*, 271-292. https://doi.org/10.2307/249772
Pinsonneault, A., & Kraemer, K. L. (1997). Middle management downsizing: An empirical investigation of the impact of information technology. *Management science*, *43*(5), 659-679. https://doi.org/10.1287/mnsc.43.5.659
Radford, A., Wu, J., Child, R., Luan, D., Amodei, D., & Sutskever, I. (2019). Language models are unsupervised multitask learners. OpenAI Blog, 1(8), 9. Retrieved December 31, 2024, from https://cdn.openai.com/better-language-models/language_models_are_unsupervised_multitask_learners.pdf
Rana, N. P., Pillai, R., Sivathanu, B., & Malik, N. (2024). Assessing the nexus of Generative AI adoption, ethical considerations and organizational performance. *Technovation*, *135*, 103064. https://doi.org/10.1016/j.technovation.2024.103064
Rhoades, L., & Eisenberger, R. (2002). Perceived organizational support: a review of the literature. *Journal of Applied Psychology*, *87*(4), 698. https://doi.org/10.1037/0021-9010.87.4.698
Ringle, C.M., Wende, S. and Becker, J-M. (2015) SmartPLS 3, SmartPLS GmbH, Boenningstedt, No. 31. Retrieved December 20, 2024, from http://www.smartpls.com
Ruthotto, L., & Haber, E. (2021). An introduction to deep generative modeling. *GAMM-Mitteilungen*, *44*(2), e202100008. https://doi.org/10.1002/gamm.202100008
Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68–78. https://doi.org/10.1037/0003-066X.55.1.68
Salah, M., Abdelfattah, F., & Al Halbusi, H. (2023). Generative artificial intelligence (ChatGPT & Bard) in public administration research: A double-edged sword for street-level bureaucracy studies. *International Journal of Public Administration*, 1-7. https://doi.org/10.1080/01900692.2023.2274801
Schramowski, P., Turan, C., Andersen, N., Rothkopf, C. A., & Kersting, K. (2022). Large pre-trained language models contain human-like biases of what is right and wrong to do. *Nature Machine Intelligence*, *4*(3), 258-268. https://doi.org/10.1038/s42256-022-00458-8
Sharon, T., & Gellert, R. (2024). Regulating Big Tech expansionism? Sphere transgressions and the limits of Europe's digital regulatory strategy. *Information, Communication & Society*, *27*(15), 2651-2668. https://doi.org/10.1080/1369118X.2023.2246526
Taylor, F. W. (1919). *The principles of scientific management*. Harper & brothers.
Tomczak, J. M. (2024). Why deep generative modeling?. In *Deep Generative Modeling* (pp. 1-13). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-64087-2_1
Van den Broeck, A., Ferris, D. L., Chang, C. H., & Rosen, C. C. (2016). A review of self-determination theory's basic psychological needs at work. *Journal of Management*, *42*(5), 1195-1229. https://doi.org/10.1177/0149206316632058
Viechnicki, P., & Eggers, W. (2017). How much time and money can AI save government? Deloitte Center for Government Insights. Retrieved December 31, 2024, from https://www2.deloitte.com/content/dam/insights/us/articles/3834_How-much-time-and-money-can-AI-save-government/DUP_How-much-time-and-money-can-AI-save-government.pdf?utm_source=chatgpt.com
Weinberg, R. S., & Gould, D. (2023). *Foundations of sport and exercise psychology*. Human kinetics.
Weisz, J. D., Muller, M., He, J., & Houde, S. (2023). Toward general design principles for generative AI applications. *arXiv preprint arXiv:2301.05578*. https://doi.org/10.48550/arXiv.2301.05578
Wirtz, B. W., Weyerer, J. C., & Geyer, C. (2019). Artificial intelligence and the public sector—applications and challenges. *International Journal of Public Administration*, *42*(7), 596-615. https://doi.org/10.1080/01900692.2018.1498103
Wörsdörfer, M. (2022). What happened to 'Big Tech'and antitrust? And how to fix them!. *Philosophy of Management*, *21*(3), 345-369. https://doi.org/10.1007/s40926-022-00193-5

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Performance Analysis of LLMs for Abstractive Summarization of Brazilian Legislative Documents

Danilo C. G. de Lucena[a*], *Ellen* Souza[b], *Hidelberg O.* Albuquerque[c], *Nádia* Félix[d], *Adriano L.I.* Oliveira[e], *André C.P.L.F.* de Carvalho[f]

[a] Centro de Informática, Federal University of Pernambuco, Recife, Brazil, dcgl@cin.ufpe.br.

[b]MiningBR Research Group, Federal Rural University of Pernambuco, Recife, Brazil, ellen.ramos@ufrpe.br.

[c]Centro de Informática, Federal University of Pernambuco, Recife, Brazil, hidelberg.albuquerque@ufrpe.br.

[d]Institute of Informatics, Federal University of Goiás, Goiás, Brazil, nadia.felix@ufg.br.

[e]Centro de Informática, Federal University of Pernambuco, Recife, Brazil, alio@cin.ufpe.br.

[f]Institute of Mathematics and Computer Sciences, University of São Paulo, São Paulo, Brazil, andre@icmc.usp.br.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. Legislative documents present substantial obstacles to summarization due to their complex argument structures and specialized terminology. This research investigates the application of Large Language Models (LLMs) in summarizing Brazilian legislative proposals from the Chamber of Deputies, examining a dataset of over 56 thousand texts from 2013 to 2023. The paper explores three main summarization methodologies: extractive, abstractive, and hybrid, with an emphasis on abstractive summarization using LLMs. The performance of the LLM LLAMA2-13b is assessed using metrics such as ROUGE, BLEU, METEOR, BERTScore, and BERTopic, compared against reference summaries. The results show that LLMs can generate coherent and informative summaries, with positive evaluation metric results. Notably, the study reveals that traditional summary evaluation metrics may not be adequate for evaluating LLMs in summarization tasks. On the other hand, metrics based on pre-trained models like BERT provide a more effective evaluation of this innovative automatic summarization approach.

Keywords. large language models, summarization, legislative proposals.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.969

1. Introduction

In the domain of Natural Language Processing (NLP), text summarization is the process of automatically generating a concise summary that retains the most relevant information from a longer text document, preserving the core or key ideas from the original document (Neto et al., 2002). The academic literature in the NLP field identifies three main types of text summarization methods: (i) extractive, (ii) abstractive, and (iii) hybrid summarization. Extractive summarization selects the most relevant sentences, phrases, or passages from the original text to build the summary without modifying the extracted content. Abstractive summarization employs state-of-the-art natural language processing techniques to interpret the text at a semantic level and generate new content and sentences for the summary. These generated summaries may be fully rephrased or completely rewritten, rather than directly extracting text spans. Hybrid summarization combines techniques that merge extractive and abstractive summarization, typically extracting key text spans from the original text and then rewriting or enhancing them for conciseness and readability (Abualigah et al., 2020; Egan et al., 2022; El-Kassas et al., 2021; Ermakova et al., 2019; Liu et al., 2022; Tas & Kiyani, 2007).

This study investigates the application of Large Language Models (LLMs) for abstractive summarization of legislative proposals from Brazil's Chamber of Deputies over the period from 2013 to 2023. The study uti-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

lizes a corpus (Souza, Vitório, et al., 2021) containing over 56 thousand legislative proposal texts, complete with textual data, metadata, and pre-generated reference summaries. Within the scope of LLMs, the LLAMA2 (refer to Section 4) model was chosen to produce an automated summary for each legislative proposal text in the dataset. The proposed work addresses the task of summarizing legal documents, a recurrent task in the domain of Legal Natural Language Processing (Jain et al., 2021). This task aims to automatically generate concise overviews that capture the key information from lengthy and complex legal texts, such as contracts, case law, regulatory documents, and government legislative documents. Legal summarization, as a specific field of knowledge, poses unique challenges compared to other domains due to the specialized terminology, complex argument structure, and the need to preserve the legal validity of summaries.

2. Related Works

2.1. Summarization in Legal Domain

In this section, we describe studies that are important for understanding the importance of summarization in legal documents. Jain et al. provide a comprehensive state-of-the-art review that categorizes summarization techniques along two dimensions: domain-specificity (independent vs. specific) and approach type (extractive vs. abstractive). Their analysis predominantly covers extractive methods while offering limited discussion of abstractive summarization, despite the latter's greater complexity and potential for legal applications (Jain et al., 2021). Lucke et al. employed a technology-neutral methodology and multi-criteria analysis to identify several potential AI applications within parliamentary legislative processes. Their research prioritized these applications by relevance and significance, highlighting four key areas: intelligent scrutiny of legislative proposals, machine-readable legislation conversion, smart law implementation, and AI-enhanced parliamentary transparency (von Lucke et al., 2022).

Galgani et al. present a hybrid approach for legal text summarization focused on catchphrase creation for case reports. Their evaluation compares extraction methods (rule-based, citation-based, and general-purpose) using Rouge scores. The rule-based system achieved higher precision, while combining it with the citation-based method improved recall without sacrificing precision (Galgani et al., 2012). In the deep learning domain, Anand & Wagh implemented a semi-supervised approach for legal document extractive summarization using neural networks. They generated labeled data from reference summaries and evaluated quality through a set of metrics against human-generated headnotes. Their model demonstrated superior performance, validating sentence transformation effectiveness for labeled data creation (Anand & Wagh, 2022).

In the field of natural language processing for Portuguese legal documents, we refer to specific initiatives in analyzing legislative documents for the Chamber of Deputies of Brazil (Albuquerque et al., 2022; Souza, Moriyama, et al., 2021; Souza, Vitório, et al., 2021; Vitório et al., 2022, 2023).

2.2. Summarization with LLMs

In related literature, we highlight conversational Large Language Models (LLMs) — models specifically fine-tuned for dialogue-based interactions — as an emerging approach for automated text summarization. The application of these conversational LLMs to legal text summarization remains an evolving field. We believe that the studies discussed below offer valuable methodological insights for future research in this domain. Throughout our experimental process, we confirmed that the approaches examined in this section demonstrate applicability to legal text summarization scenarios.

Luo et al. (Luo et al., 2023) examined ChatGPT's capability to evaluate factual inconsistencies in text summarization using zero-shot learning, a technique where a language model performs a task without any prior examples or task-specific training, relying solely on its pre-trained knowledge and the instructions provided in the prompt. Their study employed various prompts for entailment inference, summary ranking, and consistency rating tasks, comparing ChatGPT's performance against established evaluation metrics across multiple datasets. While their results demonstrated ChatGPT's potential, they identified limitations in handling abstractive summaries and prompt alignment, suggesting future research directions in prompt engineering and alignment optimization.

In related work, Wang et al. (Wang et al., 2023) investigated ChatGPT as an evaluation metric for Natural Language Generation (NLG). Their experiments spanned five NLG meta-evaluation datasets, comparing ChatGPT

with existing automatic metrics. Their findings revealed ChatGPT's strong correlation with human judgments, its sensitivity to prompt formulation, and the significant influence of meta-evaluation dataset creation methods on NLG metric effectiveness.

In the field of Generative Pre-trained Transformers (GPT) (Brown et al., 2020), Goyal et al. (Goyal et al., 2022) examined the effectiveness of prompt-based models for text summarization, using GPT-3 as their primary case study. Their research compared GPT-3 against both fine-tuned models and a multi-task instruction-tuned model, employing parallel human and automatic evaluations across diverse summarization tasks. Their findings revealed that human annotators consistently preferred GPT-3-generated summaries, which demonstrated notable flexibility in handling tasks with varying constraints. However, they identified a significant evaluation gap: current automatic metrics failed to accurately capture the quality and diversity of GPT-3 summaries, frequently assigning them lower scores despite their superior human ratings.

3. Legislative Proposal Text Dataset

This section presents a quantitative and qualitative analysis of the corpus of legislative documents of the Brazilian Chamber of Deputies (Souza, Vitório, et al., 2021). The corpus comprises several types of legislative proposals, mainly: Bill or Law Project (*"Projeto de Lei" - PL*), Complementary Bill or Law Project (*"Projeto de Lei Complementar" - PLC*), and Constitutional Amendment Proposal (*"Proposta de Emenda Constitucional" - PEC*), totaling 56,391 documents. Each document in the corpus has attributes used in this experiment: proposal identification (author's name, proposal date), original text of the proposal, and manually generated reference summaries. For the experiment conducted, the summary present in the dataset is considered the reference summary, which will be compared with the summary generated by the LLM. Other attributes were not considered in the experiment. In the experiment, the reference summaries were obtained through a process of manual summarization, carried out by the creators of the original dataset. For examples of the structure of a legislative proposal document, we refer to the document site of the Brazilian Chamber of Deputies[1].

Table 1 presents a numerical description of the corpus, detailed by year, that shows the volume of proposals generated during the period analyzed. The textual data, spanning from 2013 to 2023, show the overall variation in the number of documents per year, starting from 5,394 proposals in 2013, peaking at 6,724 in 2021, then decreasing to 4,657 in 2022, and further to 2,389 in 2023. The average text length of analyzed documents also saw significant changes, increasing from 606 words in 2013 to 782 words in 2019, followed by an increase to 1,057 words in 2023.

Throughout the analyzed period, the average length of the reference summaries remained stable, ranging from 31 to 35 words. In the dataset, all reference summaries were written manually. In contrast, the average length of summaries generated by the LLM model varied, starting at 96 words in 2013 and reaching 127 words in 2023. This discrepancy in summary lengths is attributed to the fact that creating reference summaries is more labor-intensive and time-consuming, as they depend on the availability of individuals to perform manual summarization, while the automated generation of summaries using LLMs requires mainly computational resources. This shows the model's capability to understand the text semantically in greater depth and provide longer and more elaborate summaries.

4. Experiments

4.1. Documents Preprocessing

For the preprocessing stage of the proposal texts and summaries, it was necessary to develop a pipeline for text cleaning to make them suitable for summarization tasks. In summary, the steps adopted in the study were: (i) analyzing the text to remove punctuation, line breaks, and unnecessary spacing; (ii) removing meaningless words and special characters; and (iii) sentence segmentation and tokenizing words from reference summaries for use with evaluation metrics.

[1]https://www2.camara.leg.br/a-camara/programas-institucionais/experiencias-presenciais/parlamentojovem/sou-estudante/material-de-apoio-para-estudantes/modelo-de-projeto-de-lei

Tab. 1 – Annual statistics of Brazilian legislative proposals (2013-2023). The table presents yearly document counts, average proposal length (in words), and summary length comparison between human-generated reference summaries and LLM-generated summaries. Note the consistent discrepancy between reference and LLM summary lengths across all years.

Documents			Avg. Summary Length (words)	
Year	**Document Count**	**Avg. Length**	**Reference**	**LLM**
2023	2,389	1,057.0	35.0	127.0
2022	4,657	928.5	35.1	110.5
2021	6,724	899.7	33.3	109.5
2020	6,666	986.2	34.7	117.6
2019	8,257	782.6	31.2	106.3
2018	3,116	835.2	33.3	103.6
2017	5,336	738.6	31.2	102.8
2016	4,090	804.8	30.8	103.5
2015	7,156	768.4	31.7	105.3
2014	2,606	773.1	31.7	103.2
2013	5,394	606.2	31.3	96.9

4.2. LLM and Prompt Engineering

The LLAMA2-13b model[2], a cutting-edge language model by Meta, was selected for the experiments (Touvron et al., 2023). As a member of the LLAMA2 family, it is one of several generative text models pre-trained and fine-tuned with parameters ranging from 7 billion to 70 billion.

The LLAMA2-13b model was chosen due to its optimal balance of cost and performance, as these models are known for their computational intensity and expense. This auto-regressive language model utilizes an optimized transformer architecture and has been fine-tuned through supervised fine-tuning and reinforcement learning with human feedback (RLHF) (Christiano et al., 2017), ensuring alignment with human preferences for helpfulness and safety. For the experiments, the LLAMA2-13b model was deployed in its dialogue-optimized format on the Huggingface platform [3].

Figure 1 illustrates the text summarization process using the LLAMA2-13b model. The summarization flow begins with two initial inputs: the original "Document" to be summarized and a "Reference Summary" that serves as a quality benchmark for the generated summary. The "Text Preprocessing" stage represents an intermediate step where the original document undergoes processing to eliminate unnecessary information, normalize the text, and prepare it for the summarization model. At the "Large Language Model" stage, a zero-shot prompt is provided to summarize the text. The "Input" and "Output" components indicate the language model's processing flow: the "Preprocessed Text" resulting from the text preprocessing step serves as input, while the "Summary" represents the final summarized text output.

For generating summaries with the LLAMA2-13b model, we employed specific parameters empirically determined through iterative experimentation until summary generation achieved reasonable adequacy: (i) $temperature = 0.01$, the lowest possible value to prevent model hallucination (Rawte et al., 2023); (ii) $truncate = 4,096$, to avoid processing texts with character counts exceeding this established threshold; and (iii) $max_new_tokens = 500$ as the maximum number of tokens to be generated in the summary.

5. Main Results

This section presents the outcomes of the metrics outlined in Section 1, providing both quantitative and qualitative evaluations divided into two assessment categories. In the first stage, we analyze the ROUGE, BLEU, and METEOR metrics that evaluate results at a syntactic level, analyzing words or sentences. In the second stage, we employ BERTScore and BERTopic metrics that leverage pretrained language models based on the BERT architecture for semantic-level text analysis, utilizing multilingual BERT models pretrained for Portuguese language analysis.

[2] https://ai.meta.com/llama/
[3] https://huggingface.co/blog/llama2

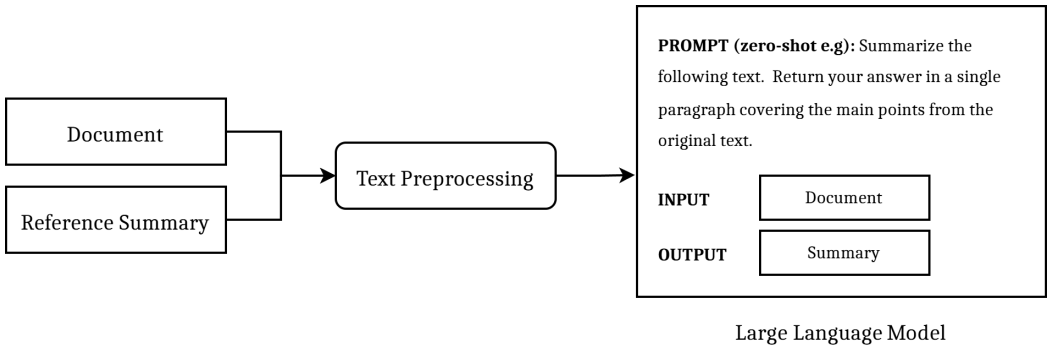


Fig. 1 – Text summarization pipeline architecture using a Large Language Model. The flowchart illustrates the complete process: (1) initial inputs consisting of the original document and its reference summary; (2) text preprocessing phase that normalizes and prepares the document for summarization; (3) the Large Language Model component featuring a zero-shot prompt, with clearly defined input (preprocessed document) and output (generated summary) pathways. The reference summary serves as an evaluation benchmark though this comparison is not explicitly shown in the diagram. This architecture was implemented using LLAMA2 as the underlying language model.

5.1. Structural Level Evaluation

This proposal utilized a set of ROUGE metrics (Lin, 2004) to evaluate lexical overlap between LLM-generated and reference summaries. Specifically, ROUGE-1 and ROUGE-2 measure unigram and bigram overlap respectively, while ROUGE-L assesses the longest common subsequence. An n-gram is a contiguous sequence of n items (typically words or characters) from a text, used as a basic unit of analysis in natural language processing to evaluate textual overlap in metrics such as ROUGE-1 and ROUGE-2 in summary quality evaluation.

The ROUGE metrics analysis reveals a consistent downward trend in LLM summarization performance over the 2013-2023 period, with all three measures (Unigram, Bigram, and L-score) showing peak values in 2013 (0.399, 0.319, and 0.346 respectively) and lowest values in 2023 (0.336, 0.260, and 0.290), representing a decline. All scores remained relatively low (below 0.4), which may reflect the considerable length disparity between reference summaries (31-35 words) and LLM-generated summaries (96-127 words) rather than actual quality deficiencies. The parallel patterns across all three metrics suggest that lexical overlap at different granularities is similarly affected by underlying factors such as increasing document complexity (606 words in 2013 to 1,057 words in 2023). These findings underscore the limitations of using lexical-based evaluation metrics for abstractive summarization tasks, particularly as legislative language evolves over time.

The *Bilingual Evaluation Understudy* (BLEU) (Lin & Och, 2004; Papineni et al., 2002) is a metric that was initially developed for the purpose of evaluating machine translation systems by comparing candidate translations to reference translations. Furthermore, it has gained relevance in other natural language processing tasks like assessing text summarization systems.

The BLEU score analysis for summarization reveals a consistent temporal decline from 2013 (0.173) to 2023 (0.140), representing a performance decrease. Despite minor fluctuations in 2018 (0.158) and 2021 (0.164), all scores remain notably low (below 0.18), with a year average of 0.149. This pattern parallels the increasing document length (606.2 to 1,057 words) over the same period, suggesting a potential correlation between source complexity and summarization difficulty. The substantial length disparity between reference (31-35 words) and LLM-generated summaries (96-127 words) further complicates interpretation, as BLEU primarily measures lexical precision without capturing semantic equivalence. These findings align with the study's position that traditional n-gram overlap metrics have inherent limitations for evaluating domain-specific abstractive summarization. LLMs may be predisposed to producing more verbose summaries than what human preferences might dictate. This observation suggests a promising avenue for future research, particularly in the realm of prompt engineering for summarization tasks. Notably, there exists a strong correlation ($R=0.96$) between the lengths of summaries generated by LLAMA2 and those of manual reference summaries. As the length of reference summaries increases, the model tends to generate proportionally longer summaries.

Tab. 2 – The table displays the evaluation results of the ROUGE, BLEU, and METEOR metrics. The "Year" column specifies the year of the text subset. The "Unigram score" and "Bigram score" columns represent the ROUGE metric values, calculated using unigram (1-gram) and bigram (2-gram) respectively, by comparing the generated summary with the reference summary. The "L-score" column shows the ROUGE metric value based on the Longest Common Subsequence, again comparing the generated summary with the reference summary. The "BLEU score" and "METEOR score" columns present the results for these two metrics.

Year	ROUGE			BLEU-score	METEOR-score
	Unigram-score	Bigram-score	L-score		
2023	0.336	0.260	0.290	0.140	0.459
2022	0.369	0.283	0.313	0.150	0.475
2021	0.384	0.305	0.330	0.164	0.500
2020	0.352	0.271	0.305	0.150	0.463
2019	0.360	0.279	0.311	0.150	0.473
2018	0.379	0.292	0.326	0.158	0.479
2017	0.360	0.275	0.304	0.145	0.466
2016	0.352	0.265	0.300	0.145	0.459
2015	0.348	0.258	0.293	0.142	0.452
2014	0.371	0.284	0.317	0.152	0.475
2013	0.399	0.319	0.346	0.173	0.511

METEOR (*Metric for Evaluation of Translation with Explicit Ordering*) (Banerjee & Lavie, 2005) is a metric initially developed for machine translation evaluation that has since been widely adopted for summarization assessment. METEOR evaluates similarity between generated and reference summaries by conducting recall analysis at multiple linguistic levels: exact matching, stem matching, synonym alignment, and paraphrase correspondence. In its scoring algorithm, METEOR assigns higher weights to exact token matches than to stems and synonyms, prioritizing precision in word choice over semantic approximations.

The METEOR evaluation shows scores ranging from 0.452 (2015) to 0.511 (2013), with a mean of 0.474 across the. Unlike the consistently declining pattern in ROUGE and BLEU metrics, METEOR exhibits more fluctuation, with a secondary peak in 2021 (0.500) before dropping to 0.459 in 2023. METEOR scores substantially outperform BLEU scores across all years, reflecting its design to capture semantic similarity through exact matches, stems, synonyms, and paraphrases rather than strict n-gram correspondence. The moderate absolute performance (scores 0.5) indicates that generated summaries capture approximately half of the reference content when accounting for lexical variations. This relatively stronger METEOR performance suggests LLMs produces summaries that maintain semantic fidelity despite using different terminology than human references. The overall temporal decline correlates with increasing document complexity, suggesting potential challenges in maintaining semantic precision as legislative texts grow more elaborate.

5.2. Semantic Level Evaluation

BERTScore (Zhang et al., 2020) was utilized to evaluate the summarization task, providing an assessment of the quality of generated summaries compared to reference summaries. As an automatic metric for text generation, BERTScore calculates a similarity score for each token in the candidate sentence against each token in the reference sentence. This calculation is performed using pre-trained contextual embeddings from BERT models, matching words in both sentences through cosine similarity. The implementation of BERTScore facilitates a comprehensive evaluation of summary quality by capturing semantic relationships beyond lexical overlap, ensuring that generated summaries are accurately compared to their reference counterparts.

BERTScore F1 values above 0.7 generally indicate strong semantic alignment. The range of 0.730-0.757 suggests that LLAMA2-13b produces summaries that capture approximately 73-76% of the semantic content in reference summaries—a reasonably strong performance. These scores significantly outperform the syntactic metrics as ROUGE and BLEU, highlighting BERTScore's ability to capture semantic rather than lexical similarity, which is particularly important for abstractive summarization. The consistently higher recall versus precision aligns with the observation that LLM summaries are longer than reference summaries. The model effectively captures the reference content but adds supplementary information. The declining trend correlates

with increasing document complexity (606 to 1,057 words), suggesting that maintaining semantic precision becomes more challenging as legislative texts grow more elaborate.

Overall, these results indicate good semantic alignment between LLM-generated and reference summaries, especially considering the inherent challenges of legal text summarization. The high recall values demonstrate the model's ability to identify and incorporate key semantic elements, though the precision gap reveals opportunities for generating more focused summaries. The relatively small variation in F1 scores suggests consistent performance despite increasing document complexity over the years.

Tab. 3 – BERTScore semantic evaluation of LLAMA2-13b generated summaries. The table presents yearly semantic similarity metrics between model-generated and human reference summaries. Precision measures how much of the generated content is relevant, Recall quantifies how much of the reference content is captured, and F1-score represents their harmonic mean.

Year	Precision	Recall	F1-score
2023	0.678	0.800	0.730
2022	0.693	0.813	0.747
2021	0.697	0.815	0.750
2020	0.685	0.804	0.739
2019	0.687	0.808	0.742
2018	0.694	0.802	0.743
2017	0.688	0.803	0.740
2016	0.684	0.798	0.735
2015	0.685	0.795	0.735
2014	0.694	0.806	0.745
2013	0.705	0.820	0.757

BERTopic is a topic modeling technique (Grootendorst, 2022) that utilizes pretrained BERT embeddings and class-based TF-IDF (*c-TF-IDF*) to generate interpretable topics and clusters from text. For this experiment, we generated topics for each reference summary (manually created), for summaries produced by the LLM model, and finally, for all topics present in the original text. The objective of this evaluation was to compare the capacity of each summary type to present the same topics identified in the original texts. Through this comparison, we aimed to determine which summary better represents the original text's information: the manual summary or the LLM-generated summary.

The results in Table 4 reveal that BERTopic produces topics that are on par with or superior to human reference summaries in a substantial number of cases, confirming its potential as an unsupervised topic modeling technique that leverages pretrained transformer models. The combined "LLM Wins + Tie" rate consistently exceeds 80% across all years, indicating that LLAMA2 summaries rarely perform substantially worse than human-crafted summaries in capturing topic alignment. For an unsupervised approach competing against human experts in a specialized domain (legislative texts), winning several of direct comparisons while maintaining topic parity in approximately almost of cases represents notable performance. The high tie percentage suggests that LLAMA2 has effectively learned to identify the most significant topics in legislative documents, which is particularly valuable for practical applications in legal information processing.

6. Conclusion

This research investigated the application of Large Language Models (LLMs) for abstractive summarization of Brazilian legislative proposals, examining a comprehensive dataset of over 56,000 texts spanning from 2013 to 2023. The study evaluated the performance of LLAMA2-13b in generating concise and informative summaries of complex legal documents, comparing them against human-created reference summaries using multiple evaluation metrics. The analysis presented provides insights into the capabilities and limitations of LLMs for summarizing legislative documents, particularly Brazilian legislative proposals. The research demonstrates that LLMs can effectively generate coherent and informative summaries of complex legal texts, though with varying degrees of alignment with human-crafted reference summaries depending on the evaluation metric employed.

Our investigation into traditional structural-based metrics such as ROUGE, BLEU, and METEOR revealed sig-

Tab. 4 – BERTopic semantic alignment comparison between reference and LLAMA2-13b generated summaries. The table presents the yearly distribution of topic modeling results using pretrained BERT embeddings and class-based TF-IDF (c-TF-IDF). "Ref. Wins" indicates cases where human-generated reference summaries exhibit stronger topic alignment with original legislative texts. "LLM Wins" represents instances where LLM summaries demonstrate superior topic correspondence. "Tie" shows the percentage of documents where both summary types maintain equivalent topic representation. Note the consistently high tie percentage (65.3%-74.2%) across all years, suggesting comparable semantic performance between human and AI-generated summaries.

Year	Ref. Wins	LLM Wins	Tie
2023	20.8%	17.1%	69.7%
2022	22.6%	13.6%	74.2%
2021	19.5%	15.7%	67.6%
2020	21.5%	18.7%	65.3%
2019	20.3%	16.6%	69.4%
2018	20.7%	16.9%	69.1%
2017	16.1%	13.8%	72.7%
2016	19.2%	15.5%	65.7%
2015	19.3%	18.2%	69.8%
2014	19.3%	15.5%	71.8%
2013	16.1%	13.3%	73.6%

nificant limitations in their applicability to abstractive summarization evaluation. These metrics consistently showed declining performance trends from 2013 to 2023, with ROUGE scores dropping from peaks of 0.399, 0.319, and 0.346 (Unigram, Bigram, and L-score respectively) in 2013 to 0.336, 0.260, and 0.290 in 2023. Similarly, BLEU scores decreased from 0.173 to 0.140, and METEOR from 0.511 to 0.459 over the same period. This decline correlates with the increasing complexity of legislative documents. However, the low performance on these traditional metrics appears to be significantly influenced by the substantial length disparity between reference summaries and LLM-generated summaries rather than actual quality deficiencies. This observation highlights a crucial limitation of lexical overlap-based evaluation for abstractive summarization, where semantic equivalence may exist without exact wording matches.

In contrast, semantic-based evaluation metrics provided more promising results. BERTScore analysis demonstrated strong semantic alignment between LLM-generated and reference summaries. The consistently higher recall versus precision values confirm that while LLM summaries effectively capture reference content, they tend to include additional information. This aligns with our observation regarding summary length differences and suggests that LLMs maintain good semantic fidelity despite using different terminology than human references. Perhaps most interestingly, the BERTopic analysis revealed that LLAMA2-13b generated summaries that were on par with or superior to human reference summaries in a substantial number of cases. The combined "LLM Wins + Tie" rate consistently exceeded 80% across all years, with high tie percentages. This indicates that the LLM can effectively identify and represent the most significant topics in legislative documents, which is particularly valuable for practical applications in legal information processing.

These findings position LLMs as efficient options for summarizing legal documents, with no significant difference between manually and automatically generated summaries in terms of topic representation. However, challenges remain in addressing the complexity of legal terminology and argumentative structures, and in developing evaluation methodologies that adequately assess semantic understanding and preservation of legal validity in generated summaries. Future work should focus on refining prompt engineering techniques to generate more concise summaries that better align with human preferences while maintaining semantic comprehensiveness. Additionally, developing specialized evaluation metrics for legal text summarization that account for domain-specific requirements would enhance the assessment of LLM performance in this context. Finally, exploring fine-tuning approaches specific to legislative documents could potentially improve summarization quality and address the observed performance variations over time.

In conclusion, this study demonstrates the promising potential of LLMs for legislative document summarization while highlighting the importance of semantic-level evaluation metrics in accurately assessing their performance. The results provide a foundation for further research into optimizing LLM applications in legal and

governmental domains where efficient information processing is increasingly crucial.

We sincerely appreciate the support provided by the research funding agencies CAPES, FAPESP, and CNPq, whose contributions have been essential to the development of this work. Furthermore, we extend our gratitude to the Brazilian Chamber of Deputies, the Center for Applied Research in Artificial Intelligence Recreating Environments (CPA IARA), and the Brazilian National Institute of Artificial Intelligence (IAIA) for their significant support in advancing this research.

References

Abualigah, L., Bashabsheh, M. Q., Alabool, H., & Shehab, M. (2020). Text summarization: A brief review. *Recent Advances in NLP: the case of Arabic language*, 1–15.

Albuquerque, H. O., Costa, R., Silvestre, G., Souza, E., da Silva, N. F., Vitório, D., Moriyama, G., Martins, L., Soezima, L., Nunes, A., et al. (2022). Ulyssesner-br: A corpus of brazilian legislative documents for named entity recognition. *International Conference on Computational Processing of the Portuguese Language*, 3–14.

Anand, D., & Wagh, R. (2022). Effective deep learning approaches for summarization of legal texts. *Journal of King Saud University-Computer and Information Sciences*, *34*(5), 2141–2150.

Banerjee, S., & Lavie, A. (2005). METEOR: An automatic metric for MT evaluation with improved correlation with human judgments. *Proceedings of the ACL Workshop on Intrinsic and Extrinsic Evaluation Measures for Machine Translation and/or Summarization*, 65–72. https://www.aclweb.org/anthology/W05-0909

Brown, T., Mann, B., Ryder, N., Subbiah, M., Kaplan, J. D., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell, A., et al. (2020). Language models are few-shot learners. *Advances in neural information processing systems*, *33*, 1877–1901.

Christiano, P. F., Leike, J., Brown, T., Martic, M., Legg, S., & Amodei, D. (2017). Deep reinforcement learning from human preferences. *Advances in neural information processing systems*, *30*.

Egan, N., Vasilyev, O., & Bohannon, J. (2022). Play the shannon game with language models: A human-free approach to summary evaluation. *Proceedings of the AAAI conference on artificial intelligence*, *36*(10), 10599–10607.

El-Kassas, W. S., Salama, C. R., Rafea, A. A., & Mohamed, H. K. (2021). Automatic text summarization: A comprehensive survey. *Expert systems with applications*, *165*, 113679.

Ermakova, L., Cossu, J. V., & Mothe, J. (2019). A survey on evaluation of summarization methods. *Information processing & management*, *56*(5), 1794–1814.

Galgani, F., Compton, P., & Hoffmann, A. (2012). Combining different summarization techniques for legal text. *Proceedings of the workshop on innovative hybrid approaches to the processing of textual data*, 115–123.

Goyal, T., Li, J. J., & Durrett, G. (2022). News summarization and evaluation in the era of gpt-3. *arXiv preprint arXiv:2209.12356*.

Grootendorst, M. (2022). Bertopic: Neural topic modeling with a class-based tf-idf procedure. *arXiv preprint arXiv:2203.05794*.

Jain, D., Borah, M. D., & Biswas, A. (2021). Summarization of legal documents: Where are we now and the way forward. *Computer Science Review*, *40*, 100388.

Lin, C.-Y. (2004). ROUGE: A package for automatic evaluation of summaries. *Text Summarization Branches Out*, 74–81. https://www.aclweb.org/anthology/W04-1013

Lin, C.-Y., & Och, F. J. (2004). ORANGE: A method for evaluating automatic evaluation metrics for machine translation. *COLING 2004: Proceedings of the 20th International Conference on Computational Linguistics*, 501–507. https://www.aclweb.org/anthology/C04-1072

Liu, Y., Jia, Q., & Zhu, K. (2022). Reference-free summarization evaluation via semantic correlation and compression ratio. *Proceedings of the 2022 conference of the North American Chapter of the Association for Computational Linguistics: human language technologies*, 2109–2115.

Luo, Z., Xie, Q., & Ananiadou, S. (2023). Chatgpt as a factual inconsistency evaluator for abstractive text summarization. *arXiv preprint arXiv:2303.15621*.

Neto, J. L., Freitas, A. A., & Kaestner, C. A. (2002). Automatic text summarization using a machine learning approach. *Advances in Artificial Intelligence: 16th Brazilian Symposium on Artificial Intelligence, SBIA 2002 Porto de Galinhas/Recife, Brazil, November 11–14, 2002 Proceedings 16*, 205–215.

Papineni, K., Roukos, S., Ward, T., & Zhu, W.-j. (2002). Bleu: A method for automatic evaluation of machine translation, 311–318.

Rawte, V., Sheth, A., & Das, A. (2023). A survey of hallucination in large foundation models. *arXiv preprint arXiv:2309.05922*.

Souza, E., Moriyama, G., Vitório, D., de Carvalho, A. C., Félix, N., Albuquerque, H. O., & Oliveira, A. L. (2021). Assessing the impact of stemming algorithms applied to brazilian legislative documents retrieval. *Anais do XIII Simpósio Brasileiro de Tecnologia da Informação e da Linguagem Humana*, 227–236.

Souza, E., Vitório, D., Moriyama, G., Santos, L., Martins, L., Souza, M., Fonseca, M., Félix, N., Carvalho, A. C., Albuquerque, H. O., & Oliveira, A. L. (2021, December). An information retrieval pipeline for legislative documents from the brazilian chamber of deputies. DOI: https://doi.org/10.3233/FAIA210326.

Tas, O., & Kiyani, F. (2007). A survey automatic text summarization. *PressAcademia Procedia*, *5*(1), 205–213.

Touvron, H., Martin, L., Stone, K., Albert, P., Almahairi, A., Babaei, Y., Bashlykov, N., Batra, S., Bhargava, P., Bhosale, S., et al. (2023). Llama 2: Open foundation and fine-tuned chat models. *arXiv preprint arXiv:2307.09288*.

Vitório, D., Souza, E., Martins, L., da Silva, N. F., de Leon Ferreira de Carvalho, A. C. P., & Oliveira, A. L. (2022). Ulysses-rfsq: A novel method to improve legal information retrieval based on relevance feedback. *Brazilian Conference on Intelligent Systems*, 77–91.

Vitório, D., Souza, E., Martins, L., da Silva, N. F., Oliveira, A. L., de Andrade, F. E., et al. (2023). Building a relevance feedback corpus for legal information retrieval in the real-case scenario of the brazilian chamber of deputies.

von Lucke, J., Fitsilis, F., & Etscheid, J. (2022). Using artificial intelligence for legislation-thinking about and selecting realistic topics. *EGOV-CeDEM-ePart 2022*, 32.

Wang, J., Liang, Y., Meng, F., Shi, H., Li, Z., Xu, J., Qu, J., & Zhou, J. (2023). Is chatgpt a good nlg evaluator? a preliminary study. *arXiv preprint arXiv:2303.04048*.

Zhang, T., Kishore, V., Wu, F., Weinberger, K. Q., & Artzi, Y. (2020). Bertscore: Evaluating text generation with bert. *International Conference on Learning Representations*. https://openreview.net/forum?id=SkeHuCVFDr

Use of AI tools in the Colombian Judiciary: Findings from Three Surveys.

Juan David Gutiérrez[a*], *David Stiven* Peralta Mendieta[b]

[a] School of Government, Universidad de los Andes, Bogotá, Colombia, juagutie@uniandes.edu.co, ORCID: https://orcid.org/0000-0002-7783-4850
[b] School of Government, Universidad de los Andes, Bogotá, Colombia, ds.peralta@uniandes.edu.co, ORCID: https://orcid.org/0009-0006-1600-1130

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. This paper aims to answer three main questions regarding the use of artificial intelligence (AI) tools in the Colombian judiciary. First, what type of AI tools do judges and judicial staff in Colombia access and use? Second, how and for what purposes are these AI tools used? Third, do demographic factors (e.g., age, gender) influence how judges and judicial staff approach AI tools? This paper is based on three comprehensive surveys conducted in 2024. Two surveys conducted by the authors targeted participants in the course "Artificial Intelligence for the Administration of Justice: Fundamentals, Applications, and Best Practices", offered by the Universidad de los Andes and the Superior Council of the Judiciary (CSdJ). A total of 1,391 judicial staff members responded at the start of the course, and 824 responded at its conclusion. A third survey, conducted later by the CSdJ, gathered responses from 3,152 judicial personnel. Our analysis reveals that training significantly improved AI familiarity among judicial personnel—initially, 63% reported minimal knowledge, but after the 50-hour course, 85% claimed moderate to high familiarity. While approximately one-third of respondents initially used AI for work tasks, this increased to nearly half post-training. Over 80% of users accessed free AI versions, raising concerns about confidentiality as these platforms may share information with third parties. Judicial officials primarily employ generative AI for information searches and document writing, particularly for jurisprudence (59%), legislation (52%), and definitions (51%). This reliance on AI for information retrieval presents risks if outputs aren't verified against reliable sources. Although age and gender disparities in AI familiarity exist, reported usage patterns show minimal demographic differences. These findings emphasize the importance of enhancing digital literacy among judicial professionals and inform our recommendations for developing appropriate regulations and guidelines governing AI systems in the justice sector.

Keywords. Artificial Intelligence, Algorithms, Large Language Models, Chatbots, Justice, Judges, Tribunals, Judicial Staff, Colombia.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1060

1. Introduction

The adoption of artificial intelligence (AI) tools can contribute significantly to the objectives of the administration of justice and, in general, to the objectives of the States (UNESCO, 2023). Magistrates, judges and other judicial staff around the world have been using AI systems for the management of processes and support in performing legal tasks over the last decade (CEPEJ, 2024; Gutiérrez, 2020).

However, the successful adoption of these systems depends on multiple factors that go beyond the characteristics of the technological tools themselves and the physical infrastructure required for their operation. The

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

effectiveness of AI systems in solving problems or achieving objectives within an organization also depends on the human factor, at both the individual and organizational levels. In that sense, the human talent that deploys and uses them is essential, in addition to the governance of the organization and the culture that shapes the behavior of the individuals who compose it.

This paper aims to answer three main questions regarding the application of AI tools in the Colombian judiciary. First, what type of AI tools do judges and judicial staff in Colombia access and use? Second, how and for what purposes are these AI tools used? Third, do demographic factors (e.g., age, gender) influence how judges and judicial staff approach AI tools?

This is the most comprehensive article published to date on the use of AI systems in Colombia's public sector. The study is based on three surveys conducted among Colombian judicial personnel. The surveys were conducted in the first semester of 2024 through electronic forms. Two surveys were answered by judicial officials who took part in the course "Artificial Intelligence for the Administration of Justice: Fundamentals, Applications and Best Practices", offered jointly by the Universidad de los Andes and the Superior Council of the Judiciary (CSdJ) - the body in charge of governing the judiciary in Colombia. The first survey was answered at the beginning of the course by 1,391 judicial personnel, and the second at the end of the course by 824 judicial personnel. The third survey was administered directly by the CSdJ and answered by 3,152 judicial personnel. This paper, based on the survey data, explores the ways in which judicial personnel use AI tools, focusing on Generative Artificial Intelligence (GAI) systems.

The paper is divided into four sections, in addition to this introduction. The first section provides a brief literature review on empirical research that has examined how judicial operators worldwide use these tools. The second section details the methodology employed to conduct the research, emphasizing the design and processing of the surveys. Next, the third section outlines the main findings regarding the uses of the tools. The final section synthesizes the key findings from the surveys.

2. Literature review

The use of AI tools in the justice sector precedes the "boom" of GAI systems that detonated globally, in November 2022, with the launch of the ChatGPT tool by OpenAI. For example, since November 2017, the Prosecutor's Office of the Autonomous City of Buenos Aires, Argentina, has been using the Prometea system for "the digital automation of reiterative task processes and the application of AI for the predictive elaboration of legal opinions in analogous cases for whose solution there are already reiterative judicial precedents" (Estevez et al., 2020, p. 46). In Brazil, since 2019, the Federal Supreme Court (STJ) implements the Victor tool to support the review the admissibility of appeals concerning the requirement of "general repercussions" (Ministro do Superior Tribunal de Justiça, 2020; UNESCO, 2023).

The "Resource Centre Cyberjustice and AI" database, created by the Council of Europe's European Commission for the Efficiency of Justice (CEPEJ), lists over 140 different AI tools used by judges and courts on different continents. In Colombia, for example, since 2021 the Constitutional Court has been using the PretorIA tool, a machine learning system that assists in the search for information for the selection of tutelas in the review process (proceso de revisión) (Corte Constitucional, 2020, 2024; Gutiérrez, 2020; Gutiérrez & Muñoz-Cadena, 2023; Saavedra & Upegui, 2021).

More recently, there has been a growing interest in incorporating GAI systems into legal work by judges, prosecutors, and lawyers (Gutiérrez, 2024c; UNESCO, 2023). For example, (Gutiérrez, 2023a, 2023b, 2023c, 2023d, 2024a) has documented cases in which judges and courts have used chatbots operating from large-scale language models (LLMs) to support the drafting of judicial decisions and their participation in court hearings.

While there are case studies on specific AI tools deployed in the justice sector, such as those mentioned earlier, and monographs that document various types of AI tools, like (UNESCO, 2023), scholarship on how these tools are utilized in practice by magistrates, judges, and judicial staff remains limited. Only recently, an emerging literature has sought to understand the use of AI systems in the justice sector through surveys. The studies examine how judicial officers and lawyers utilize these systems in their professional roles. This section overviews the findings of four recent surveys conducted by the Conselho Nacional de Justiça do Brasil (CNJ), the United Nations Educational, Scientific and Cultural Organization (UNESCO), LexisNexis, and Thomson Reuters.

First, the Brazilian CNJ (Conselho Nacional de Justiça, 2024) studied aspects of the governance of the use of GAI systems in the judiciary and evaluated the impacts of these tools in the Brazilian judicial system. The results presented below focus on the second part of the survey regarding the use of these tools by the Brazilian judiciary. The questionnaire was sent to all active magistrates and judicial personnel between May and June 2024. The target population consisted of 16,844 magistrates and 278,755 judicial personnel. In total, responses were obtained from 1,681 magistrates (9.1%) and 16,844 judicial personnel (6%).

Due to the concern related to the reliability of the texts generated by GAI systems, the study inquired about the reasons for their use. The main uses of GAI tools identified by the survey correspond to text generation, proofreading, translation, and synthesis, among others. However, the results also highlight the use of these tools for tasks such as general information searches (approximately 50%) and case law searches (15% of magistrates and 11% of judicial personnel). When evaluating the potential uses of these tools, most magistrates (70%) and judicial personnel (60%) considered them helpful for case law searches, both for professional practice and research.

When asked about potential limitations to the use of these tools, the central reported limitation was a lack of knowledge in their use (51.9%), followed by distrust in the reliability of the results (32.6%), a lack of regulation (15%), and ethical concerns regarding their use (10%). These results are analogous to those found in the survey that we conducted in Colombia, particularly regarding the perceptions of magistrates, judges, and other judicial personnel on the barriers to the adoption of AI systems in the administration of justice in Colombia. However, the results of the Brazilian survey suggest that there is optimism in the use of these systems due to their potential benefits for various tasks (80% of magistrates and 70% of judicial personnel). In addition, more than 95% of those surveyed consider it appropriate to receive training in the use of GAI tools in the workplace.

Second, the survey conducted by UNESCO at the end of 2023 targeted its global network of judicial operators, including judges, judicial staff, prosecutors, lawyers, and legal researchers. In total, 563 judicial operators from 96 countries responded to the survey (Gutiérrez, 2024c). Among the main findings of the survey, 31% of respondents considered themselves "expert" or "very familiar" with AI systems, 41% answered that they were "moderately familiar" with AI, and 27% were somewhat or not at all familiar. On average, respondents reported greater familiarity with AI systems than the Colombian judicial personnel who responded to the survey at the beginning of the CSdJ Course.

The UNESCO study also identified that 44% of respondents reported having used AI tools in the work context, but half of these reported sporadic use (monthly or once). This proportion is lower relative to the average of those who responded to the Colombian survey at the start of the CSdJ course, but similar to those who responded to the exit survey. Among the main tasks for which GAI systems are used, according to the respondents of the UNESCO survey, were searching for information related to the justice sector, drafting documents, and exploring ideas. This pattern was similar to that found in the responses of the Colombian judicial personnel who were surveyed at the start and end of the CSdJ course.

Despite the widespread adoption of GAI tools, 69% of respondents to the UNESCO survey consider that there are risks associated with the use of these systems in the administration of justice due to the quality of the text generated, the potential violation of personal data protection law, potential copyright violations, and opacity in the operation of these systems, among others. In the case of the beginning and exit surveys of the CSdJ Course, the proportion of Colombian judicial personnel who identify potential risks is higher, but the types of risks identified are similar.

In third place, Lexis Nexis, a multinational business and legal information technology analytics company, conducted a survey of 4,180 lawyers, law students, and U.S. citizens (LexisNexis Legal & Professional, 2023). The objective of the survey was to better identify familiarity, usage, and adaptation of AI systems for legal matters. Among the main results, the respondents' familiarity with AI stands out. 98% of respondents under 45 years old and 82% over 45 years old are aware of the existence of these systems, despite being a relatively new technology. The survey also shows the gap between awareness of these tools and their use, both personally and professionally: 36% of lawyers reported using these tools, compared to 44% of law students and 32% of citizens.

When asked about the reasons for use, the main answers were research on various topics (59%), writing

documents (45%), writing emails (38%), and understanding new legal concepts. These results regarding the types of uses of the tools are similar to those found in the UNESCO global survey and in the surveys conducted in Colombia. Concerning the perception of impact, 29% of the lawyers considered it to be significant, and 10% viewed it as transformative. When asked about the type of impact, 15% believed it would be positive, 62% saw it as mixed (both positive and negative), 11% thought it would be negative, and 12% indicated that the impact is uncertain. In comparison, the judicial personnel who responded to the surveys in Colombia seemed to be slightly more optimistic about the future impact of these technologies.

Despite the potential uses reported by respondents, 87% of lawyers expressed concerns regarding the ethical implications of using these systems: somewhat (54%), very (29%), or significantly (4%). Both the UNESCO global survey and the Colombia surveys found a high percentage of people who believed that the use of AI tools in the justice sector posed risks and potential negative consequences. The answers to the open-ended questions were analyzed by Lexis Nexis with the assistance of AI systems. The results indicate that while lawyers see potential benefits from these systems, AI will not replace the human function in law. The primary concern expressed by respondents is the prospect of job losses.

Finally, Thomson Reuters, a multinational information and technology company, surveyed professionals in English-speaking countries across various sectors, including legal, tax and accounting, risk and fraud, as well as officials from government entities, to understand their perceptions of GAI tools and how they are being introduced in the workplace (Thomson Reuters, 2024). The sample for the survey was constructed from a company database. A total of 1,128 people were surveyed between January and February 2024. All respondents came from English-speaking countries such as the United States (48%) and the United Kingdom (19%), among others. Regarding the perceptions observed, 46% of the participants reported feeling hopeful and enthusiastic about the use of these tools, while 18% expressed worry or fear. Respondents from the justice sector were the most concerned (31%) and least enthusiastic (15%) of all participating sectors.

When asked whether GAI tools can be implemented in their fields of work, 85% of the respondents from the legal area answered in the affirmative. However, when answering the question of whether these tools should be implemented in their fields of work, 51% of respondents from the legal sector agreed. When delving deeper into the reasons why GAI tools should or should not be implemented in the legal sector, respondents perceived that these tools help save costs and increase efficiency in the use of workers' time in high-value tasks. However, the legal sector workers surveyed also identified two of the main reasons why they did not consider it appropriate to use GAI tools: the lack of reliability and accuracy of the answers provided.

When exploring expectations regarding the use of GAI systems, a significant gap can be observed in Thomson Reuters' survey. Specifically for the justice sector, only 14% of organizations report that they use these tools, 12% plan to use them, 35% are considering their use, and 40% have no current plans to use these systems. Respondents were also asked about barriers to adopting these tools, and the primary concerns raised by them included the potential risk of inaccurate information (70%), worries about data security (68%), and the privacy and confidentiality of information shared with GAI systems (62%). These results are similar to those identified in the responses to the questions on the risks associated with the use of GAI in the justice sector in the UNESCO global survey and the surveys in Colombia.

As observed in this literature review, the interest in understanding the use of AI systems in judicial systems globally is growing. This trend motivates the present research to examine their adoption, implementation, perceptions, and ethical and legal implications in Colombia. The four major surveys (Conselho Nacional de Justiça, 2024; Gutiérrez, 2024b; LexisNexis Legal & Professional, 2023; Thomson Reuters, 2024) indicate that a significant percentage of people have begun to implement AI tools in the justice sector, and the share of judicial personnel who report using AI tools appears to be increasing. Additionally, in contrast to the optimism about the potential improvement in efficiency and productivity that dominates the narratives of tech companies and some policymakers, the surveys suggest that there is concern about the lack of regulation, low access to formal training, and the potential risks associated with the inappropriate or malicious use of these systems.

This research aims to contribute to the literature by analyzing the use of AI systems by magistrates, judges, and other judicial staff in Colombia. Our findings highlight the importance of enhancing digital literacy among professionals who use AI systems in the administration of justice. Based on these findings, our article offers insights and recommendations for future regulations and guidelines regarding the use of AI systems in the justice sector.

3. Methodology and Data

This research is based on three surveys conducted with judicial personnel in Colombia about the uses and governance of AI tools in the justice sector. The authors conducted two surveys as part of the CSdJ Course delivered by Universidad de los Andes between January and May 2024, and a third survey was administered directly by the CSdJ at the beginning of the second semester of 2024. The CSdJ considered the questions from the first two surveys, replicated some of them, and created its own questionnaire. The survey delivered by the CSdJ was sent to all judicial servants, allowing them to independently respond if they had attended the CSdJ Course.

The two surveys administered as part of the CSdJ course mirrored the UNESCO global survey but included additional questions, such as the perceived barriers to adopting AI tools by the judiciary. The questionnaires of the two surveys included open and closed questions focusing on three areas of interest: familiarity with and uses of AI systems, perceptions of the implications of their usage, and governance of AI tools. First, about familiarity and uses, the questions included the frequency of use in work environments, the reasons why judicial personnel use these systems, and how they access these systems. Second, regarding the implications of using AI tools, judicial personnel were asked about the perceived risks and negative aspects of AI systems, as well as their views on the potential impact of these systems on society and the justice sector. Finally, regarding governance, the questions addressed the perception of barriers to adoption, training for using these systems, best practices, and current regulations governing these systems. The analysis of the last two types of questions, regarding potential risks and AI governance, is not included in this paper due to space constraints and will be addressed in future publications.

Due to the different number of responses, we compare the relative frequencies of the main sociodemographic variables between baseline (1.311 responses) and endline (824 responses). As presented in Table 1, there are no differences in the relative frequencies by sociodemographic variables, which helps in the comparison among the surveys conducted as part of the CSdJ Course by the Universidad de los Andes.

Tab. 1 – Sociodemographic characteristics of participants at baseline and endline.

Sociodemographic variables		**Baseline**	**Endline**
Gender	Male	44.14%	46.05%
	Female	55.50%	53.58%
	Prefer not to answer	0.36%	0.36%
Position	Judge	19.00%	23.67%
	Magistrate	12.50%	11.04%
	Other judicial staff	68.51%	65.29%
Age range	Under 26 years old	1.73%	1.33%
	26–35	24.19%	24.76%
	36–45	35.55%	36.53%
	46–55	25.77%	25.24%
	56–65	11.42%	11.29%
	Over 65 years old	1.29%	0.73%
	Prefer not to answer	0.07%	0.12%

Notes: Percentages may not sum to exactly 100% due to rounding.

3.1. CSdJ Course Surveys

The CSdJ Course taught the fundamentals of AI for the administration of justice to personnel in the Judicial Branch of Colombia. The course examined how various AI technologies are utilized by the judiciary across different jurisdictions, their potential benefits and risks, and avenues for preventing serious risks such as the violation of fundamental rights. The primary objective of the course was to develop and strengthen competencies for the responsible use of AI systems in the administration of justice.

The course comprised 18 class sessions organized into three modules: 1) Fundamentals of AI, 2) Applications in the justice sector and ethical framework for the use of AI, and 3) Good practices in the implementation of AI systems within the justice sector. In total, each student had the opportunity to have 50 hours of training: 35

in remote and synchronous sessions (through the Zoom platform) and 15 in asynchronous sessions (through Bloque Neón, the digital platform of the Universidad de los Andes).

The course was attended by 1,400 students who voluntarily registered following the call for applications issued by the CSdJ in December 2023. The students who registered for the CSdJ Course represented almost 4% of the total number of judicial officers in the country. The CSdJ established the following requirements for pre-enrollment in the course: 1) To be an employee of the Judicial Branch, with a continuous relationship of no less than three years; 2) Not to have a disciplinary record and 3) To have complied with the academic activities to which he/she has been previously admitted.

Participation in the course was balanced in terms of gender; 54% of the students were female (767) and 45% were male (633). Thirty-seven percent of the students who participated in the CSdJ course were between 36 and 45 years of age, followed by 24% of students between 26 and 35 years of age and 24% between 46 and 55 years of age. The remaining percentage of students belonged to a different age group. Thanks to the virtual format of the course, students from 138 municipalities in the country, located in 27 of Colombia's 32 departments, in addition to the capital, Bogotá, were able to participate (Figure 1a). Bogotá stood out as the city with the highest judicial personnel participation (341), followed by Medellín (81) and Cali (52).

As part of the activities implemented during the CSdJ Course, participants were asked to answer a survey at the beginning of the course (after being introduced to basic concepts of AI, such as what an AI tool is) and another one at the end of the course. The baseline survey was answered by 1,391 students (99% of registered judicial personnel), while the endline survey obtained 824 responses (58% of registered judicial personnel). One reason for the lower response rate in the endline survey is that completing the questionnaire was not mandatory for course certification, and by the end of the course, some students may have been less willing to participate voluntarily. Despite repeated efforts to distribute the questionnaire, the responses could not be matched to those from the baseline survey.

3.2. Survey administered by the CSdJ

The third survey was directly administered by the CSdJ between July 11 and 26, 2024. The CSdJ's survey was answered by 3,152 judicial officers throughout the country (Figure 1b). In this sense, more than 8% of Colombia's judicial personnel responded to this survey conducted by the CSdJ. The survey inquired about the use of AI systems, the perception of relevant AI regulatory guidelines, and the perceived ethical risks associated with the use of such systems.



(a) Number of students who participated in the CSdJ Course by department.

(b) Number of judicial personnel who responded to the CSdJ survey by department.

Fig. 1 – Location of judicial personnel participating in the CSdJ Course (left picture) and judicial personnel who responded to the CSdJ survey (right) by Department.

As can be seen in figure 1b, Bogotá presents the highest frequency of judicial officers who responded (689); Antioquia is the territorial jurisdiction with the second highest number of judicial officers (496). On the other hand, there were no responses from judicial officials in three departments of the country: Guainía, Vaupés and Vichada.

3.3. Survey data processing

Most of the questions in the three surveys provided multiple options for the judicial officers to choose from. These responses were sorted, and the resulting databases were organized to obtain basic descriptive statistics and generate various visualizations to represent them. The surveys also included some open-ended questions in order to better understand and analyze the multiple-choice answers provided by the participants. The open-ended questions analysis is not included in this paper due to space constraints and will be addressed in future publications.

4. Main Findings

4.1. Familiarity with the AI systems of judicial personnel.

To evaluate the use of AI systems and their various aspects, we chose to compare the results of the initial measurement conducted on the participants of the CSdJ Course with those of the final measurement. It is pertinent to mention that the judicial staff responded to the first survey after being exposed to basic concepts, such as what an AI system is, while the second survey was completed by the end of the course when students had finalized 50 hours of training. Where information was available, the results were compared with those obtained from the survey directly administered by the CSdJ. To facilitate the comparability of the results before and after, we chose to analyze the relative frequencies.

As shown in Figure 2, at the end of the course, the perceived familiarity with AI systems increased. Before starting the training, 63% of the trainees indicated that they had no or little knowledge of AI systems; this result contrasts with the 85% of trainees who indicated that they had moderate or a great deal of familiarity with these systems at the end of the course. It is worth noting that, at the end of the training, the percentage of older judicial personnel who perceived themselves to be experts in the use of AI systems did not change. As mentioned before, the level of familiarity with AI systems perceived by judicial officers in Colombia is relatively lower than that reported by judicial operators responding to the UNESCO Global Survey.

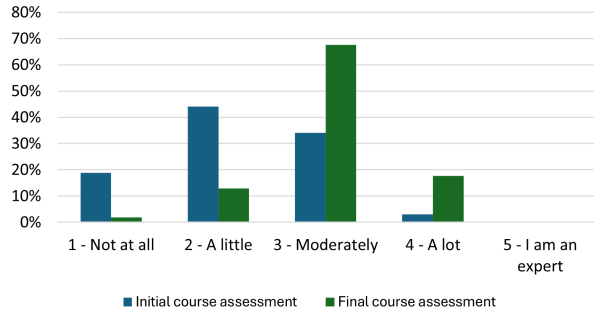


Fig. 2 – Familiarity with AI systems of judicial personnel (comparison before and after the CSdJ Course).

To evaluate the variations of relevant questions according to demographic variables such as gender and age, as well as the frequency of AI system usage, the differences observed exclusively in the entry survey of the CSdJ Course were compared using relative frequencies. First, with respect to the gender of the participants, it is observed that women responded having no or little familiarity with AI systems to a greater extent than men; for their part, men who indicated having moderate familiarity with these systems are 38% of the total, compared to 30% of women; finally, the minority of respondents indicate having a lot of knowledge or being experts in the use of AI systems (Figure 3).

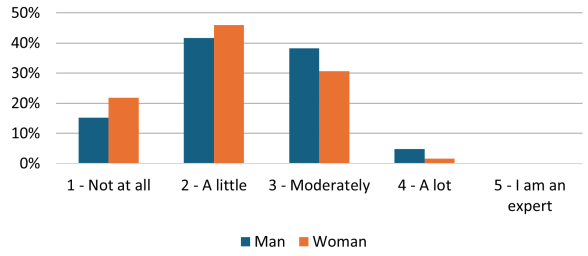


Fig. 3 – Comparison by gender of the familiarity with AI systems of judicial officers who participated in the Course.

When comparing familiarity with AI across different age ranges of the respondents in the CSdJ Course entry survey, several aspects stand out (Figure 4): Generally, it is observed that as age increases, the level of null familiarity with these systems rises; this relationship is inversely related to moderate familiarity. Therefore, it is noted that older judicial personnel tend to have less familiarity with AI systems.

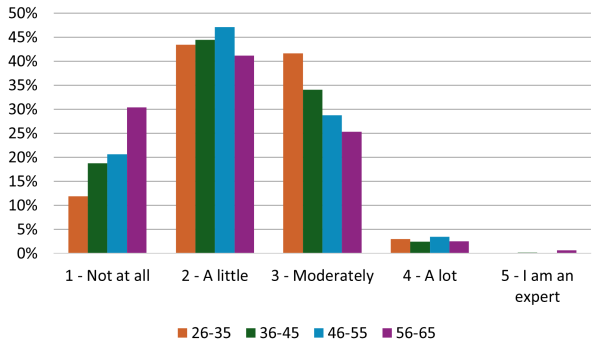


Fig. 4 – Comparison by age range of the familiarity with AI systems of the judicial officers who participated in the CSdJ Course. Observations for judicial personnel under 26 and over 65 are omitted since together they represent less than 2% of the data.

4.2. Uses of AI systems by judicial personnel.

The survey administered by the CSdJ asked judicial personnel if they had used "any AI tool or application that helps you make your job easier or faster." 29% of those who responded to the survey answered affirmatively (920 judicial personnel).

The two surveys conducted as part of the CSdJ Course also asked about the use of AI and GAI tools. At the beginning of the course, 34% of the trainees reported having used some AI tool for work purposes, and 26% reported having used GAI tools for the same purposes (Figures 5 and 6).

These data suggest that the learners who enrolled in the CSdJ Course and answered the course's baseline survey tended, on average, to be slightly more likely to use AI tools at work than the judicial personnel who answered the survey directly administered by the CSdJ. This observation is likely because students in the CSdJ Course had a greater interest in these tools, which is why they enrolled in the course (in short, a self-selection factor may contribute to explaining the different results). As mentioned before, these frequencies of use reported by judicial personnel in Colombia are somewhat lower than those reported by judicial operators who responded to the UNESCO global survey.

At the end of the CSdJ Course, the percentages reporting the use of AI systems for work-related issues increased significantly: 56% for any AI tool and 44% for GAI tools (Figures 5 and 6). These results suggest that the CSdJ Course may have influenced a significant number of students to use AI tools in their work for the first time and that lacking basic training is a barrier to testing and adopting these types of tools for work purposes.

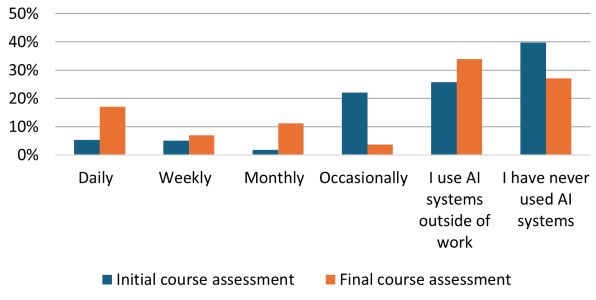


Fig. 5 – Frequency of use of AI systems (comparison before and after the CSdJ).

When studying the frequency of use of AI systems before and after the CSdJ Course, an increasing trend in use was observed after the course (Figure 5). Specifically, before the CSdJ Course, 39% of the trainees had never used AI systems, while this percentage dropped to 27% after the course. Similarly, the percentage of judicial personnel who began to use these systems in areas other than the workplace increased, as indicated by the students' responses, which showed an approximately 8% rise after the CSdJ Course. The greatest variation was observed in the percentage of trainees who used AI systems daily. Before starting the CSdJ Course, only 5% reported using these systems daily, compared to 17% at the end of the course. The percentage of judicial

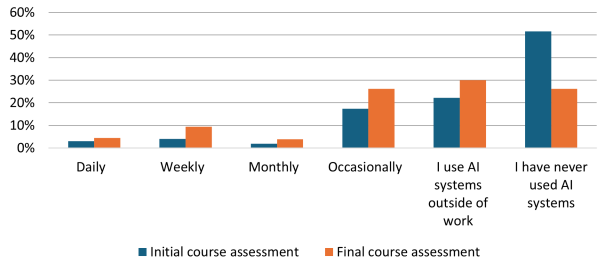


Fig. 6 – Frequency of use of AI chatbots (comparison before and after the CSdJ).

officers who started using these systems on a weekly and monthly basis also increased at the end of the CSdJ Course.

A similar pattern is observed with respect to the frequency of use of GAI systems (AI chatbots) to perform work activities (Figure 6). Before starting the CSdJ Course, 52% of judicial personnel reported never having used GAI systems, while at the end of the course, this figure dropped to 26%. The largest increase in reported use of AI chatbots after the CSdJ Course was for occasional use for work activities, which rose from 17% to 26%. To a lesser extent, daily, weekly, and monthly work-related use also increased after the CSdJ Course.

On the other hand, when comparing the frequency of AI system use by men and women, the largest difference lies in the reported lack of experience using these tools. Specifically, 35% of men reported never having used AI systems, compared to 44% of women. Regarding the frequency of use of AI systems for work purposes, most of the responses reported by men and women (daily, weekly, and occasional use) were relatively similar (Figure 7).

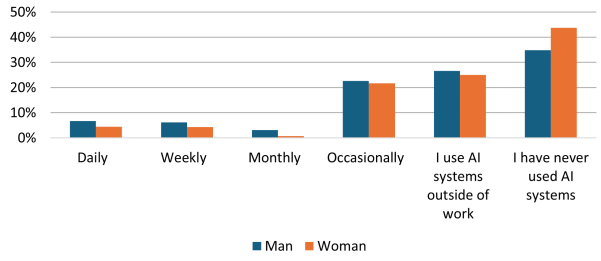


Fig. 7 – Comparison by gender of the frequency of use of AI systems by the judicial officers who participated in the Course.

In addition, when comparing the variations in the frequency of use of AI systems by age range, it is observed that, for each age range, approximately 40% of judicial personnel stated in the CSdJ Course entry survey that they had never used AI systems (Figure 8). Regarding all frequencies of use of AI systems for work tasks, there are no differences greater than 6% between age ranges.

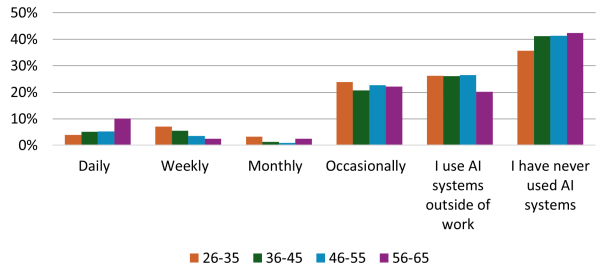


Fig. 8 – Comparison by age range of the frequency of the use of AI systems by judicial officers who participated in the CSdJ Course. Observations for judicial personnel under 26 and over 65 are omitted since together they represent less than 2% of the data.

However, these differences are mainly observed when comparing 26 to 35 years age group with the 56 to 65 years age group. In this regard, 10% of the judicial personnel between 56 and 65 years of age reported using AI systems daily, compared with 4% of those between 26 and 35 years of age. In this case, only 20% of judicial personnel aged 56 to 65 reported using these tools outside of work, while 26% of all other judicial personnel reported using these tools outside of work.

In sum, although, on average, younger trainees tended to report a greater familiarity with AI systems than older trainees, the propensity to use AI systems for work purposes does not diverge much between the age ranges of the judicial officers who responded to the CSdJ Course start-up survey.

4.3. What AI systems are used in the Judicial Branch?

In addition to identifying the main reasons for using AI systems, participants in the CSdJ Course were also asked about the specific systems they use in their professional activities. The word cloud (Figure 9) illustrates the AI tools most frequently mentioned by the respondents. Notably, *ChatGPT* (128 mentions) emerged as the most cited tool, with a frequency three times higher than that of the second most mentioned tool, *Copilot* (56 mentions). All other tools received fewer than 16 mentions, with *Gemini* (16 mentions), *Microsoft* (7 mentions), and *SAMAI* (5 mentions) standing out.



Fig. 9 – AI systems most commonly used at work by judicial officers who participated in the Course.

It should be noted that *SAMAI* is not currently considered an AI tool. Rather, it is a digital platform used within the contentious-administrative jurisdiction, offering functionalities such as online consultation of judicial case information, document authenticity validation and verification, and virtual document filing.

The survey conducted directly by the CSdJ also included a closed-ended question regarding the tools used by judicial personnel (Figure 10). Unlike the open-ended format used in the Course questionnaire, this version asked respondents to select tools from a predefined list. Nonetheless, the findings were consistent with those from the Course responses. *ChatGPT* was again the most frequently selected tool, with twice the number of mentions as *Copilot* (Microsoft), the second most used tool, followed by *Gemini* (Google) and *Bing* (Microsoft).

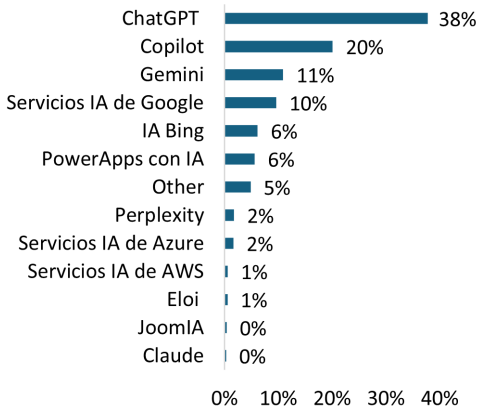


Fig. 10 – AI systems used by judicial personnel who responded to the CSdJ's surveys.

4.4. How are GAI systems being used in the Judicial Branch?

In the three surveys, judicial personnel were asked about their use of GAI systems to carry out professional activities. The question was presented in a multiple-choice format (with predefined subcategories of use), but allowed judicial personnel to add other types of uses if deemed necessary.

Figure 11 presents the most common uses reported by survey respondents: searching for caselaw (59%); searching for legislation (49% to 52%, which increased after completing the course); searching for meanings and definitions (increased from 46% to 51% by the end of the course); other uses (42% to 47% by the end of the course); and summarizing texts (40% to 41% by the end of the course) are the primary reasons judicial personnel utilize GAI systems.

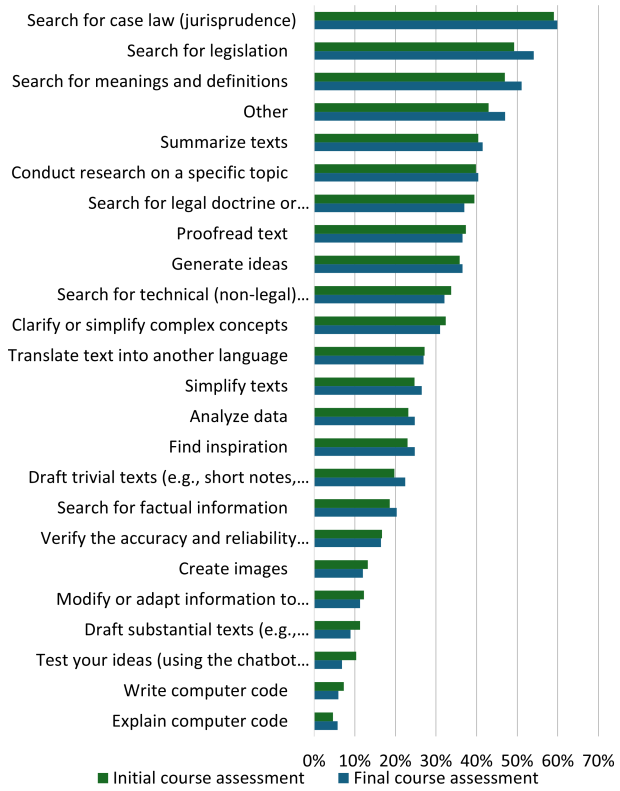


Fig. 11 – Uses of AI chatbots for work activities reported by judicial personnel (before and after the CSdJ's course).

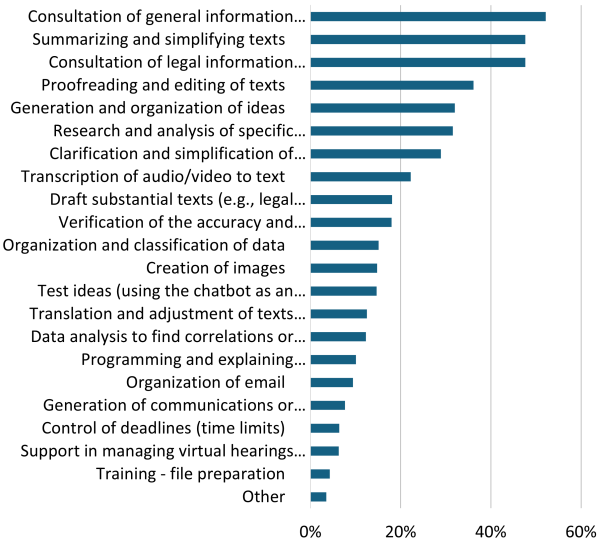


Fig. 12 – Uses of AI chatbots for work activities reported by judicial personnel who responded to the survey conducted directly by the CSdJ.

There is no major variation in the order of the most frequent uses reported by the students; however, in most cases, there is a slight increase in the reporting of each respective use, suggesting that the CSdJ Course may have diversified the types of uses to which judicial personnel apply AI chatbots. Additionally, a significant percentage of respondents indicated "other uses" apart from those listed in the survey question, highlighting the importance of further research into the potential applications that judicial personnel make of these tools.

Regarding the results of the survey conducted directly by the CSdJ (Figure12), the most common work uses that judicial personnel assign to AI chatbots were: consulting general information (52%), consulting legal information (48%), summarizing and simplifying texts (48%), proofreading and editing texts (36%), and generating and organizing ideas (32%).

The CSdJ Course surveys also sought to identify how learners used the responses generated by the AI chatbots. A very low percentage of respondents answered that they used the chatbot-generated response "without any verification or correction" (between 4% and 1% before and after the course, respectively). The vast majority of court judicial personnel either verify or correct the information before using it or use it to understand the issue and then formulate their own text (Figure 13). This result is similar to the one reported in the UNESCO global survey.

The main difference observed in the measurements at the beginning and end of the CSdJ Course is that the total number of judicial personnel that report verifying and correcting the information provided by the chatbots increases by 11 percentage points. This variation decreases by 8 percentage points with respect to the rate of judicial personnel who report using the information to learn and understand the information provided.

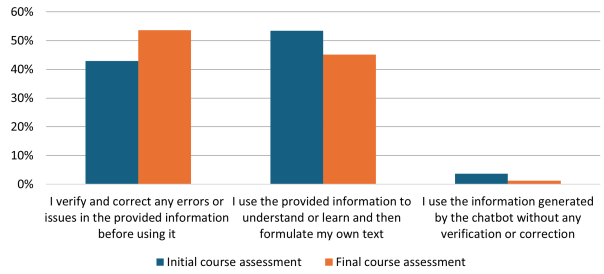


Fig. 13 – Form of use of the results generated by the chatbots (comparison before and after the CSdJ course).

When studying the responses on how the chatbots' results are used, distinguished by gender, it is observed that 56% of women reported using the information received to analyze it and better understand the context, compared to 50% of men (Figure 14). For both genders, less than 5% reported the information from the chatbots without any verification or correction, but it is worth highlighting that the proportion of women reporting this practice was half that of men.

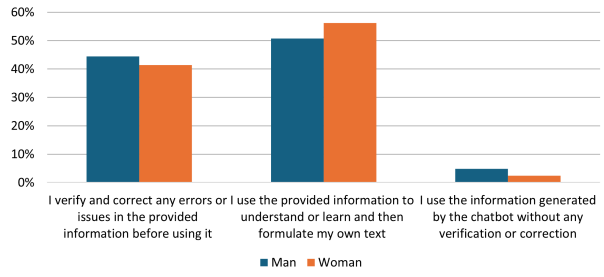


Fig. 14 – Comparison by gender of form of use of the results generated by the chatbots.

When comparing the results of chatbot usage by age, no significant differences were observed among the age groups. However, students aged 56 to 65 reported that they utilized the information to a greater extent (66%) for understanding or learning while also indicating that they wrote their own texts.

5. Conclusions

This research sought to answer fundamental questions about how judicial personnel in Colombia use AI systems in their work. The study was based on three surveys conducted among various types of judicial personnel in Colombia between January and July 2024. The first survey was completed at the beginning of the CSdJ Course by 1,391 judicial personnel, the second upon completion of the course by 824 judicial personnel, and the third survey, administered directly by the CSdJ, involved 3,152 judicial personnel. These are the largest surveys conducted to date in Colombia on the subject and among the largest in the world.

In this section, we synthesize the main findings of the surveys and reflect on the policy implications derived

from these findings, which are primarily relevant to the Colombian Judicial Branch but may also provide insights for organizations that govern the Judicial Branch in other countries.

5.1. Familiarity with AI systems

The familiarity with AI systems exhibited significant changes before and after completing the CSdJ course. In general, the percentage of learners with moderate or high knowledge of AI systems increased (85%). This degree of familiarity is lower compared to that evidenced by the judicial personnel who responded to the CSdJ survey. Concerning gender, women showed lower familiarity with these systems compared to men. When comparing age, there was a higher proportion of null familiarity among the older age range.

These findings suggest that awareness among judicial staff regarding the existence and relevance of AI tools is high even though the availability and access to tools such as AI chatbots proliferated relatively recently, in late 2022. Moreover, awareness is expected to increase as the adoption of these technologies is a priority in many jurisdictions, including Colombia.

5.2. Use of AI systems

Regarding the use of AI systems, 29% of the judicial officers who responded to the CSdJ survey indicated that they had used them to facilitate their work. This is in line with the percentage of students who took the CSdJ course and reported using AI systems (34%) and GAI (26%) for the same purposes before starting the course. Furthermore, at the end of the course, the use of these AI tools (55%) and GAI (43%) increased considerably. This suggests that one of the main barriers to using AI tools to support labor-related activities is a lack of basic training, such as understanding how these tools are developed, what types of tools are available, their limitations, and associated risks (key topics addressed in the 50-hour CSdJ Course).

Similarly, the frequency of AI system usage increased by the end of the course; the percentage of judicial personnel who had never used AI systems dropped from 39% to 27%, and for GAI systems from 52% to 26%. Moreover, the daily use of AI tools rose from 5% to 17%. This suggests that basic training on the use of AI tools can increase not only the likelihood of using the tools but also the frequency of use, thereby enhancing the impact (both positive and negative) of AI in the administration of justice.

Moreover, the tendency to use AI systems for work purposes does not vary significantly across the age ranges of the judicial personnel who responded to the CSdJ Course survey. This finding challenges the notion that younger workers are more likely to use AI tools than their older co-workers. However, participants in the CSdJ Course survey may be more likely to use AI tools than the judicial staff who did not take the course since their enrollment in the training was voluntary and may signal their original interest in using the tool regardless of their age or gender.

The findings also challenge the notion that members of the judiciary are generally resistant to innovation or reluctant to change the way work is conducted. Moreover, the fact that 1,400 magistrates, judges, and judicial staff voluntarily enrolled in a 50-hour AI course signals the demand for learning about new tools.

5.3. Access to AI systems

The majority of students who responded to the CSdJ baseline and exit surveys indicated that they accessed free versions of AI tools, whereas fewer than 20% paid for access to AI systems or indicated that the Judicial Branch provided the tools. This has important implications regarding the security of the information and, consequently, for the protection of privacy and personal data. Most companies that offer free versions of AI chatbots state in their terms of use that the information provided by users may be used for future training of models and that it may be shared with third parties (Gutiérrez, 2024a). Therefore, the use of these types of tools by judicial officials can jeopardize the confidentiality of information related to the judicial process and put fundamental rights at risk.

A key implication of this finding is that the judiciary needs to take action to prevent information breaches through a combination of human, technical, and administrative measures. These measures include prohibiting the use of generative AI tools that are offered for free or specifying which AI tools can be used (these can

take the form of rules or technical solutions, such as blocking access to the tools on institutional devices); alternatively, mandating that any information and documents introduced into these AI systems are anonymized and free from reserved data; providing alternatives for judicial staff to access generative AI tools that offer higher levels of information security and personal data protections; and, lastly, enhancing basic digital literacy skills through training programs.

In the case of the Colombian judiciary, some of these measures were taken by the end of 2024. Through the Agreement PCSJA24-12243 of December 16, 2024, the CSdJ adopted its guidelines "for the respectful, responsible, safe, and ethical use and exploitation of artificial intelligence in the Judicial Branch." The guidelines established "security of information" and "personal data protection and privacy" as two of the principles that must be abided by when using AI tools (article 1) and established that judicial personnel should "abstain from using general or commercial AI chatbots in its free versions" (article 8.1).

5.4. Reasons for using AI systems

The reasons for using AI systems among the judicial staff are diverse. Among the main reasons, five main categories were identified: systematization, writing, learning, idea generation, and analysis. Regarding the tools with the highest frequency of use by CSdJ Course participants, ChatGPT was the most frequently mentioned tool, followed by Copilot and Gemini. This result is similar in order of hierarchy to that observed in the responses of the judicial personnel who answered the survey administered by the CSdJ. However, the reported use of AI tools in the Colombian judiciary may have changed in 2025 due to the prohibition on using the free version of AI chatbots established by Agreement PCSJA24-12243, and because Copilot Chat is now available for Microsoft 365 business customers.

The survey's findings also highlight the need for the Colombian judiciary to provide a more diversified set of AI tools that are accessible to all or most of its judicial staff. Following the example of other Latin American jurisdictions, such as tools for assisted search of case law available for judicial staff and the general public (in late 2024, the Constitutional Court of Colombia launched such a tool for constitutional case law); automatic classification of documents submitted in judicial processes and assignment of those documents in workflows; anonymization tools; editing and summarizing AI tools; translation tools, both for text and live verbal translation; and tools for transcribing audio recordings of hearings (Muñoz-Cadena et al., 2025).

5.5. How GAI systems are used

When evaluating how the students of the CSdJ Course used GAI tools, the survey suggests that the highest priority was given to tasks related to information search and document writing, in that order. The result was similar to that shown in the survey conducted directly by the CSdJ, with the difference that document writing emerged as the most relevant category, followed by information search. These results align with the findings of UNESCO's Global Survey on the use of AI tools by judicial operators. When evaluating specific tasks, searching for jurisprudence remained unchanged at 59% after completing the course; searching for legislation increased from 49% to 52% after completing the course, and searching for meanings and definitions rose from 46% to 51% after completing the course, representing the main functions that CSdJ Course students assigned to these tools.

The predominant use of GAI tools to search for information generates additional risks, especially considering that most respondents access free versions of the systems. Given that there is a high probability that the answers provided by AI chatbots are imprecise, incorrect, or even false, a judicial official who does not contrast these outputs with reliable sources may make baseless decisions. (Gutiérrez, 2024a) has already mapped situations in which justices used AI chatbots in Bolivia, Brazil, Colombia, Peru, and Mexico to draft rulings and intervene in judicial hearings by copy-pasting answers or reading them out loud without checking on the reliability of the chatbot's output.

Moreover, the survey highlights the limitations of AI training in shaping the practical application of AI tools. While the CSdJ Course stressed the limitations of AI chatbots to participants, and even though the surveys indicated that the judicial staff were aware of the quality issues of AI chatbots, they still used them as a tool for searching for information. A policy implication from this finding is that the Judiciary cannot rely on a single type of action to ensure the responsible use of AI tools (e.g., training); it needs to complement various technical and regulatory measures.

5.6. Limitations and future research

Our research has several limitations, and there are potential future avenues of inquiry. First, the respondents of the three surveys were not selected randomly, nor were specific measures taken to ensure the representativeness of the samples. For example, the judicial staff that self-enrolled in the CSdJ Course and answered the corresponding start and end-line surveys were likely more interested in AI tools than their average peers, making them more prone to report higher and more diverse use of AI tools. Moreover, the design of the surveys did not allow for the identification of the effects of the training since there were no treatment and control groups.

Second, while the surveys allow for the identification of specific trends among the respondents, another data collection strategy—such as semi-structured interviews—would be necessary to understand why such trends arise and to provide a deeper interpretation of the survey results. Furthermore, this paper did not address other important aspects of AI tool deployment and usage in the justice sector, including specific perceptions of the risks associated with using AI tools and the need for AI governance arrangements. While the CSdJ Course surveys included questions on these topics, due to space constraints, we could not discuss them in this paper.

Finally, future research could explore in-depth cases of specific AI tools used by the judiciary in Colombia to understand how they are (or are not) changing labor roles and occupations within the judiciary and their impact on particular tasks, such as case management, decision-making processes, and drafting rulings.

Acknowledgement

The authors of this paper would like to thank the Superior Council of the Judiciary for allowing access to the anonymized data from the survey of Judicial Branch employees.

Contributor Statement

Table 2 presents the contributions of the authors to the development of the article, detailing the specific responsibilities of each during the research and writing process.

Tab. 2 – Authors' Contribution and Statement

Role	Author a	Author b
Conceptualization	Yes	No
Data Curation	No	Yes
Formal analysis	No	Yes
Funding acquisition	Yes	No
Investigation	Yes	Yes
Methodology	Yes	Yes
Project administration	Yes	No
Software	No	Yes
Supervision	Yes	No
Resources	Yes	No
Validation	Yes	No
Visualization	No	Yes
Writing – Original Draft	Yes	Yes
Writing - Review & Editing	Yes	Yes

Notes: This table describes the contribution of each author to the article.

Use of AI

During the preparation of this work, the authors used ChatGPT (model GPT-4) and Claude (model 3.7) to assist in the construction of tables and the revision of the English text. After using this tools, the authors reviewed, edited, made the content their own and validated the outcome as needed, and takes full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

CEPEJ. (2024). Resource centre cyberjustice and ai [European Commission for the efficiency of justice (CEPEJ)].

Conselho Nacional de Justiça. (2024). O uso da inteligência artificial generativa no poder judiciário brasileiro: Relatório de pesquisa. https://www.cnj.jus.br/wp-content/uploads/2024/09/cnj-relatorio-de-pesquisa-iag-pj.pdf

Corte Constitucional. (2020). Pretoria, un ejemplo de incorporación de tecnologías de punta en el sector justicia.

Corte Constitucional. (2024). Abc pretoria [Corte Constitucional].

Estevez, E., Linares, S., & Fillottrani, P. (2020). *Prometea: Transformando la administración de justicia con herramientas de inteligencia artificial*. Banco Interamericano de Desarrollo. DOI: https://doi.org/10.18235/0002378.

Gutiérrez, J. D. (2020). Retos éticos de la inteligencia artificial en el proceso judicial. In ICDP (Ed.), *Derecho procesal. nuevas tendencias. xli congreso colombiano de derecho procesal*. Instituto Colombiano de Derecho Procesal (ICDP) y Universidad Libre. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4011179

Gutiérrez, J. D. (2023a). Chatgpt in colombian courts: Why we need to have a conversation about the digital literacy of the judiciary [VerfBlog].

Gutiérrez, J. D. (2023b). Hablemos sobre el uso de chatgpt para redactar decisiones judiciales [La Silla Vacía].

Gutiérrez, J. D. (2023c). Judges and magistrates in peru and mexico have chatgpt fever [Tech Policy Press].

Gutiérrez, J. D. (2023d). A jueces y magistrados de perú y méxico también le cayó la «fiebre» de chatgpt [Agenda Estado de Derecho].

Gutiérrez, J. D. (2024a). Chapter 24: Critical appraisal of large language models in judicial decision-making. In *Handbook on public policy and artificial intelligence* (pp. 323–338). Edward Elgar Publishing. DOI: https://doi.org/10.4337/9781803922171.00033.

Gutiérrez, J. D. (2024b). Document for consultation: Draft unesco guidelines for the use of ai systems in courts and tribunals [United Nations Educational, Scientific and Cultural Organization (UNESCO)].

Gutiérrez, J. D. (2024c). Unesco global judges' initiative: Survey on the use of ai systems by judicial operators [United Nations Educational, Scientific and Cultural Organization (UNESCO)].

Gutiérrez, J. D., & Muñoz-Cadena, S. (2023). Adopción de sistemas de decisión automatizada en el sector público: Cartografía de 113 sistemas en colombia. *GIGAPP Estudios Working Papers*, *10*(270), 365–395.

LexisNexis Legal & Professional. (2023). Generative ai & the legal profession: 2023 survey report. https://www.lexisnexis.com/pdf/ln_generative_ai_report.pdf

Ministro do Superior Tribunal de Justiça. (2020). Artificial intelligence: Technology applied to conflict resolution in the brazilian judiciary [Fundação Getulio Vargas].

Muñoz-Cadena, S., Gutiérrez, J. D., Castellanos-Sánchez, M., & Peralta, D. S. (2025). Sistemas de ia en el sector público de américa latina y el caribe (versión v2.3) [Abril de 2025].

Saavedra, V., & Upegui, J. C. (2021). Pretoria y la automatización del procesamiento de causas de derechos humanos [Derechos Digitales América Latina y Dejusticia].

Thomson Reuters. (2024). 2024 generative ai in professional services. https://www.thomsonreuters.com/en/reports/2024-generative-ai-in-professional-services

UNESCO. (2023). Kit de herramientas global sobre ia y el estado de derecho para el poder judicial [Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura].

Track 11: GovTech and Digital Autonomy

Track Description

Governments no longer hold monopolies on designing and delivering digital solutions for the public sector. Under the GovTech label, startups, scaleups, and multi-helix initiatives are pounding at the gates with digital solutions built on state-of-the-art technologies. Examples include AI-based digital assistants for citizens and public professionals, digital identities, data wallets, and digital twins. Institutions such as the World Bank and the World Economic Forum have highlighted the significance of the rise of GovTech across both developing and developed countries. The European Commission stimulates GovTech development through the Interoperable Europe Act, a public-private collaboration for digital transformation in the public sector. While there are opportunities in embracing GovTech, risks include long-term stability, transparency, and safety. Considering current geopolitical tensions, the lack of strategic digital autonomy is also becoming a growing concern. Many public agencies depend on a few BigTech corporations for critical processes. This dependence can hamper the implementation of new policies, impede innovation, and promote problematic vendor lock-in. Digital autonomy is multi-dimensional, and policymakers struggle to shape adequate instruments. So, the track aimed to gather studies on the opportunities, risks, and potential mitigation strategies, and showcase GovTech and digital autonomy developments worldwide.

Track Chairs

N. Bharosa, Delft University of Technology, The Netherlands
T. Janowski, Gdańsk University of Technology, Poland; University for Continuing Education Krems, Austria
L. Pinheiro, Positivo University, Brazil
Y. K. Dwivedi, Swansea University, United Kingdom

Contents

Breaking Tech Monopolies: The Role of Public Procurement in Fostering SME-Led Innovation in Europe 684
J. *Westermann, G. Klassen, L. T. Bauer, and R. Fritzsche*

Diversity in GovTech: Who's Represented in Innovative Technology Supplied to Public Administration? 699
L. T. Bauer, M. Wyszynski, and B. Niehaves

From Complexity to Clarity: A Taxonomy of GovTech Startup Business Models for Public Sector Innovation 713
L. Daßler, T. Ruckstuhl, A. Hein, and H. Krcmar

Move Fast and Break Things? Barriers to GovTech Procurement in the United Kingdom 728
N. Davies, K. McBride, and M. Kleinaltenkamp

Breaking Tech Monopolies: The Role of Public Procurement in Fostering SME-Led Innovation in Europe

Jan Westermann[a*], *Gerhard* Klassen[b], *Luca T.* Bauer[c], *Robin* Fritzsche[d]

[a]Digital Public, University of Bremen, Bremen, Germany, westerma@uni-bremen.de, 0009-0009- 3004-1982.
[b]Digital Public, University of Bremen, Bremen, Germany, gerhard.klassen@uni-bremen.de, 0000-0002-1458-6546.
[c]Digital Public, University of Bremen, Bremen, Germany, bauerl@uni-bremen.de, 0009-0003-6140-9918.
[d]Digital Public, University of Bremen, Bremen, Germany, robfri@uni-bremen.de, 0009-0002-8784-585X.
Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. The growing dominance of large technology companies in Europe's digital markets raises concerns about innovation concentration, limited competition, and reduced technological sovereignty. Public procurement represents a powerful yet underutilized instrument to address these dynamics by enabling smaller firms to compete, innovate, and scale within critical sectors. This study examines how public procurement can strengthen innovation capacity and economic diversity in the European information and communication technology sector. Focusing on the participation of startups and small businesses, we provide large-scale empirical evidence on structural barriers and market concentration in cross-border procurement practices. Our study reveals that public procurement systems often reproduce existing power asymmetries, despite policy ambitions to foster inclusivity and competition. Our findings highlight the significance of procedural complexity, limited outreach, and insufficient institutional capacity as key obstacles to startup participation. Moreover, we show that small and medium sized companies are far from homogeneous, necessitating targeted policy responses rather than uniform support measures. By framing startup inclusion as a systemic condition for innovation and digital sovereignty, the study contributes to ongoing theoretical debates on demand-side innovation policy and strategic governance. It also offers actionable insights for policymakers and procuring agencies aiming to design inclusive, innovation-oriented procurement ecosystems. In doing so, the study advances the academic discourse on public procurement and provides practical insights to support a more competitive and resilient European ecosystem by leveraging public procurement volume.

Keywords. Public Procurement, Digital Government, Startups, GovTech, SME, Innovation.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.973

1. Introduction

The rapid advancements in information and communication technologies (ICT) have spurred intense competition among major technology corporations. This race is characterized by the accumulation of intellectual monopolies through proprietary innovations, patents, and extensive data collection, resulting in the formation of highly concentrated tech oligopolies (Rikap and Lundvall, 2021). These powerful entities wield significant influence over the trajectory of technological development, innovation priorities, and market dynamics, often overshadowing smaller players in the industry.
Public procurement emerges as a crucial mechanism to drive innovation and foster a more balanced technological ecosystem in the European Union, accounting for an estimated 14% of its GDP. By strategically guiding

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

public procurement, governments can stimulate competition, promote technological diversity, and counteract the dominance of large tech firms. Public procurement programs that prioritize inclusivity and accessibility can provide startups and small and medium-sized enterprises (SMEs) with the resources, visibility, and opportunities needed to develop and deploy cutting-edge technologies (Commission, 2024). This approach, employed by the European Union among others, not only encourages innovation but also ensures that a broader range of stakeholders can contribute to and benefit from advancements in ICT (Commission, 2024).

In this paper, we focus on the role of public procurement in fostering competition and innovation within the European ICT ecosystem. While previous literature on e-procurement has emphasized digitalization and efficiency gains (Gunasekaran and Ngai, 2008; Vaidya et al., 2006), this technocratic lens often neglects the institutional and strategic complexity of public procurement. In the European context, it is deeply embedded in regulatory frameworks and political objectives, including innovation promotion, SME inclusion, and digital sovereignty (Edler and Georghiou, 2007; Edquist and Zabala-Iturriagagoitia, 2012; Uyarra et al., 2014). This paper adopts the latter perspective, situating public procurement as a policy instrument with transformative potential for the European digital ecosystem. Specifically, we analyze the market share of startups and small companies within the European public procurement landscape, examining their participation rates and success metrics (Niehaves et al., 2024).

Our research questions are as follows: What factors influence the access of startups and small to medium-sized enterprises (SMEs) in the ICT sector to public procurement opportunities at the European level? To what extent do the complexity and administrative burden of public procurement procedures impact the participation of startups and SMEs in European tenders?

This study contributes to the ongoing discourse on strategic public procurement by providing large-scale, empirical insights into how European market structures influence SME and startup participation (Lukkien et al., 2023; Niehaves et al., 2024). While prior research has examined general barriers to SME access, it often focuses on national case studies, lacks cross-sector comparability, or fails to differentiate between startups, micro-, small-, and medium-sized enterprises. By addressing these gaps, the study highlights how procurement design and administrative complexity shape competitive dynamics and outlines opportunities to foster a more dynamic and diversified procurement landscape—supporting the EU's broader goals of innovation, competitiveness, and digital autonomy.

The findings of our study underscore the importance of fostering transparency and accessibility in public procurement processes. Ensuring that smaller companies have equal opportunities to compete for contracts requires addressing structural barriers such as complex application procedures, lack of awareness, and limited organizational capacity. Our analysis reveals significant heterogeneity within the SME category, particularly between startups, microenterprises, and more established small and medium-sized firms, which has important implications for procurement design. One-size-fits-all approaches are insufficient; instead, differentiated and targeted measures are needed to address the specific constraints of distinct SME subgroups. Our research supports and extends the findings of Klassen et al. Klassen et al., 2024 by demonstrating that procurement systems can act as a counterweight to emerging tech oligopolies when designed to empower smaller actors. By conceptualizing SME inclusion as a structural feature of innovation systems, our work contributes to a more nuanced understanding of procurement as a policy instrument. Policymakers should consider targeted interventions, such as procedural simplification, tailored outreach, or quota-based incentives, to strengthen participation and promote inclusive innovation.

2. Theoretical Background and Relevant Work

Public procurement research gains relevance and traction, as scholars and policymakers recognize its potential to foster innovation and support the participation of small and medium-sized enterprises (SMEs)(Commission, 2024). It is important to distinguish between e-procurement and public procurement as two conceptually and practically distinct research strands. While e-procurement focuses on the digitization of procurement processes and the resulting administrative efficiencies (Gunasekaran and Ngai, 2008; Neupane et al., 2012), public procurement research is mainly concerned with the strategic governance of purchasing decisions to achieve broader societal goals (Edler and Georghiou, 2007; Edquist and Zabala-Iturriagagoitia, 2012). These include fostering innovation, addressing market failures, and enhancing digital sovereignty. In this regard, challenges specific to public procurement include complex stakeholder coordination, legal constraints, and multidimensional trade-offs between cost-efficiency, innovation, and inclusivity (Uyarra et al., 2014). A considerable body of work has emerged, focusing on understanding how recent procurement policies and practices can create opportunities for these firms, especially in local and regional markets (Grandia and Meehan, 2017). However, there remains a significant gap in the literature regarding the broader European public procurement landscape, where SMEs are still disadvantaged by aggregation of demand despite accounting for the

majority of European economy. Answering this gap we explore the market share of startups and SMEs in European procurement. In doing so, this paper considers the increasing reliance on big tech companies, a trend that poses potential risks to the EU's critical infrastructure and underscores the need for diversified and inclusive procurement practices to support a coherent and sovereign European innovation ecosystem (Bharosa, 2022; Roberts et al., 2021; Vardanyan and Kocharyan, 2023). Developing a robust understanding of public procurement market dynamics and the impact of procurement frameworks is essential for policymakers and practitioners to meet the strategic goals of public procurement.

2.1. Public Procurement Promoting Innovation

Research on public procurement as a driver of innovation dates back to the 1970s. Early empirical studies explored the relationship between procurement and innovation, concluding that public procurement has a more significant long-term impact on innovation than research and development (R&D) subsidies (Mowery and Rosenberg, 1979; Rothwell, 1984; Geroski, 1990). Their findings highlighted the potential of public procurement to stimulate demand-driven innovation. Despite these early insights, (Edquist and Hommen, 2000) argue that the promotion of innovation through public procurement has even declined in Europe during the 1990s due to the emergence of more stringent competition regulations. These regulations, while aimed at ensuring fairness and efficiency, have inadvertently limited the capacity of public procurement to serve as a catalyst for innovation (Edler and Georghiou, 2007).
More recently, however, the publication of numerous articles on public procurement promoting innovation (PPPI) reflects a renewed and heightened interest in the topic (Georghiou et al., 2014, Amann and Essig, 2015,Chicot and Matt, 2018, Wesseling and Edquist, 2018). Scholars have advocated for a more strategic use of public procurement as a tool to foster demand-driven innovation, emphasizing its potential to mobilize innovation on a large scale. Leveraging the extensive European public procurement landscape and its significant volume has been proposed as a way to stimulate innovation while simultaneously delivering improved services to citizens (Edler and Georghiou, 2007).
These arguments have influenced policy developments, culminating in the inclusion of strategic procurement goals in initiatives such as EU Directive 2014/24/EU or the Interoperable Europe Act (Commission, 2024). This directive explicitly articulates the strategic use of public procurement to promote innovation, marking a significant step toward embedding innovation objectives into procurement practices across Europe (Harland et al., 2021). Despite this progress, significant challenges remain. Amann and Essig, 2015 highlight time consumption and procedural complexity as major obstacles to the successful implementation of PPPI practices in the public sector. Additionally, their findings, aligned with those of Nyiri et al., 2007, reveal that modern public procurement often incorporates multiple objectives, such as cost savings, environmental sustainability, and social responsibility. These diverse goals are not always easily reconciled, as they frequently entail trade-offs. For example, prioritizing cost efficiency may conflict with the higher costs associated with procuring innovative products and services. Uyarra et al., 2014 conducted a supply-side survey identifying that lack of demand for innovation and lack of interaction with the procuring organisations are due to reduced contract sizes in pursuit of minimising transaction costs.
The type of procurement procedure employed plays a critical role in shaping innovative outcomes and SME access. According to Soliño and de Santos, 2010, the negotiated procedure is particularly conducive to innovation, as it facilitates a more detailed formulation and discussion of specifications and requirements. However, this approach entails higher time and resource expenditures compared to an open procurement process. The findings of Soliño and de Santos, 2010 are consistent with those of Uyarra et al., 2014, further supporting the notion that procurement design significantly influences innovation potential and multiple objectives may result in strategic dilemmas. This growing body of research underscores the need for a more strategic and nuanced approach to public procurement, one that balances competing objectives while leveraging its potential as a driver of innovation.

2.2. Roles of Startups in Innovation

Startups gain an increasing role as drivers of technological innovation (Bharosa, 2022; Niehaves et al., 2024). Innovation is understood here not only as technological novelty, but as the ability to generate, apply, and scale contextually relevant solutions that create systemic value across public and private sectors. This broad understanding aligns with Isenberg's concept of entrepreneurial ecosystems, where startups serve as dynamic agents of change embedded in interdependent networks of institutions, markets, and policy frameworks (Isenberg, 2010). In this view, fostering startup participation in public procurement contributes to innovation not merely by introducing new products, but by reshaping the structure of the innovation system itself.

This is particularly evident in the information technology field and public sector, where startups develop solutions that not only address specific market needs but also spur organizational digital transformation (Lukkien et al., 2023). By offering tools and platforms, startups empower public organizations to modernize their operations and enhance service delivery for their clients (Bauer, 2025). In the public sector, these innovations can lead to significant improvements in how public administrations interact with citizens and manage public resources (Bharosa and Janowski, 2024; Niehaves et al., 2024). However, the remaining and increasing dominance of BigTech companies (Jácome de Moura et al., 2024) introduces significant challenges for fostering innovation ecosystems, especially in Europe (Lukkien et al., 2023). In the context of this study, we define "Big Tech companies" as large multinational technology firms that exert disproportionate influence over digital infrastructure, data ecosystems, and innovation agendas, often through control of platforms, standards, and intellectual property rights. Their market power is reinforced by economies of scale, network effects, and high entry barriers for smaller actors (Rikap and Lundvall, 2021; Gleiss et al., 2023). This dependency exacerbates concerns regarding Europe's digital sovereignty, as reliance on non-European providers can expose vulnerabilities in terms of data control, security, and strategic autonomy (Rikap et al., 2024). Addressing such issues requires a response that aligns innovation policy with the principles of sovereignty and competitiveness, as becoming visible through the European Commissions endeavors like the AI and Interoperable Europe Act (Commission, 2024; Commission, 2022).
In the context of the European single market, public procurement holds the potential to bridge gaps for startups, enabling them to overcome barriers to entry and scale (Niehaves et al., 2024). However, these mechanisms are not without limitations. Market barriers, including cross-border challenges and preferential procurement practices, restrict the effective deployment of innovative solutions (Niehaves et al., 2024). By addressing market barriers and promoting a more inclusive approach to procurement, policymakers could significantly enhance the innovation landscape (Nose, 2023; Edquist and Zabala-Iturriagagoitia, 2012).
The participation of SMEs and startups in public procurement is not only a matter of economic inclusion but also of systemic innovation capacity. Building on the concept of National Innovation Systems (Lundvall, 1992), these firms act as vital carriers of knowledge diversity, experimentation, and adaptive innovation. Unlike large incumbents, startups often deliver context-specific, non-standardized solutions that challenge established technological trajectories and governance models. However, this lack of standardization introduces complexities for public buyers, who are often required to conform to strict procedural rules, risk-averse contracting standards, and interoperability constraints. As a result, the very heterogeneity that makes startups valuable for dynamic innovation ecosystems can conflict with procurement regimes optimized for stability and scale. Addressing this tension requires procurement frameworks that accommodate exploratory and learning-oriented interactions between public buyers and smaller, innovative suppliers (Uyarra et al., 2014).

2.3. SME Participation in Public Procurement

SME participation in the European procurement landscape has long been a focal point of interest. The European Commission has consistently addressed challenges and opportunities related to SMEs in public procurement, as reflected in numerous initiatives and policy documents (Commission, 1990; Commission, 2022; Commission, 2024). Recognizing the critical role of SMEs in driving innovation and economic growth, these efforts have sought to create a more inclusive and accessible procurement environment.
The barriers that impede SMEs from fully participating in the European procurement market were systematically examined by a recent study of the OECD, 2018. Their report on practices and strategies for shared benefits of SMEs in public procurement identified structural and procedural obstacles, such as complex administrative requirements, high tendering costs, and a preference for larger contracts, which collectively hinder SMEs' ability to compete effectively. These findings underline the persistent challenges that remain despite policy interventions aimed at enhancing SME access. To address these challenges, the European Commission introduced Directive 2014/24/EU, explicitly targeting SME inclusion in the procurement process. Among its key measures was the encouragement to divide contracts into smaller, more accessible lots, thereby reducing contract sizes to increase SME participation and improve their success rates. While this approach initially appeared promising, empirical studies have presented mixed results regarding its effectiveness (Glas and Eßig, 2018; Hoekman and Taş, 2022). Simply dividing tender contracts into smaller lots is insufficient to transform the European public procurement market into an innovative ecosystem Timmermans and Zabala-Iturriagagoitia, 2013. Successfully fostering startup and SME access while promoting innovation, requires a strategic and holistic approach (Timmermans and Zabala-Iturriagagoitia, 2013).
A related critique comes from Flynn et al., 2015, who examined disparities in tendering capabilities among SMEs, which are often mistakenly perceived as a homogeneous group. He highlighted that the current "one-size-fits-all" policy approaches fail to account for the vast differences between e.g. micro-enterprises and

medium-sized companies, all of which are collectively categorized under the term SMEs. By attempting to address the needs of such diverse entities simultaneously, these policies introduce additional complexity into procurement processes, frustrating public buyers and thereby further limiting the intended benefits for SMEs. Beyond the discussion on tender lot sizes, Directive 2014/24/EU also addressed procurement aggregation strategies in Articles 37 to 39. Aggregation techniques such as central purchasing bodies, framework agreements, and electronic catalogs were promoted as tools to enhance efficiency and achieve economic and administrative benefits. However, many researchers, including Sanchez Graells and Herrera Anchustegui, 2014 and Albano et al., 2010, have raised concerns about the potential negative consequences of these strategies. They caution that aggregated and centralized demand may lead to market concentration, suppressing SMEs and, over time, fostering oligopolistic competition that could undermine innovation and market diversity. Oligopolistic dependencies not only undermine the intended economic benefits of aggregation strategies but can also have adverse effects on digital sovereignty in areas such as critical infrastructure within Europe. Initial empirical evidence supporting these concerns has been found in the national Spanish procurement market (Arosa et al., 2025).
Building on these insights, this paper aims to investigate the factors influencing startup and SME access to public procurement at the European level, with a focus on the ICT sector. By addressing this gap, the study seeks to offer valuable insights into the challenges and opportunities for public authorities and decision-makers leveraging PPPI and promoting SME participation in the increasingly centralized and competitive procurement market. Additionally, the paper provides a robust methodology for utilizing the open government data platform, Tenders Electronic Daily (TED).

3. Data and Methodology

An exploratory quantitative methodology was adopted for this study to effectively answer the research question. The choice of this method aligns with the characteristics of the European procurement landscape, where a substantial volume of contract and award notices is published daily. The identification of data sources was grounded in a thorough review of the literature.

3.1. Data Sources

Building on the identified data sources from the literature review, the database for our analysis was compiled from three major sources: the procurement platform Tenders Electronic Daily (TED) 'European Union', n.d. firm-level data from the commercial database Orbis Moodyś, n.d. and the UN Treasury, which provided historical exchange rates 'United Nations', n.d.
TED is the official EU portal for high-value public procurement and mandated under Directives 2014/24/EU and 2014/25/EU. Its legal authority and accessibility make it highly suitable for analyzing procurement patterns relevant to EU innovation and digital sovereignty goals. In addition, TED offers rich metadata including procedure types, contract values, and buyer identities, enabling detailed structural analysis across sectors.
Firm-level data was sourced from Orbis due to its harmonized classification of SMEs and startups across countries, based on standardized financial and operational thresholds. Alternative sources such as national registers lack this consistency. Orbis also enables historical tracking and reliable firm identification via e.g. standardized company IDs, supporting clean integration with TED data.
This multi-source approach ensures policy relevance, analytical depth, and robust cross-country comparability for studying SME and startup participation in European ICT procurement.

3.2. Data acquisition

Building on the data sources introduced earlier, the process of data acquisition and preparation focused on collecting TED, Orbis, and UN Treasury data to construct a comprehensive and analyzable database. TED data served as the foundational source, providing detailed public procurement notices. Specific attention was given to extracting the winner field from the TED JSON documents, which included identifiers for successful bidders. These identifiers were mapped to individual countries using three-letter ISO country codes. However, a subset of entries with non-standard codes (e.g., "1A0") could not be mapped and was excluded from the analysis. To enable firm-level classification and enhance the granularity of the dataset, Orbis data played a pivotal role.

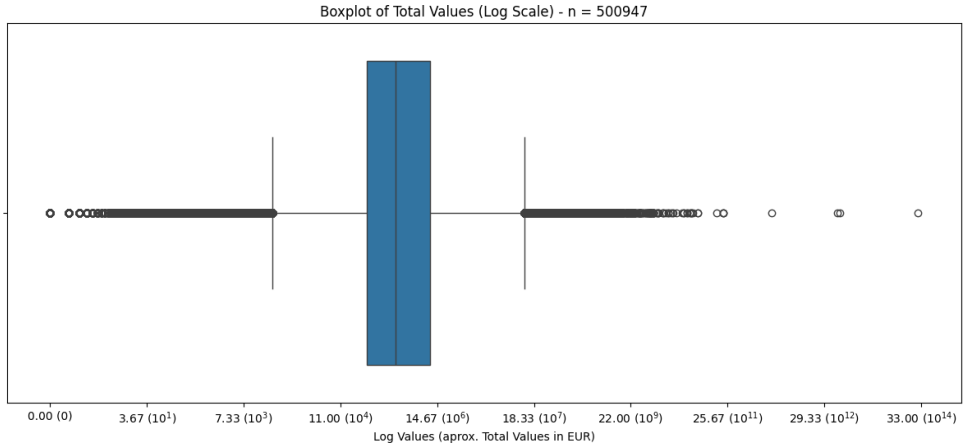


Fig. 1 – Boxplot of Total Values per Tender (Log Scale).

Orbis provided essential corporate information, which was crucial for categorizing entities, such as startups and SMEs, based on their size, operational scope and date of incorporation. Since country-specific identifier formats, such as VAT numbers, tax numbers, and commercial register entries, varied significantly, a systematic multi-step matching process was implemented. Identifiers were first queried within the most likely category for each country, and unmatched entries were subsequently searched in alternative categories. While this approach maximized the match rate, countries with insufficient Orbis coverage or unmappable identifiers were excluded from the final analysis.
The integration of TED and Orbis data required a robust storage and processing infrastructure. While TED data was initially stored in MongoDB for flexibility during processing, key fields were imported into a PostgreSQL relational database. PostgreSQL's capability to query JSON and array structures allowed for seamless integration of TED and Orbis data. Additionally, the database adhered to the first normal form by normalizing company identifiers into a separate table, ensuring efficient and atomic storage of values.
The fully integrated database enabled efficient querying and analysis through SQL operations, joins, and aggregations. By aligning tender data, company classifications derived from Orbis, and financial metrics, the study was equipped to investigate tender outcomes, market shares and influencing dynamics of public procurement across the European Union and various branches of industry.

3.3. Data Exploration and Preprocessing

After collecting the data, we conducted an initial analysis of the distribution across various variables. Our primary focus was on the tender value, as this variable is often strongly correlated with the size of the winning company, as discussed in Section 2.3. During this exploration, we identified significant anomalies in the total value variable, such as a large proportion of contract values equaling 0, as well as tender lots valued at 1 billion euros, published by, e.g. a local Austrian municipality. These anomalies suggested an extreme value distribution, prompting us to apply a log transformation to improve the data's interpretability and mitigate the influence of outliers. A boxplot was created to visualize the adjusted data and identify outliers (see Fig. 1). The interquartile range (IQR) was calculated to determine the boundaries for typical values, with the lower whisker extending to €4,544.04 and the upper whisker to €63,379,652 in the transformed dataset. Values falling below or exceeding these thresholds were classified as outliers.

3.4. Dataset

The initial dataset retrieved for this study comprised 1.7 million contract and award notices from the open government data platform TED, of which 939,165 unique contracts were identified. These unique records serve as the foundation for the subsequent analysis, providing a reliable and well-structured dataset for investigating public procurement dynamics across the European Union. Building on the data exploration and preprocessing steps outlined in the previous section, table 1 provides a detailed summary of the refined database. This overview highlights the key outcomes of the cleaning process and outlines the structure of the dataset as utilized in the following analyses.

TED Dataset	
Retrieved notices	1,642,250
Unique notices	939,165
Unique notices with CPV-Code classification	771,016
Unique notices with winner information	259,487
Retrieved winners	496,445
Unique winners	209,464
Unique notices with information on tender value (> 0)	491,073
Unique notices with information on tender value (> 4,544. < 63,379,652)	461,043
Unique notices with defined buyer country	858,822
Unique notices with defined winner country	259,487

Tab. 1 – Summary of the TED Dataset Used for Our Analysis

To address our research question, we employed a classification system to identify startups and SMEs within the dataset, leveraging the firm-level data provided by the Orbis database. Startups were defined as small companies with no branches and a founding date after January 1, 2015. This definition allowed us to identify 18,191 winner companies in our combined dataset that met these criteria.
The Orbis database categorizes companies by size based on financial and operational metrics. Very large companies (VL) are those that meet at least one of the following thresholds: operating revenue of ≥ 100 million EUR, total assets of ≥ 200 million EUR, a workforce of ≥ 1,000 employees, or listing on a stock exchange, provided their revenue or asset-per-employee ratios are not disproportionately low. Additionally, companies with unknown financial metrics but capital exceeding 5 million EUR are also classified as very large. Large companies (L), on the other hand, meet at least one of these criteria: operating revenue of ≥ 10 million EUR, total assets of ≥ 20 million EUR, or a workforce of ≥ 150 employees, while also maintaining reasonable revenue or asset-per-employee ratios. Companies with unknown revenue, assets, or employee counts but capital between 500,000 EUR and 5 million EUR fall into this category.
Medium-sized companies (M) are identified as those that meet at least one of the following conditions: operating revenue of ≥ 1 million EUR, total assets of ≥ 2 million EUR, or a workforce of ≥ 15 employees, but do not qualify as large or very large companies. All companies that fail to meet the criteria for these categories are classified as small companies (S).
This classification system was crucial in systematically identifying startups and SMEs within the dataset, ensuring alignment with the study's objectives.

4. Results

In order to address our research question, we conducted an extensive analysis of our database, focusing on variables that influence market dynamics, with particular emphasis on the access of SMEs and startups in the ICT sector. We aim to uncover key factors that shape the competitive landscape and provide insights into the challenges and opportunities faced by smaller firms within public procurement processes. Relevant variables considered in this analysis include sectoral distribution, measured through the European Common Procurement Vocabulary (CPV codes), and European procurement procedure types. Additionally, the procedure types provided valuable context regarding how procurement practices influence participation and success of SMEs. By analyzing these variables, we gain a deeper understanding of the barriers that startups and SMEs face in accessing the European public procurement market for ICT.

4.1. SME Access in European Public Procurement for ICT

We focused on CPV codes we assume to be relevant to ICT industries, selecting the following divisions: 48: 'Software packages and information systems'; 72: 'IT services: consulting, software development, Internet, and support'; 30: 'Office machinery, equipment, and supplies'; 32: 'Radio, television, and communication equipment'; 50: 'Repair and maintenance services'. Filtering tenders by these CPV-Divisions yielded 24,277 unique tenders and 34,287 tender lots. These lots were awarded to 15,346 distinct companies, categorized based on Orbis classifications. For a complete display of the distribution see Table 2. The sum of tenders is higher than 24,277 as multiple companies can participate in a tender.

	Unique Companies	Lots Won	Tenders Participated in
Small Companies	3,465	5,744	4,638
Medium Companies	5,954	11,695	9,246
Large Companies	3,331	10,461	8,647
Very Large Companies	1,497	6,387	5,529

Tab. 2 – Distribution of Companies in Public Procurement for ICT

Figure 2 illustrates the values presented in 2 and makes the comparison between the distribution of company sizes in the ICT procurement landscape and their success rates. Small companies are disproportionately disadvantaged, with their share of lots won (16.75%) being significantly below their respective presence (24.32%) in the ICT procurement market. In contrast, large and very large companies outperform expectations. Large companies, representing 23.38% of the landscape, secure 30.51% of the lots. Very large companies exhibit the most pronounced overperformance, winning 18.63% of the lots while constituting just 10.51% of companies engaging in ICT tenders.

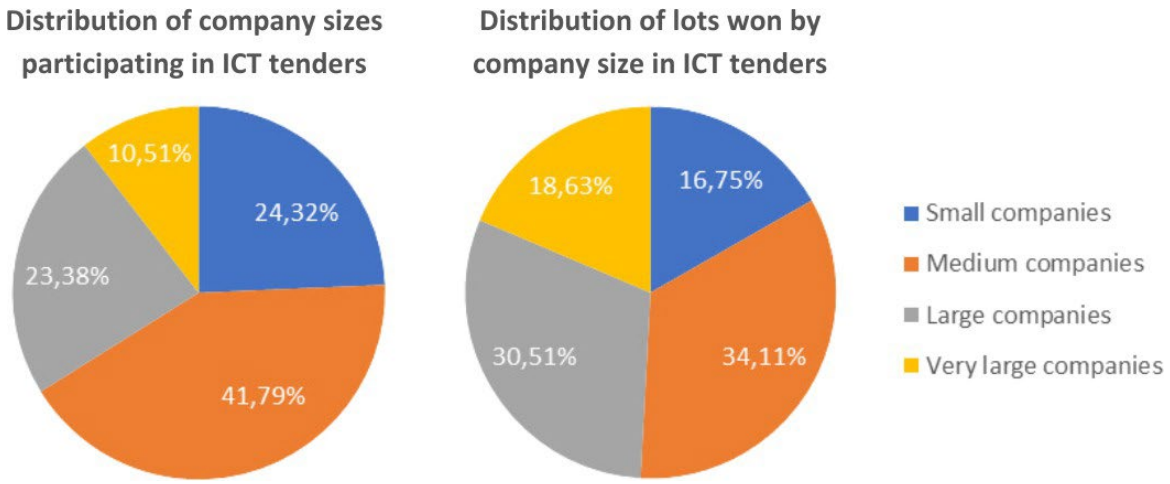


Fig. 2 – Distribution of Company Sizes in Public Procurement for ICT.

Based on our initial observations, we analyzed the values per tender lot to gain deeper insights into the patterns and the accessibility of of the ICT procurement landscape in respect to company sizes. A descriptive summary of all results can be found in Table 3. We analyzed all tenders in our database, as well as ICT-specific tenders, to gain insights into the unique characteristics of the ICT sector. We conducted our analysis both unfiltered (contract value > 0) and filtered, using the predefined value range introduced in Section 3.4 to exclude abnormal outliers. It is important to note that contract values may appear multiple times in this analysis. When multiple companies are listed as winners, the corresponding contract value is attributed to each company, as the quality of the data extracted from TED did not allow for proportional allocation.

Small companies win only 16.2% of ICT tender lots and 17.2% of the total procurement value, far lower than their share in overall public procurement, where they account for 37.5% of lots and 38.9% of value. On the other hand, medium-sized companies perform relatively well in ICT procurement, capturing 32.6% of ICT tender lots and 31.1% of the total value, much higher than their share in the general public procurement sector, where they only account for 5.9% of lots and 5.8% of contract value. The contrast between small and medium companies in ICT is striking — medium-sized companies have nearly double the share of ICT procurement in both lots and value, which is the opposite of the general public procurement sector, where small companies have a higher share. This suggests that procurement practices and market characteristics of the ICT sector, with its demand for specialized skills and larger project scopes, tend to favor medium-sized companies over small ones.
Additionally, filtering the data reveals that outliers significantly distort the unfiltered data, particularly in the general procurement sector, where the presence of large, extreme values inflates the overall figures. Filtering

Company classification	Avg value	Total value	Tender count
Small	5,382,428.71	504,660,807,387.35	93,751
Medium	6,303,362.00	921,866,693,037.66	146,250
Large	8,408,545.19	104,428,452,369.87	124,193
Very large	11,067,923.32	988,343,416,295.43	89,298
Small (filtered)	2,472,323.29	213,505,671,951.45	86,358
Medium (filtered)	2,365,978.21	32,060,049,531.27	13,540
Large (filtered)	2,775,745.37	321,475,725,687.79	115,816
Very large (filtered)	3,370,755.36	27,689,069,468.58	82,145
Small companies in ICT	5,432,224.01	54,313,175,671.39	9,998
Medium sized companies in ICT	3,208,348.39	63,775,549,325.60	19,878
Large companies in ICT	6,994,184.93	128,315,316,733.52	18,346
Very large companies in ICT	15,928,020.16	171,783,679,466.77	10,785
Small companies in ICT (filtered)	2,230,218.78	20,397,580,921.04	9,146
Medium sized companies in ICT (filtered)	1,996,922.82	36,879,170,666.26	18,468
Large companies in ICT (filtered)	2,493,002.64	43,190,001,643.78	17,292
Very large companies in ICT (filtered)	3,654,161.85	35,434,407,496.17	9,697

Tab. 3 – Count and Tender Value per Company classification

out extreme outliers significantly reduces the total procurement sums in both sectors. However, the effect is more pronounced in the general sector. Once these outliers are removed, the values in the ICT sector remain consistently higher, emphasizing the unique characteristics and importance of ICT procurement in Europe.

4.2. Procurement procedures

As highlighted in Section 2.1, procedure types are considered to exert a direct influence on SME access in public procurement (Soliño and de Santos, 2010) Procurement procedures not only determine the accessibility of tenders for different company sizes but also influence the alignment of procurement goals, ranging from cost efficiency to fostering innovation. Drawn from our extensive literature review, we sought to examine the different types of procurement procedures within the subset of ICT procurement data (CPV Divisions 48, 72, 30, 32, and 50). Our analysis identified a total of 24,277 unique tenders within this subset, offering a comprehensive view of the distribution of procedure types and the participation of various company sizes. A summary of this distribution can be found in Table 4, highlighting the dominance of Open Procedures (71.91%), followed by negotiated procedures without call (10.49%) and restricted procurement tenders (8.25%).

Procedure Type	Count Tenders	Small Companies	Medium Companies	Large Companies	Very Large Companies
Open	1,745,8	3,554	6,821	6,124	3,925
Negotiated without Call	2,546	308	749	845	698
Restricted	2,004	396	868	743	378
Negotiated with Call	1,207	169	438	455	312
Other Single	900	184	311	409	164
Not Defined	54	13	28	28	18
Competitive Dialogue	48	7	17	15	16
Other Multiple	33	5	8	15	8
Competitive Tendering	27	2	6	13	10

Tab. 4 – Procurement Procedures and SME Access in Public Procurement for ICT

As anticipated, small companies are most frequently represented in Open Procedures. In contrast, small companies are notably underrepresented in more complex, resource-demanding processes such as Negotiated Procedures and Competitive Dialogue. Medium-sized companies, on the other hand, exhibit a more balanced distribution across various procedure types. They are particularly well-represented in Negotiated Procedures without call and Restricted Procedures. Large and very large companies, with their substantial resources, predominantly participate in Negotiated and Restricted Procedures. Very large companies, in particular, tend to dominate procedures like Competitive Dialogue and Negotiated Procedures with Call, which are typically used for high-value, resource-intensive projects. While their involvement in Open Procedures is relatively limited, both large and very large firms maintain a presence.

Building on the previous analysis of participation patterns across different procurement procedures, we now extend our focus to the contract values and earnings within these procedure types. This offers a more complete understanding of how market access and procedural complexity affect not only the number of tenders small, medium, large, and very large companies participate in, but also the financial returns they achieve. By analyzing the distribution of total contract values within these procedures and the average contract values won by each company classification, we provide insights into how different procurement procedures impact the financial performance of companies of varying sizes and can provide further insights on factors influencing SME access in ICT procurement.

For small companies, despite their significant participation in Open Procedures — comprising 93% of their engagement in tender lots — they win only a modest share of the total contract value. In fact, their total contract value in Open Procedures amounts to approximately €13.67 billion, with an average contract value of €4.18 million, as shown in Table 6. In procedures like Negotiated with Call for Tenders, small companies capture only a small proportion of the total contract value, with an average contract value of approximately €5.93 million in this category. In contrast, medium-sized companies exhibit a more balanced participation profile across various procedures. They are notably active in Open, Negotiated without Call, and Restricted Procedures, with a significant share of their tenders being awarded through Restricted Procedures (25%) and Negotiated Procedures without Call (30%). As shown in Table 7, the average contract value for medium-sized companies in Open Procedures is approximately €1.62 million. However, their presence in more complex tenders, such as Restricted and Negotiated Procedures, allows them to secure larger contracts, with average values reaching €2.64 million in Restricted Procedures and €3.78 million in Negotiated Procedures with Call. As a result, medium-sized companies capture a more substantial share of the total value. In fact, medium-sized companies account for approximately 42.1% (Restricted) and 20.4% (Negotiated with Call), overperforming in respect to their market presence.

Large companies dominate the Negotiated and Restricted Procedures, where high-value contracts are often awarded. As illustrated in Table 8, in Restricted Procedures, the average contract value for large companies is approximately €3.85 million, while in Negotiated Procedures with Call, it rises to over €6.91 million. These firms are particularly well-suited to handle large-scale and complex IT projects, and as a result, they consistently capture a significant share of the total contract value.Large companies win 50.6% of the total value procured via Restriced procedure and 56.3% of competitive tender procedures.

Very large companies are the primary participants in the most complex and high-value tenders, such as Competitive Dialogue and Negotiated Procedures with Call. As seen in Table 9, the average contract value for very large companies in Negotiated Procedures with Call exceeds €17.48 million, while in Competitive Dialogue, the average contract value is even higher, at €34.57 million. As a result, very large companies capture the lion's share of total contract values, accounting for approximately €62,520 billion and 48.7% of the total procurement value in the overall ICT sector.

5. Discussion

Our analysis of European public procurement in the ICT sector highlights a distinct advantage for large and very large firms in securing tenders. While medium-sized companies form the majority of participants, their share of lots won is lower than expected. Small companies, in particular, are disproportionately disadvantaged, capturing significantly fewer tender lots and lower total contract values relative to their overall presence.

These findings align with prior literature emphasizing the barriers SMEs face in public procurement, including resource limitations, stringent procedural requirements, and economies of scale favoring larger firms (Soliño and de Santos, 2010). The procurement landscape for ICT reflects these structural challenges, with larger firms leveraging their financial and technical capacity to secure high-value contracts. Small firms, by contrast, are more reliant on Open Procedures, which offer lower entry barriers but tend to result in smaller contract values.

The contrast between small and medium-sized enterprises (SMEs) is particularly notable. While small companies struggle with access, medium-sized firms perform relatively well in ICT procurement compared to general public procurement. This suggests that ICT procurement favors firms with a moderate level of specialization and resources, a finding that supports the argument that a "one-size-fits-all" SME policy approach may not be suitable (Soliño and de Santos, 2010). Instead, differentiated policies are needed to support smaller firms without undermining the competitiveness of medium enterprises.

The impact of procurement procedures on firm participation further reinforces these observations. Small companies are most active in Open Procedures, whereas larger firms dominate more complex processes such as Negotiated and Competitive Dialogue tenders. These procedures often involve resource-intensive require-

ments, making them less accessible to smaller firms. Medium-sized enterprises demonstrate a balanced distribution across procedure types, suggesting that they have the capacity to navigate moderately complex procurement processes. These results emphasize the need to differentiate procurement procedures not only by legal form but also by their de facto complexity and resource demands. Smaller firms often lack the legal expertise, internal capacity, or financial flexibility to engage with complex procedures such as restricted or negotiated tenders. This indicates that administrative burden acts as a structural barrier, reinforcing asymmetries in participation and limiting the intended strategic effect of public procurement; a central concern addressed in our second research question.

Moreover, filtering out extreme contract values (outliers) significantly alters the observed distribution in general procurement. However, in the ICT sector, even after applying our filter, large firms continue to hold a dominant share of awarded contracts. This indicates that ICT tenders, by nature, involve high-value contracts that favor companies with substantial financial and operational capacity. The limited impact of filtering on the ICT sector suggests strong data quality and highlights the sector's economic and societal relevance.

From a theoretical perspective, this study contributes to the growing literature on public procurement as an instrument of innovation policy by offering large-scale empirical evidence on structural asymmetries in startup and SME access. Building on and extending previous work by Edler and Georghiou (2007) and Uyarra et al. (2014), it highlights how procurement design, rather than being neutral, actively shapes competitive dynamics in digital markets. By conceptualizing startup participation as a systemic innovation function, our analysis aligns with the National Innovation Systems framework Lundvall, 1992, illustrating how the inclusion or exclusion of smaller actors affects the adaptive capacity of public sector innovation. Furthermore, the integration of procurement, firm-level, and financial data offers a replicable methodological approach for studying innovation ecosystems from a structural perspective. In sum, the study advances theoretical understanding of how procurement processes interact with broader institutional and market structures.

6. Limitations and Further Research

This study analyzed 14 months of European procurement data, providing valuable insights into the state of public procurement datasets as well as startup and SME participation in the European public procurement landsace. The relatively short timeframe covered may limit the ability to generalize the results. Longer-term studies will be necessary to confirm whether the observed trends and patterns in procurement practices and participation are stable over time. The use of exploratory data analysis (EDA) and descriptive statistics, while effective for uncovering patterns, also introduced certain limitations. These include the potential for subjectivity, scalability challenges when handling larger datasets, and the possibility of overfitting or selectively highlighting patterns. The study did not employ more advanced statistical techniques, such as regression analysis or machine learning, due to the poor quality of the underlying data. This restriction limited the ability to explore deeper correlations or causations. Future research should address these limitations by extending the analysis period and employing advanced methodologies to derive more nuanced and robust insights.

In Europe, initiatives such as GovTech Connect and GovTech Lab have been established to tackle the challenges addressed in this paper and explore potential solutions (PUBLIC. et al., n.d. 'Innovation Agency Lithuania', n.d.). However, no significant impact on improving access for startups and SMEs has been observed thus far. Further investigation is required to assess whether these initiatives can effectively enhance long-term participation and lower existing barriers in public procurement.

As data quality continues to improve, the application of advanced statistical techniques could uncover critical trends, inefficiencies, and causal relationships. This, in turn, would enhance the reliability of procurement data, supporting data-driven policymaking and enabling more targeted, evidence-based interventions. By leveraging these insights, policymakers can optimize the allocation of public procurement funds, ensuring that well-defined and informed strategies maximize the economic impact of European procurement initiatives.

7. Conclusions

Our study underscores the structural challenges small firms face in European ICT public procurement. While medium-sized firms perform relatively well, small companies remain underrepresented in awarded tenders and contract values. Larger firms, particularly very large ones, dominate high-value contracts and complex procedures, reinforcing existing market advantages and dependencies.

These findings suggest that policy interventions should be tailored to address the specific challenges of small firms while ensuring a competitive environment for medium-sized enterprises. Reforms in procurement processes, such as lowering barriers in complex procedures or providing targeted support mechanisms, could

enhance SME participation without compromising efficiency and competition and thereby leveraging procurement volume for strategic objectives like an innovative European ecosystem and digital autonomy.

Acknowledgement

- **Funding or Grant**: Research done in the frame of the research project 'Procurdat' funded by the German ministry of education and research. Funding code: 02K23A010
- **Data/Software Access Statement**: Collected data being available at request.
- **Contributor Statement**: Jan Westermann: Conceptualization, Methodology, Data analysis, Writing - Reviewing and Editing, Final approval; Robin Fritzsche: Conceptualization, Methodology, Data analysis, Writing - Reviewing and Editing; Gerhard Klassen: Methodology, Data analysis; Luca T. Bauer: Writing - Editing.
- **Use of AI**: During the preparation of this work, the author(s) used ChatGPT in order to correct spelling and grammar. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Albano, G. L., Ballarin, A., & Sparro, M. (2010). Framework agreements and repeated purchases: The basic economics and a case study on the acquisition of it services. *SSRN Electronic Journal*. DOI: https://doi.org/10.2139/ssrn.2534496

Amann, M., & Essig, M. (2015). Public procurement of innovation: Empirical evidence from EU public authorities on barriers for the promotion of innovation. *Innovation: The European Journal of Social Science Research*, *28*(3), 282–292. DOI: https://doi.org/10.1080/13511610.2014.998641

Arosa, D., Arribas, I., & Vila, J. (2025). Negative effects on SMEs' success rates when framework agreements are used in bidding for public contracts. *Public Money & Management*, *45*(1), 53–61. DOI: https://doi.org/10.1080/09540962.2024.2312223

Bauer, L. T. (2025). Commercialization for public value: A path for civic technology innovation to diffuse into public administrations [Verfügbar auf Google Scholar: https://scholar.google.com/citations?hl=de&user=dqSDrvIAAAAJ]. *1st Symposium on Data Driven Smart Government*.

Bharosa, N. (2022). The rise of govtech: Trojan horse or blessing in disguise? a research agenda. *Government Information Quarterly*, *39*, 101692. DOI: https://doi.org/10.1016/j.giq.2022.101692

Bharosa, N., & Janowski, T. (2024). The GovTech Challenge ?V GovTech and Public Value Creation. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 1043–1045. DOI: https://doi.org/10.1145/3657054.3659125

Chicot, J., & Matt, M. (2018). Public procurement of innovation: A review of rationales, designs, and contributions to grand challenges. *Science and Public Policy*, *45*(4), 480–492. DOI: https://doi.org/10.1093/scipol/scy012

Commission, E. (1990). Promoting SME participation in public procurement in the Community. Communication from the Commission to the Council. COM (90) 166 final, 7 May 1990 [Num Pages: 16].

Commission, E. (2022). Regulation (eu) 2022/1925 of the european parliament and of the council of 14 september 2022 on contestable and fair markets in the digital sector and amending directives (eu) 2019/1937 and (eu) 2020/1828 (digital markets act).

Commission, E. (2024). Regulation (eu) 2024/903 of the european parliament and of the council of 13 march 2024 laying down measures for a high level of public sector interoperability across the union (interoperable europe act).

Edler, J., & Georghiou, L. (2007). Public procurement and innovation—Resurrecting the demand side. *Research Policy*, *36*(7), 949–963. DOI: https://doi.org/10.1016/j.respol.2007.03.003

Edquist, C., & Hommen, L. (2000). Public Technology Procurement and Innovation Theory [Series Title: Economics of Science, Technology and Innovation]. In C. Antonelli, B. Carlsson, C. Edquist, L. Hommen, & L. Tsipouri (Eds.), *Public Technology Procurement and Innovation* (pp. 5–70). Springer US. DOI: https://doi.org/10.1007/978-1-4615-4611-5_2

Edquist, C., & Zabala-Iturriagagoitia, J. M. (2012). Public procurement for innovation as mission-oriented innovation policy. *Research Policy*, *41*, 1757–1769. DOI: https://doi.org/10.1016/j.respol.2012.04.022

'European Union'. (n.d.). tenders electronic daily [Accessed: 31 Jan. 2025]. https://ted.europa.eu/en/

Flynn, A., McKevitt, D., & Davis, P. (2015). The impact of size on small and medium-sized enterprise public sector tendering. *International Small Business Journal: Researching Entrepreneurship*, *33*(4), 443–461. DOI: https://doi.org/10.1177/0266242613503178

Georghiou, L., Edler, J., Uyarra, E., & Yeow, J. (2014). Policy instruments for public procurement of innovation: Choice, design and assessment. *Technological Forecasting and Social Change*, *86*, 1–12. DOI: https://doi.org/10.1016/j.techfore.2013.09.018

Geroski, P. (1990). Procurement policy as a tool of industrial policy. *International Review of Applied Economics*, *4*(2), 182–198. DOI: https://doi.org/10.1080/758523673

Glas, A. H., & Eßig, M. (2018). Factors that influence the success of small and medium-sized suppliers in public procurement: Evidence from a centralized agency in Germany. *Supply Chain Management: An International Journal*, *23*(1), 65–78. DOI: https://doi.org/10.1108/SCM-09-2016-0334

Gleiss, A., Degen, K., & Pousttchi, K. (2023). Identifying the patterns: Towards a systematic approach to digital platform regulation. *Journal of Information Technology*, *38*, 180–201. DOI: https://doi.org/10.1177/02683962221146803

Grandia, J., & Meehan, J. (2017). Public procurement as a policy tool: Using procurement to reach desired outcomes in society. *International Journal of Public Sector Management*, *30*, 302–309. DOI: https://doi.org/10.1108/IJPSM-03-2017-0066

Gunasekaran, A., & Ngai, E. W. T. (2008). Adoption of e-procurement in hong kong: An empirical research. *International Journal of Production Economics*, *113*(1), 159–175. DOI: https://doi.org/10.1016/j.ijpe.2007.04.012

Harland, C. M., Eßig, M., Lynch, J., & Patrucco, A. (2021). Policy-led public procurement: Does strategic procurement deliver? [Publisher: Emerald Publishing Limited]. *Journal of Public Procurement*, *21*(3), 221–228. DOI: https://doi.org/10.1108/JOPP-09-2021-089

Hoekman, B., & Taş, B. K. O. (2022). Procurement policy and SME participation in public purchasing. *Small Business Economics*, *58*(1), 383–402. DOI: https://doi.org/10.1007/s11187-020-00414-z

'Innovation Agency Lithuania'. (n.d.). GovTech Lab [Accessed: 31 Jan. 2025]. https://govtechlab.lt/

Isenberg, D. (2010). How to start an entrepreneurial revolution. *Harvard Business Review*, *88*(6), 40–50. https://hbr.org/2010/06/the-big-idea-how-to-start-an-entrepreneurial-revolution

Jácome de Moura, P., dos Santos Junior, C. D., Porto-Bellini, C. G., & Dias Junior, J. J. L. (2024). The Over-Concentration of Innovation and Firm-Specific Knowledge in the Artificial Intelligence Industry. *Journal of the Knowledge Economy*. DOI: https://doi.org/10.1007/s13132-024-01974-1

Klassen, G., Bauer, L. T., Fritzsche, R. J., Kordyaka, B., & Niehaves, B. (2024). Turning tenders into tinder: How ai and open data can spark bidding matches. In M. Wimmer, M. Räckers, & H. Hünemohr (Eds.), *Fachtagung rechts- und verwaltungsinformatik (rvi 2024)* (pp. 137–148). Lecture Notes in Informatics (LNI), Gesellschaft für Informatik, Bonn.

Lukkien, B., Bharosa, N., & Reuver, M. D. (2023). Barriers for developing and launching digital identity wallets. *Proceedings of the 24th Annual International Conference on Digital Government Research*, 289–299. DOI: https://doi.org/10.1145/3598469.3598501

Lundvall, B.-Å. (1992). *National systems of innovation: Towards a theory of innovation and interactive learning*. Pinter Publishers.

Moodyś. (n.d.). Orbis Database [Accessed: 31 Jan. 2025]. https://orbis.bvdinfo.com/

Mowery, D., & Rosenberg, N. (1979). The influence of market demand upon innovation: A critical review of some recent empirical studies. *Research Policy*, *8*(2), 102–153. DOI: https://doi.org/10.1016/0048-7333(79)90019-2

Neupane, A., Soar, J., Vaidya, K., & Yong, J. (2012). Role of public e-procurement technology to reduce corruption in public procurement. *International Journal of Information Technology & Management*, *11*(4), 273–284. DOI: https://doi.org/10.1504/IJITM.2012.049730

Niehaves, B., Klassen, G., & Manzoni, M. (2024). *GovTech: Influencing factors, common requirements and recommendations - Supporting the development of cross-border, interoperable GovTech practices in the European landscape* (tech. rep. KJ-01-24-133-EN-N (online),KJ-01-24-133-EN-C (print)) [ISBN: 978-92-68-21888-4 (online),978-92-68-21889-1 (print) ISSN: 1831-9424 (online),1018-5593 (print)]. Publications Office of the European Union. Luxembourg (Luxembourg). DOI: https://doi.org/10.2760/1598146(online),10.2760/3930235(print)

Nose, M. (2023). *Inclusive govtech: Enhancing efficiency and equity through public service digitalization*, International Monetary Fund.

Nyiri, L., Osimo, D., Özcivelek, R., Centeno, C., & Cabrera, M. (2007). Public Procurement for the Promotion of R&D and Innovation in ICT.

OECD. (2018). SMEs in Public Procurement.

PUBLIC., the Lisbon Council., Politecnico Milano., & Intellera. (n.d.). GovTech Connect [Accessed: 31 Jan. 2025]. https://www.govtechbootcamps.com
Rikap, C., Durand, C., Paraná, E., Gerbaudo, P., & Marx, P. (2024). *Reclaiming digital sovereignty: A roadmap to build a digital stack for people and the planet*. UCL Institute for Innovation and Public Purpose.
Rikap, C., & Lundvall, B.-Å. (2021). *The Digital Innovation Race: Conceptualizing the Emerging New World Order*. Springer International Publishing. DOI: https://doi.org/10.1007/978-3-030-89443-6
Roberts, H., Cowls, J., Casolari, F., Morley, J., Taddeo, M., & Floridi, L. (2021). Safeguarding European Values with Digital Sovereignty: An Analysis of Statements and Policies. DOI: https://doi.org/10.2139/ssrn.3937345
Rothwell, R. (1984). Technology-Based Small Firms and Regional Innovation Potential: The Role of Public Procurement. *Journal of Public Policy*, *4*(4), 307–332. DOI: https : / / doi . org / 10 . 1017 / S0143814X00002774
Sanchez Graells, A., & Herrera Anchustegui, I. (2014). Impact of Public Procurement Aggregation on Competition: Risks, Rationale and Justification for the Rules in Directive 2014/24. *SSRN Electronic Journal*. DOI: https://doi.org/10.2139/ssrn.2534496
Soliño, A. S., & de Santos, P. G. (2010). Transaction costs in transport public–private partnerships: Comparing procurement procedures. *Transport Reviews*, *30*(3), 389–406. DOI: https://doi.org/10.1080/01441640903037941
Timmermans, B., & Zabala-Iturriagagoitia, J. M. (2013). Coordinated unbundling: A way to stimulate entrepreneurship through public procurement for innovation. *Science and Public Policy*, *40*(5), 674–685. DOI: https://doi.org/10.1093/scipol/sct023
'United Nations'. (n.d.). UN Treasury - UN Operational Rates of Exchange [Accessed: 31 Jan. 2025]. https://treasury.un.org/operationalrates/OperationalRates.php
Uyarra, E., Edler, J., Garcia-Estevez, J., Georghiou, L., & Yeow, J. (2014). Barriers to innovation through public procurement: A supplier perspective. *Technovation*, *34*(10), 631–645. DOI: https://doi.org/10.1016/j.technovation.2014.04.003
Vaidya, K., Sajeev, A. S. M., & Callender, G. (2006). Critical factors that influence e-procurement implementation success in the public sector. *Journal of Public Procurement*, *6*(1-3), 70–99. DOI: https://doi.org/10.1108/JOPP-06-01-03-2006
Vardanyan, L., & Kocharyan, H. (2023). Critical views on the phenomenon of EU digital sovereignty through the prism of global data governance reality: Main obstacles and challenges. *European Studies*, *9*(2), 110–132. DOI: https://doi.org/10.2478/eustu-2022-0016
Wesseling, J. H., & Edquist, C. (2018). Public procurement for innovation to help meet societal challenges: A review and case study. *Science and Public Policy*, *45*(4), 493–502. DOI: https://doi.org/10.1093/scipol/scy013

Appendix A

Procedure Type	Count	Total Contract Value (€)	Average Contract Value (€)
Competitive Dialogue	43	1,486,523,770.82	34,570,320.25
Competitive Tendering	25	62,927,801.36	2,517,112.05
Negotiated with Call for Tenders	832	5,625,854,590.79	6,761,844.46
Negotiated without Call for Tenders	2,161	5,499,865,404.65	2,545,055.72
Open Procedure	16,139	51,872,502,336.93	3,214,108.83
Other Multiple Criteria	23	324,529,932.18	14,109,997.05
Other Single Criteria	899	520,697,904.54	579,196.78
Restricted Procedure	1,797	4,868,040,008.73	2,708,981.64
Undefined	36	131,362,405.14	3,648,955.70

Tab. 5 – Contract Value Distribution for All Tenders in ICT CPV Divisions

Procedure Type	Count	Total Contract Value (€)	Average Contract Value (€)
Competitive Dialogue	7	1,168,918,730.88	166,988,390.13
Competitive Tendering	2	4,582,231.80	2,291,115.90
Negotiated with Call for Tenders	108	640,350,225.68	5,929,168.76
Negotiated without Call for Tenders	268	414,451,337.87	1,546,460.22
Open Procedure	3,269	13,669,217,379.58	4,181,467.54
Other Multiple Criteria	5	12,649,841.47	2,529,968.29
Other Single Criteria	183	136,316,550.96	744,899.19
Restricted Procedure	371	603,243,056.16	1,625,992.07
Undefined	2	10,293,805.78	5,146,902.89

Tab. 6 – Contract Value Distribution for Small Companies

Procedure Type	Count	Total Contract Value (€)	Average Contract Value (€)
Competitive Dialogue	13	61,724,884.48	4,748,068.04
Competitive Tendering	5	7,497,671.15	1,499,534.23
Negotiated with Call for Tenders	304	1,147,851,037.74	3,775,825.78
Negotiated without Call for Tenders	620	959,754,964.45	1,547,991.88
Open Procedure	6,266	10,140,826,689.81	1,618,389.19
Other Multiple Criteria	4	2,225,457.36	556,364.34
Other Single Criteria	311	101,872,882.65	327,565.54
Restricted Procedure	776	2,050,869,906.89	2,642,873.59
Undefined	12	64,171,698.08	5,347,641.51

Tab. 7 – Contract Value Distribution for Medium-Sized Companies

Procedure Type	Count	Total Contract Value (€)	Average Contract Value (€)
Competitive Dialogue	14	83,902,274.06	5,993,019.58
Competitive Tendering	12	35,378,754.01	2,948,229.50
Negotiated with Call for Tenders	350	2,420,550,563.86	6,915,858.75
Negotiated without Call for Tenders	761	1,831,238,233.93	2,406,357.73
Open Procedure	5,776	24,586,145,412.01	4,256,604.12
Other Multiple Criteria	9	172,993,397.94	19,221,488.66
Other Single Criteria	409	199,938,129.50	488,846.28
Restricted Procedure	640	2,462,100,278.66	3,847,031.69
Undefined	18	41,076,130.25	2,282,007.24

Tab. 8 – Contract Value Distribution for Large Companies

Procedure Type	Count	Total Contract Value (€)	Average Contract Value (€)
Competitive Dialogue	16	215,097,924.66	13,443,620.29
Competitive Tendering	9	21,137,015.36	2,348,557.26
Negotiated with Call for Tenders	208	3,635,625,184.17	17,478,967.23
Negotiated without Call for Tenders	564	2,323,112,631.88	4,118,994.03
Open Procedure	3,598	28,877,588,629.31	8,026,011.29
Other Multiple Criteria	8	288,661,235.40	36,082,654.43
Other Single Criteria	164	203,678,925.60	1,241,944.67
Restricted Procedure	347	2,218,329,180.21	6,392,879.48
Undefined	5	22,307,885.00	4,461,577.00

Tab. 9 – Contract Value Distribution for Very Large Companies

Diversity in GovTech: Who's Represented in Innovative Technology Supplied to Public Administration?

Luca T. Bauer[1*], *Marc Wyszynski*[2], *Björn Niehaves*[3]

[a 1] Digital Public, University of Bremen, Bremen, Germany, bauerl@uni-bremen.de, 0009-0003-6140-9918.
[2] Digital Public, University of Bremen, Bremen, Germany, wyszynski@uni-bremen.de, 0000-0002-5292-4083.
[3] Digital Public, University of Bremen, Bremen, Germany, niehaves@uni-bremen.de, 0000-0002-2682-6009.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. This study investigates the potential role of diversity in shaping innovation outcomes within the GovTech sector, an emerging domain where startups collaborate with public administrations to drive digital transformation. While GovTech is positioned as a vehicle for more agile, inclusive, and citizen-oriented public services, its effectiveness hinges on the extent to which it mirrors the populations it serves. Grounded in theories of diversity management and diffusion of innovation, this research explores how the demographic composition of GovTech founders compares to public administration employees, the broader startup ecosystem, and the general citizenry in Germany. The study employs a mixed-methods approach, combining 108 expert interviews with GovTech founders and comparative analysis using secondary data from national datasets. It focuses on three diversity dimensions: gender, migration background, and socio-economic (labor vs. academic) background. The findings reveal substantial misalignments. GovTech startups are heavily male-dominated (85.7% male founders), starkly contrasting with the higher female representation in public administration (58.6%) and the near gender parity in the citizenry. Migration background is also underrepresented among GovTech founders (22.7%) relative to citizens (28.6%), though aligned with general startup trends. GovTech shows relatively strong socio-economic inclusivity, with 62.8% of founders from labor backgrounds, exceeding both startup and citizen benchmarks. These demographic mismatches raise concerns about the representational legitimacy and inclusiveness of GovTech solutions, which may limit their relevance, adoption, and impact. Public administrations, while more gender-diverse, also exhibit gaps, particularly in migration and socio-economic representation, potentially compounding the disconnect between technology providers and end-users. The study proposes strategic responses, including inclusive procurement policies, support for diverse founders, and cross-sector alignment initiatives to strengthen equity in digital public services.

Keywords. GovTech, government technology, diversity management, public sector innovation.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.970

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1. Introduction

The intersection of diversity and digital innovation in the public sector has garnered significant attention, as public administrations strive to deliver equitable, citizen-centric services through technological transformation (Chandler, 1984; Nose, 2023). In this context, GovTech — an emerging technology market at the crossroads of government and technology — has emerged as a relevant supplier for public sector innovation (Bharosa, 2022; Niehaves and Klassen, 2024). Through partnerships between public administrations and startups, GovTech promises to overcome traditional bureaucratic constraints and foster solutions that are more inclusive and reflective of diverse citizen needs (Niehaves and Klassen, 2024).

Nevertheless, a new avenue to procure solutions, does not necessitate a higher degree of diversity. It has long been recognized that public administrations actions are biased through culture, socialization and bureaucratic structures (Battaglio et al., 2019). Such biases may foster prejudice, which can negatively affect how individuals evaluate and interact with others, potentially leading to unequal treatment or exclusion (Wyszynski, 2020). Research in the last few years depicts a similar trend in the results of technologies, specially those used as decision support systems in public organizations (Buolamwini, 2018; O'Connor and Liu, 2024). As such, both solutions and the organizational makeup of solution providers are becoming more central in shaping digital services for citizens (Bauer, 2025).

Despite the providers of GovTech solutions, GovTechs, being attributed high potential and a clear value proposition (Bharosa, 2022), a gap exists in research on how diversity within GovTech compares to other relevant groups, such as the broader startup ecosystem, public administration personnel, and the citizenry their solutions aim to serve. Without this understanding, it remains unclear whether GovTech can fulfill the promise of fostering equity and inclusion or rather simply replicates existing disparities (Bharosa, 2022). This study addresses such gap by posing the research questions:

RQ: How do diversity measure in GovTech boards compare to their clients and service recipients? Which effects on representation and bias does this entail?

To answer the question, we draw on the theoretical lenses of diversity management and diffusion of innovation theory (McNutt et al., 2016; Sabharwal et al., 2018). Diversity management highlights the organizational benefits of inclusive team compositions, while diffusion of innovation theory emphasizes the importance of alignment between stakeholders for successful technology adoption. Together, these perspectives provide a robust foundation for analyzing diversity's role in shaping GovTech's impact.

Previous research in diversity management and public sector innovation (vom Brocke et al., 2009, 2015) suggest three attributes of diversity as most pertinent for further investigation: 1. *gender*, 2. *migration backgrounds*, and 3. *working-class/labor backgrounds* (Chen, 2014; Gross-Gołacka et al., 2022; McGrandle, 2017). Thus, our research involves collecting and analyzing data on these diversity dimensions from GovTech startups, general startups, public administration employees, and citizens. The findings reveal notable alignments and misalignments. GovTech startups closely mirror the broader startup ecosystem but diverge significantly from the demographics of their public administration clients and citizen end-users. These discrepancies show opportunities for innovation and areas where improved representation could enhance trust, alignment, and inclusivity.

This study contributes to the emerging discourse on GovTech and public sector innovation by offering a data-driven assessment of diversity across relevant groups. By identifying gaps and proposing pathways for addressing them, we provide insights for policymakers, GovTech startups, and public administrations seeking to foster equity and inclusion in the digital age. Additionally, we outline future research directions to deepen understanding and extend the applicability of our findings, including the exploration of international contexts and the use of focus groups to further evaluate diversity's role in GovTech's evolution.

2. Conceptual and Theoretical Background

2.1. Diversity in the Public Sector

Public administrations serve as the extended arm of political institutions, tasked with representing and safeguarding the interests of citizens. This role becomes especially significant in the design and implementation of

digital infrastructure that provides critical governmental services to often under-served populations (Bharosa and Janowski, 2024; Desai and Manoharan, 2024). Inclusive and equitable infrastructures are essential to reduce the digital divide and ensure that all citizens, in particular those from marginalized communities, have access to critical digital public services (Denhardt and Denhardt, 2015). For this, representation plays a central role in safeguarding citizen interests by ensuring diverse perspectives are embedded in the development and governance of such systems (Chandler, 1984).

Diversity management has been widely shown to have a significant positive impact on the performance of teams and organizations, enhancing creativity, problem-solving, and decision-making quality (Bassett-Jones, 2005). However, research on diversity in general often times lacks carryover, as public institutions represent a specific case due to their highly structured and hierarchical nature (Choi and Rainey, 2010; Sabharwal et al., 2014). While these structures enable standardization and accountability, they also limit the adaptability needed to effectively integrate components of diversity into decision-making processes (Oppong, 2013). Furthermore, public administrations are increasingly expected to adhere to international frameworks, such as the *United Nations Global Compact on Diversity, Equity, and Inclusion* or the *Charta of Diversity*, which emphasize the importance of embedding these values into organizational practices and culture.

Despite aspirations, public administrations often struggle to realize diversity, equity, and inclusion goals not only externally through politically created policy, but also internally. Issues such as under representation of minority groups, limited avenues for inclusive participation, and the bureaucratic inertia inherent in many public institutions present persistent challenges (Sabharwal et al., 2018). These struggles can undermine their ability to act as representatives of diverse citizen interests, particularly in the context of rapidly evolving digital governance demands (McNutt et al., 2016). Addressing these challenges requires not only systemic reforms to improve representation within public institutions but also a commitment to incorporating diverse stakeholder input into the design and operation of digital public infrastructure, a process that becomes even more pressing in the face of an overaging populus of public servants and a lack of aspiring junior staff (Desai and Manoharan, 2024).

2.2. Diversity in Diffusion of Innovation

Diversity within public administrations is not only critical for equitable representation, but may also serve as a driver of innovation and success (Desai and Manoharan, 2024). The integration of diverse perspectives fosters creative problem solving (Bassett-Jones, 2005) and enables public institutions to design digital public infrastructures that are more inclusive and aligned with the needs of all citizens. This becomes even more relevant in times of growing biases visible through solutions deployed (O'Connor and Liu, 2024). The need for such diversity-driven approach is particularly relevant in the context of the diffusion of innovation, where the acceptance and adoption of new technologies are influenced by the alignment between stakeholders (Tseng et al., 2024).

Isomorphism, a concept from institutional theory, highlights the tendency of organizations to become similar over time, driven by normative, mimetic, and coercive pressures (DiMaggio and Powell, 1983). This similarity fosters positive business relationships by reducing uncertainty, increasing trust, and facilitating collaboration (Bartoli and Rouet, 2023; Bauer, 2025; Li and Chung, 2020). Previous research on GovTech has found indicators, that startups conform in their organizational makeup to better represent public administration officials wishes (Bauer, 2025). In theory, when public administrations share commonalities with the citizenry they serve and the technology providers they engage with, the likelihood of successful relationship development and innovation diffusion increases (Frumkin and Galaskiewicz, 2004; Lodge and Wegrich, 2005). For instance, public institutions that reflect the diversity of their citizens are better positioned to understand and address their unique needs, thereby enhancing the acceptance of new technologies and services.

The principle of similarity creating higher acceptance underscores the importance of diversity as a strategic asset in public administrations (Li and Chung, 2020). By mirroring the diversity of the populations they represent and fostering alignment with technology solution providers, public institutions can build stronger relationships and facilitate smoother innovation adoption. This alignment not only enhances trust but also ensures that digital public infrastructures are designed with inclusivity and accessibility in mind, addressing societal challenges such as the digital divide (Frumkin and Galaskiewicz, 2004).

The expectation, therefore, is that a higher degree of diversity mirroring between public administrations, cit-

izens, and technology solution providers will lead to a greater probability of successful diffusion of innovation. This dynamic exemplifies the interconnectedness of diversity, representation, and innovation, sketching around the need for public institutions to prioritize diversity as a core component of their digital transformation strategies.

2.3. Government Technology - GovTech

Government technology - or GovTech - has emerged as a promising trend to address the restrictions faced by public administrations in attaining technology-driven innovation (Bharosa, 2022). By creating partnerships between public and private actors, GovTech offers an alternative pathway for digital transformation, bypassing the challenges inherent in traditional public sector structures (Bharosa and Janowski, 2024; Niehaves and Klassen, 2024). Defined by the European Union as "*technology-based cooperation[s] between public and private sector actors supporting public sector digital transformation*", the concept is further refined to focus on startups and small- to medium-sized enterprises (SMEs) (of the European Union, 2024). These dynamic entities are seen as key players in driving future technology innovation diffusion within the public sector.

In the broader sense, GovTech represents the most recent wave of emerging technology markets, with an estimated market size exceeding 50 billion € in Europe alone (Fund, 2024; Selke et al., 2024). The sector is largely driven by small-scale entrepreneurs who provide innovative technology solutions without relying on the dominant influence of BigTech actors (Niehaves and Klassen, 2024). This independence not only fosters competition but also enhances the diversity of ideas and approaches available for public sector transformation (Kolain and Hillemann, 2022). Startups within the GovTech ecosystem are often deeply personal ventures, reflecting the values, creativity, and diversity of their founders (Isenberg, 2010). This founder-driven ethos imbues GovTech solutions with unique perspectives, further emphasizing the role of diversity in driving innovation (Bharosa, 2022; Nose, 2023).

According to Bharosa (2022), GovTech ventures promise higher levels of citizen centrism and deliver direct value to the recipients of public services. This citizen-centric focus underscores the importance of diversity within GovTech teams, as their composition directly influences the inclusivity and relevance of the solutions they develop (Isenberg, 2010; Nose, 2023). The diversity at the highest levels of these organizations can ensure that public services are designed to meet the varied needs of the populations they serve.

Striving for higher degrees of diversity within GovTech teams is essential to align with the broader goals of diversity management discussed earlier. This alignment may be necessary so that the solutions procured by public administrations not only reflect the values of inclusivity but are also developed by teams that embody those values. As GovTech continues to grow as a sector, the emphasis on diversity—both within the teams and the solutions they offer—will play a critical role in shaping its impact on public sector digital transformation and societal progress (Edquist and Zabala-Iturriagagoitia, 2012).

To summarize, this study exploratorily investigates how diversity within GovTech compares to public administrations and the citizenry, examining key dimensions such as gender, migration background, and socioeconomic status. The findings highlight significant disparities between these groups, emphasizing the critical role of representation in fostering equity and innovation in public sector digital transformation.

Building on the theoretical insights into diversity management and diffusion of innovation in the context of GovTech, the following section outlines the methodological approach of this study. We then report the findings, describing diversity metrics across the examined groups. In the discussion section, we comprehensively discuss the results, addressing implications for practice and policy. Finally, we outline limitations and propose directions for future research.

3. Data and Methods

To collect data on diversity attributes, previous research suggests three primary methods : 1) using publicly available data through social media outlets, e.g., LinkedIn (Hickey et al., 2022), 2) conducting surveys, e.g., Statista (2024) (Wise and Tschirhart, 2000), or 3) data collection through expert interviews, e.g., self-collected information available in this paper (Schultze and Avital, 2011).

For the current study, we collect data using a combination of survey and expert interview approaches. Data on diversity attributes among GovTech founders in Germany were collected as part of a larger qualitative study to examine GovTech success factors. We conducted interviews with 108 GovTech founders where we also gathered specific information on diversity attributes (i.e. distribution of gender, migration background and labor background in the composition of the founding teams) based on a questionnaire. From these 108 interviewees, we received 100 responses to the questions on diversity attributes of 238 GovTech-founders. To compare the data with the diversity structure of GovTech clients and services recipients (i.e., startups in general, public administration employees, and citizen demographics), we retrieved data from publicly available sources with a temporal variance of one to three years due to differing data availability. In particular, the data sets were sourced from Bertelsmann Stiftung (2024), Bundesinstitut für Bevölkerungsforschung (BiB) (2022), Bundesverband Deutsche Startups e.V. (2023), and Statista (2023, 2024) and Statista (2021).

For the following paper we use founders self-assessment for the named dimensions without further discussion or elaboration. In general an understanding of the three dimensions had emerged as:

Gender: A social and cultural construct that classifies individuals based on characteristics typically associated with masculinity and femininity, often aligning with but distinct from biological sex. In the study, we did not find any non-binary attributed founders.

Migration Background: Refers to individuals who are either immigrants themselves or have at least one parent born outside the country of residence, encompassing both first- and second-generation migrants.

Labor (or Academic) Background: Denotes an individual's parents employment history, occupational status, or socioeconomic position related to the labor market, often shaped by factors such as education, job type, and industry. Here we included only founders as labor background individuals, whose parents were both non-academic.

4. Results

Table 1 shows an descriptive overview of the distributions of diversity attributes across GovTech founders, startups in general, public administration employees, and citizen demographics. To statistically account for the overall discrepancies between the proportions of diversity attributes across the groups, we performed χ^2-tests (see below). Note that, gender is attributed as binary, as information provided by GovTech founders and publicly available statistics only accounts for them. Migration is defined as per the European Unions understanding (European Migration Network, 2024).

Tab. 1 – Overview of the proportional distributions of diversity attributes across GovTech founders, startups, public administration employees, and citizen demographics. Key: m = male, f = female, nm = no migration background, mi = migration background, lb = labor background, and ab = academic background.

		Gender		**Migration background**		**Labor background**
GovTechs	m	85,7%	nm	77,3%	lb	62,8 %
	f	14,3%	mi	22,7%	ab	37,2%
Startups	m	79,0%	nm	70,0%	lb	54,5%
	f	21,0%	mi	21,0%	ab	45,5%
Public administration	m	41,4%	nm	92,0%	lb	./.
	f	58,6%	mi	8,0%	ab	./.
Citizens	m	50,7%	nm	71,4%	lb	72,2%
	f	49,3%	mi	28,6%	ab	27,8%

4.1. Gender Differences

Interview information and further data sourced from Bundesinstitut für Bevölkerungsforschung (BiB) (2022) and Statista (2024) were included in the analysis. The χ^2-test revealed a highly significant difference in the proportion of males and females across GovTechs, startups, public administration and citizens ($\chi^2 = 60.19, p < 0.001$) indicating that the distribution of gender differs significantly depending on the group.

In GovTech startups, 85.7% of founders identify as male, while only 14.3% identify as female, see Figure 1). This is slightly higher than the gender distribution in startups more broadly, where 79% of founders identify as male and 21% as female. In comparison, public administration employees demonstrate a starkly different distribution, with 41.4% identifying as male and 58.6% as female, aligning more closely with the near-equal gender distribution among the general citizen population (50.7% male, 49.3% female).

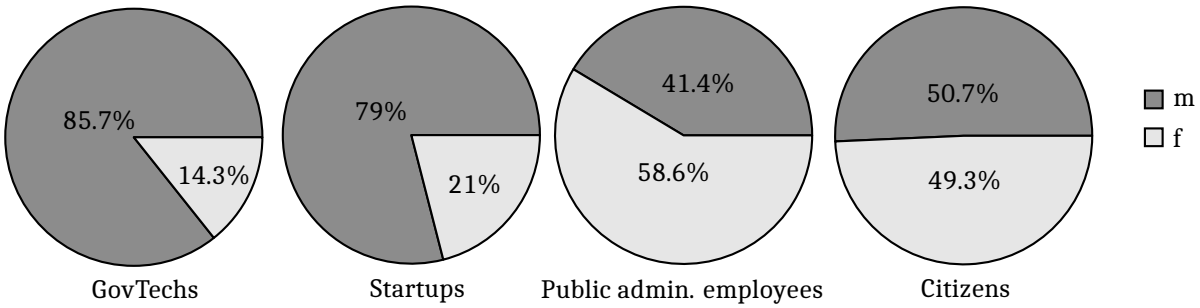


Fig. 1 – Distribution of founders' gender identification in Germany (dark=male, light=female).

The pronounced gender disparity in GovTech startups suggests potential barriers to female participation at the entrepreneurial level. This imbalance may limit the diversity of perspectives in GovTech solutions, potentially impacting their inclusivity and effectiveness. Public administrations, with a higher representation of women, could serve as a model or partner to promote more gender-equitable practices in the GovTech sector.

4.2. Migration Background

The analysis of the combined data from interviews and Bundesinstitut für Bevölkerungsforschung (BiB) (2022), Bundesverband Deutsche Startups e.V. (2023), and Statista (2023) showed a significant difference of the proportions of people having a migration background across the groups ($\chi^2 = 14.16, p < 0.01$). This suggests that the migration distribution varies significantly across the categories.

In particular, the data indicate that 22.7% of GovTech founders have a migration background, closely mirroring the 21% found in the broader startup ecosystem. In stark contrast, only 8% of public administration employees report having a migration background, compared to 28.6% of the general citizen population, see Figure 2. This gap between public institutions and the citizenry they serve raises concerns about representation.

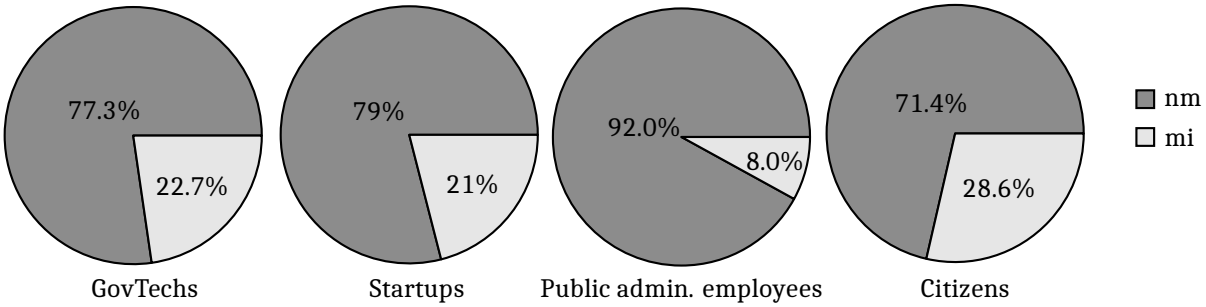


Fig. 2 – Distribution of founders' with migration background in Germany (dark=no migration, light=migration).

The relatively low presence of individuals with migration backgrounds in public administrations highlights a significant underrepresentation issue. This discrepancy could hinder the ability of public institutions to address the needs of diverse populations effectively. The alignment of GovTech startups with general startup migration demographics indicates a potential avenue for fostering innovation through more diverse team compositions, but might also hint at potential pitfalls for similarity-driven acceptance of solution procurement teams in public administrations.

4.3. Labor Background

For the labor background diversity attribute, the χ^2-test showed a significant difference between the distributions ($\chi^2 = 6.75, p < 0.05$) indicating that the proportions of individuals with labor backgrounds differ significantly across the groups. Note that we have excluded missing values of public administration employees. In addition to the data collected during our interviews, we retrieved data from Bertelsmann Stiftung (2024) and Statista (2021).

In particular, the data indicates that 62.8% of GovTech founders come from labor backgrounds, while 37.2% have academic backgrounds, see Figure 3. Startups overall show a slightly more balanced distribution, with 54.5% from labor backgrounds and 45.5% from academic ones. Unfortunately, no detailed data on the labor or academic backgrounds of public administration employees was available for comparison. Among the general citizenry, 72.2% have labor backgrounds, while 27.8% have academic backgrounds.

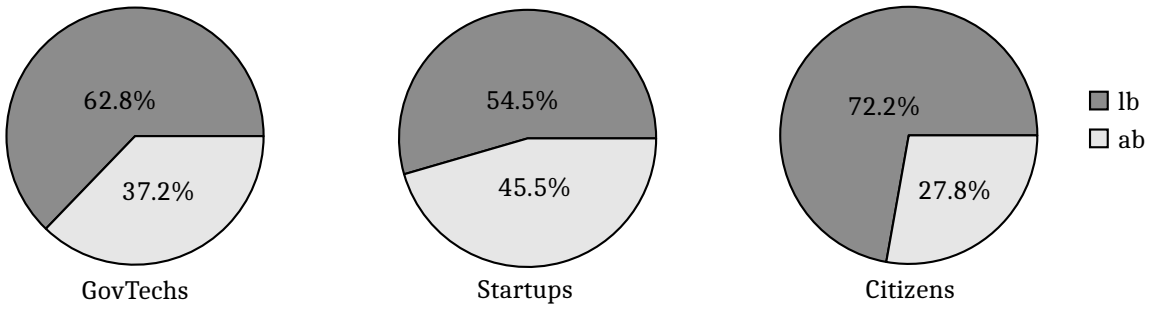


Fig. 3 – Distribution of founders' with labor background in Germany (dark=labor, light=academic).

The high proportion of GovTech founders with labor backgrounds underscores the accessibility of the GovTech sector for individuals outside traditional academic pathways. This inclusivity may foster practical, grounded solutions. However, the absence of equivalent data for public administration employees highlights a need for further research to assess how aligned public institutions are with the populations they serve.

4.4. Generalization of Findings

Our study show significant disparities in diversity across GovTech startups, public administration, and citizen demographics, depicting both opportunities and challenges in achieving equity and representation. They carry relevant implications for the GovTech sector and its potential to drive inclusive digital transformation (Bharosa, 2022).

Gender representation: The stark gender disparity in GovTech startups, with only 14.3% of founders identifying as female, contrasts sharply with the more balanced gender distribution in public administrations (58.6% female). This disparity limits the diversity of perspectives in GovTech leadership and, consequently, the inclusivity of the solutions developed. Given that GovTech ventures are deeply founder-driven, this underrepresentation likely influences the prioritization of user needs in GovTech solutions. Addressing gender diversity in the GovTech ecosystem may show to be an inhibitor to fostering more citizen-centric innovations that resonate with diverse end-users. Public administrations, with their comparatively higher representation of women, could serve as key partners in advocating for more gender-equitable practices in GovTech teams.

Migration backgrounds: The underrepresentation of individuals with migration backgrounds in public administrations (8%) compared to the general citizen population (28.6%) is another critical gap. In contrast, GovTech startups exhibit relatively higher diversity, with 22.7% of founders having migration backgrounds, aligning more closely with citizen demographics. This alignment positions GovTech as a promising avenue for amplifying diverse voices and addressing societal needs that may be overlooked in less representative public institutions.

Labor and academic backgrounds: The high representation of individuals from labor backgrounds among GovTech founders (62.8%) contrasts with broader societal trends, where labor-background representation in professional leadership roles is typically lower. This inclusivity in GovTech shows a potential avenue to serve

as a platform for practical and grounded innovation, often driven by founders' lived experiences. However, the lack of comparable data for public administration employees creates a blind spot in understanding the socio-economic alignment between public institutions and the populations they serve. As GovTech teams develop solutions for public sector challenges, their diverse socio-economic backgrounds may offer advantages in crafting solutions that address real-world needs effectively, but there is a need for additional data.

5. Discussion

The findings highlight a complex landscape of representation across GovTech startups, the broader startup ecosystem, public administration, and citizen demographics. These differences in representation reveal both challenges and opportunities for the GovTech sector in addressing diversity and fostering innovation (Bharosa, 2022; Niehaves and Klassen, 2024).

GovTech startups exhibit the closest resemblance to the broader startup ecosystem in terms of diversity metrics, such as gender, migration background, and socio-economic representation. This alignment underscores the entrepreneurial roots of GovTech as a sector driven by small-scale innovators who share the characteristics and challenges of startups in general (Isenberg, 2010). However, in some areas GovTech teams diverge significantly from public administration employees and the citizens they aim to serve (Bharosa, 2022). For example, public administrations display greater gender parity but are less representative of migration diversity, while GovTech founders exhibit high socio-economic diversity but lower gender and migration balance.

These discrepancies suggest that while GovTech startups are reflective of entrepreneurial norms, they fall short of mirroring the diversity of the populations their solutions target. Public administrations, on the other hand, are more aligned with societal expectations for inclusivity in certain areas, such as gender, but fail to address other critical aspects of representation, such as migration and socio-economic background diversity. This divergence raises questions about where representation matters most and how alignment can be improved across these groups.

The relevance of representation is arguably highest at the point of citizen interaction, where digital public infrastructure solutions directly impact the lives of diverse communities (Bharosa and Janowski, 2024; Frumkin and Galaskiewicz, 2004). GovTech startups, as providers of these solutions, must embody the diversity of their end-users to ensure their products are inclusive, accessible, and effective (Bharosa, 2022). Similarly, public administrations, as the procurers and implementers of GovTech solutions, must prioritize diversity to align their governance and oversight with the needs of the populations they represent.

The current alignment of GovTech startups with the broader startup ecosystem rather than with their client base (public administrations) or end-users (citizens) presents a misalignment that may limit the inclusivity and societal relevance of their solutions (Nose, 2023). Representation within GovTech teams is not only a matter of equity but also a critical factor in fostering trust, collaboration, and innovation. Diverse teams are better equipped to understand and address the multifaceted challenges faced by marginalized groups, enabling the development of more equitable digital public infrastructures (Bassett-Jones, 2005).

Several factors contribute to the observed disparities in representation. In GovTech startups, entrepreneurial norms and the reliance on founder-driven ventures often perpetuate existing patterns of underrepresentation, particularly in terms of gender and migration backgrounds, as these often are counter-elite indicators. These challenges are compounded by systemic barriers, such as limited access to capital and networks for underrepresented groups, which affect participation in the broader startup ecosystem (Isenberg, 2010).

Public administrations, while more structured and inclusive in certain areas, face their own constraints. Bureaucratic inertia, limited recruitment pipelines, and historical biases have contributed to a lack of diversity, particularly in migration and socio-economic backgrounds. These disparities are further exacerbated by the aging workforce and difficulties in attracting younger, more diverse talent (Niehaves, 2011).

To fully realize the potential of GovTech as a driver of public sector innovation, deliberate efforts are needed to address these disparities and align diversity metrics across GovTech teams, public administrations, and the citizens they serve. GovTech startups must prioritize diversity in their leadership and team composition, ensuring that their solutions reflect the needs of diverse communities. Public administrations, as procurers and

partners, play a role in incentivizing this shift by embedding diversity requirements into procurement processes and fostering partnerships with startups that embody inclusive values (Grandia and Meehan, 2017). Previous work indicates an already existing under-representation in female founded ventures in public procurement (Saunders, 2022). As such we see a general trend, that needs to be a addressed. A diversity centered may approach not only strengthens the societal relevance of digital public infrastructure solutions but also build trust and collaboration between public institutions, GovTech startups, and citizens.

6. Limitations and Outlook

The relevance of exploring diversity in GovTech and its alignment with public administration and citizen demographics cannot be overstated. As digital public infrastructures play an increasingly vital role in shaping societal outcomes, understanding how diversity impacts the design, procurement, and delivery of these solutions is essential for fostering inclusivity and equity (Bassett-Jones, 2005; Bharosa, 2022; Bharosa and Janowski, 2024). This study provides an initial overview on alignments and misalignments in representation within one national example, highlighting strengths and gaps within the GovTech sector, public administrations, and their potential interactions with the populations they serve.

Our findings reveal strong alignments between GovTech startups and the broader startup ecosystem, particularly regarding migration and socio-economic diversity (Isenberg, 2010; Niehaves and Klassen, 2024). However, GovTech diverges markedly from public administrations and citizens in terms of gender representation, while public administrations demonstrate notable underrepresentation of migration and socio-economic diversity compared to the citizenry. As such, we were able to exemplarily answer the first part of our research question. Nevertheless, our descriptive data - combined with previous literature - is insufficient to draw substantiated conclusions on the effects this might entail. We see a need for further qualitative research and sense making.

Another critical limitation of this study is the piecing together of data from differing sources. As no research has yet been conducted on our topic, we had to included data from different outlets as well as within a one and a half year timespan between publication. This limits quality and is intensified by the absence of detailed data on the labor and academic backgrounds of public administration employees. Without this information, it remains challenging to assess the socio-economic alignment of public institutions with the populations they represent. Future research must address this gap to provide a more comprehensive understanding of diversity dynamics in public sector organizations.

Additionally, the study's focus on a single country with strong public administrations limits its generalizability. An international comparison would offer valuable insights into how diverse governance contexts influence representation and innovation dynamics in GovTech. This is especially relevant, as both GovTech definitions are used politically motivated depending on the national contexts (Bharosa, 2022; Niehaves and Klassen, 2024), national metrics of migration and and academic versus labor, and public administrations culture differ greatly between national contexts. Such comparisons could reveal best practices and provide a broader foundation for understanding how diversity impacts digital public infrastructure globally.

Further data collection is essential to deepen our understanding of the factors driving discrepancies in representation across groups. Key areas for exploration include: 1) The reasons for observed discrepancies, particularly systemic barriers and organizational practices that hinder diversity. 2) The relative relevance of diversity dimensions, such as gender, migration background, and socio-economic status, from the perspectives of both public administrations and citizens. 3) Potential management practices that public institutions and GovTech startups can adopt to address diversity shortcomings and foster more inclusive ecosystems.

One promising approach for addressing these gaps is the use of focus groups that include representatives from all four groups—GovTechs, public administrations, citizens, and startups in geneal (Belanger et al., 2012; Conboy et al., 2012). These discussions could serve as a platform for evaluating the interplay between diversity, representation, and innovation, generating actionable insights and fostering collaborative problem-solving.

This study relies on descriptive statistics, providing an essential but limited foundation for understanding the complexities of diversity in GovTech. While these statistics offer valuable insights into the current state of representation, they do not capture the underlying dynamics or causal relationships that drive the observed pat-

terns. Future research may adopt mixed methods approaches, integrating qualitative and quantitative analyses to explore further topics relating diversity in GovTech.

Acknowledgement

- **Data/Software Access Statement**: Data supporting research results can be found as part of the References with collected data being available at request.
- **Contributor Statement**: Luca T. Bauer: Conceptualization, Methodology, Data analysis, Writing – Reviewing and Editing, Final approval; Marc Wyszynski: Conceptualization, Data analysis, Writing, Final approval; Björn Niehaves: Supervision, Final approval.
- **Use of AI**: During the preparation of this work, the authors used ChatGPT, Overleaf and Grammerly in order to enhance style and readability. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Bartoli, A., & Rouet, G. (2023). Diversity and inclusion: Isomorphism," washing process", or actual strategic approach? *Global, Social and Technological Development and Sustainability*.

Bassett-Jones, N. (2005). The paradox of diversity management, creativity and innovation. *Creativity and Innovation Management*, *14*, 169–175. DOI: https://doi.org/10.1111/j.1467-8691.00337.x.

Battaglio, R. P., Belardinelli, P., Bellé, N., & Cantarelli, P. (2019). Behavioral public administration ad fontes: A synthesis of research on bounded rationality, cognitive biases, and nudging in public organizations. *Public Administration Review*, *79*, 304–320. DOI: https://doi.org/10.1111/puar.12994.

Bauer, L. T. (2025, March). Commercialization for public value - a path for civic technology innovation to diffuse into public administrations. In L. Ackermann, F. Schäfer, & M. Wimmer (Eds.), *1st symposium on data driven smart city science and transferability (dascit)* (pp. 1–15). Lecture Notes in Informatics (LNI).

Belanger, F., et al. (2012). Theorizing in information systems research using focus groups. *Australasian Journal of Information Systems*, *17*(2).

Bertelsmann Stiftung. (2024). Startups und soziale herkunft [Accessed: 2025-01-18]. https : / / www . bertelsmann - stiftung.de / fileadmin / files / PicturePark / 2024 - 05 / Startups_und_soziale_Herkunft_ .pdf

Bharosa, N. (2022). The rise of govtech: Trojan horse or blessing in disguise? a research agenda. *Government Information Quarterly*, *39*, 101692. DOI: https://doi.org/10.1016/j.giq.2022.101692.

Bharosa, N., & Janowski, T. (2024). The govtech challenge - govtech and public value creation. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 1043–1045. DOI: https://doi.org/10.1145/3657054.3659125.

Bundesinstitut für Bevölkerungsforschung (BiB). (2022, March). *Vielfalt in der öffentlichen verwaltung nimmt langsam zu* [Accessed: 2025-01-18]. https://www.bib.bund.de/DE/Presse/Mitteilungen/2022/2022-03-30-Vielfalt-in-der-oeffentlichen-Verwaltung-nimmt-langsam-zu.html

Bundesverband Deutsche Startups e.V. (2023). Migrant founders monitor 2023 [Accessed: 2025-01-18]. https : / / startupverband . de / fileadmin / startupverband / forschung / studien / mfm / MigrantFoundersMonitor2023_final.pdf

Buolamwini, J. (2018). Why this matters [Accessed: 2025-04-08]. https://www.media.mit.edu/projects/gender-shades/why-this-matters/

Chandler, R. C. (1984). The public administrator as representative citizen: A new role for the new century. *Public Administration Review*, *44*, 196. DOI: https://doi.org/10.2307/975564.

Chen, V. H.-H. (2014). Facilitating social inclusion of migrant workers through digital game play. *GlobDev 2014*.

Choi, S., & Rainey, H. G. (2010). Managing diversity in u.s. federal agencies: Effects of diversity and diversity management on employee perceptions of organizational performance. *Public Administration Review*, *70*, 109–121. DOI: https://doi.org/10.1111/j.1540-6210.2009.02115.x.

Conboy, K., Fitzgerald, G., & Mathiassen, L. (2012). Qualitative methods research in information systems: Motivations, themes, and contributions. *European Journal of Information Systems*, *21*(2), 113–118.

Denhardt, J. V., & Denhardt, R. B. (2015, March). *The new public service* (4th ed.). Routledge. DOI: https://doi.org/10.4324/9781315709765.

Desai, A., & Manoharan, A. P. (2024). Digital transformation and public administration: The impacts of india's digital public infrastructure. *International Journal of Public Administration*, *47*, 575–578. DOI: https://doi.org/10.1080/01900692.2024.2350762.

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review*, *48*, 147. DOI: https://doi.org/10.2307/2095101.

Edquist, C., & Zabala-Iturriagagoitia, J. M. (2012). Public procurement for innovation as mission-oriented innovation policy. *Research Policy*, *41*, 1757–1769. DOI: https://doi.org/10.1016/j.respol.2012.04.022.

European Migration Network. (2024, March). *Person with a migratory background - glossary* [Accessed: 2025-01-18]. https://home-affairs.ec.europa.eu/networks/european-migration-network-emn/emn-asylum-and-migration-glossary/glossary/person-migratory-background_en#:~:text=A%20person%20who%20has%3A,of%20residence%20as%20a%20migrant%20.

Frumkin, P., & Galaskiewicz, J. (2004). Institutional isomorphism and public sector organizations. *Journal of public administration research and theory*, *14*(3), 283–307.

Fund, G. (2024, July). *We invest in startups that modernize the operations of government.*

Grandia, J., & Meehan, J. (2017). Public procurement as a policy tool: Using procurement to reach desired outcomes in society. *International Journal of Public Sector Management*, *30*, 302–309. DOI: https://doi.org/10.1108/IJPSM-03-2017-0066.

Gross-Gołacka, E., Kusterka-Jefmańska, M., Jefmański, B., Kupczyk, T., & Warwas, I. (2022). Diversity management in organizations – the measuring of the benefits: Visegrad group (v4) countries perspective. DOI: https://doi.org/10.24251/HICSS.2022.684.

Hickey, P. J., Erfani, A., & Cui, Q. (2022). Use of linkedin data and machine learning to analyze gender differences in construction career paths. *Journal of Management in Engineering*, *38*(6), 04022060.

Isenberg, D. J. (2010). How to start an entrepreneurial revolution. *Harvard Business Review*, 1–11.

Kolain, M., & Hillemann, D. (2022). Government technology (govtech). *SSRN Electronic Journal*. DOI: https://doi.org/10.2139/ssrn.4051971.

Li, J., & Chung, K. (2020). Decomposing isomorphism: What drives similarity in the adoption of new public management? *Administration & Society*, *52*, 375–404. DOI: https://doi.org/10.1177/0095399718811307.

Lodge, M., & Wegrich, K. (2005). Control over government: Institutional isomorphism and governance dynamics in german public administration. *Policy Studies Journal*, *33*(2), 213–233.

McGrandle, J. (2017). Understanding diversity management in the public sector: A case for contingency theory. *International Journal of Public Administration*, *40*(6), 526–537.

McNutt, J. G., Justice, J. B., Melitski, J. M., Ahn, M. J., Siddiqui, S. R., Carter, D. T., & Kline, A. D. (2016). The diffusion of civic technology and open government in the united states. *Information Polity*, *21*, 153–170. DOI: https://doi.org/10.3233/IP-160385.

Niehaves, B. (2011). Iceberg ahead: On electronic government research and societal aging. *Government Information Quarterly*, *28*, 310–319. DOI: https://doi.org/10.1016/j.giq.2011.01.003.

Niehaves, B., & Klassen, G. (2024, July). Govtech in europe: Influencing factors, common requirements and recommendations.

Nose, M. (2023, November). *Inclusive govtech: Enhancing efficiency and equity through public service digitalization*, International Monetary Fund.

O'Connor, S., & Liu, H. (2024). Gender bias perpetuation and mitigation in ai technologies: Challenges and opportunities. *AI & Society*, *39*, 2045–2057. DOI: https://doi.org/10.1007/s00146-023-01675-4.

of the European Union, C. (2024, March). Regulation (eu) 2024/903 of the european parliament and of the council of 13 march 2024 laying down measures for a high level of public sector interoperability across the union (interoperable europe act). https://eur-lex.europa.eu/eli/reg/2024/903/oj

Oppong, N. Y. (2013). Talent management: A bundle of hurdles. *Public Policy and Administrative Research*, *3*(8), 63–73.

Sabharwal, M., Hijal-Moghrabi, I., & Royster, M. (2014). Preparing future public servants: Role of diversity in public administration. *Public Administration Quarterly*, *38*(2), 206–245. Retrieved January 20, 2025, from http://www.jstor.org/stable/24372053

Sabharwal, M., Levine, H., & D'Agostino, M. (2018). A conceptual content analysis of 75 years of diversity research in public administration. *Review of Public Personnel Administration*, *38*, 248–267. DOI: https://doi.org/10.1177/0734371X16671368.

Saunders, M. (2022, April). Pursuing greater diversity in public procurement [Accessed: 2025-04-08]. DOI: https://doi.org/10.17615/1nrp-vh53.

Schultze, U., & Avital, M. (2011). Designing interviews to generate rich data for information systems research. *Information and Organization*, *21*, 1–16. DOI: https://doi.org/10.1016/j.infoandorg.2010.11.001.

Selke, D., Kilian, M., & Jonge, R. D. (2024). Govtech in europe - the govtech opportunity.

Statista. (2021). *Soziale herkunft der studierenden in deutschland seit 1982* [Accessed: 2025-01-18]. https://de.statista.com/statistik/daten/studie/155540/umfrage/soziale-herkunft-der-studierenden-in-deutschland-seit-1982/

Statista. (2023). *Bevölkerung mit und ohne migrationshintergrund nach erwerbsbeteiligung 2023* [Accessed: 2025-01-18]. https://de.statista.com/statistik/daten/studie/3384/umfrage/bevoelkerung-mit-migrationshintergrund-nach-beteiligung-am-erwerbsleben/#:~:text=Bev%C3%B6lkerung%20mit%20und%20ohne%20Migrationshintergrund%20nach%20Erwerbsbeteiligung%202023&text=Im%20Jahr%202023%20gab%20es,Migrationshintergrund%20(im%20weiteren%20Sinne).

Statista. (2024). *Startups in deutschland - statista thema* [Accessed: 2025-01-18]. https://de.statista.com/themen/3077/startups-in-deutschland/

Tseng, F.-M., Jade, N. B. N., Weng, H.-H. R., & Lu, F.-Y. (2024). Effects of team diversity, emergent leadership, and shared leadership on team performance in a multi-stage innovation and creativity crowdsourcing competition. *The International Journal of Management Education*, *22*, 100948. DOI: https://doi.org/10.1016/j.ijme.2024.100948.

vom Brocke, J., Simons, A., Niehaves, B., & Cleven, A. (2009). Reconstructing the giant: On the importance of rigour in documenting the literature search process. *17th European Conference on Information Systems (ECIS)*.

vom Brocke, J., Simons, A., Riemer, K., Niehaves, B., Plattfaut, R., & Cleven, A. (2015). Standing on the shoulders of giants: Challenges and recommendations of literature search in information systems research. *Communications of the Association for Information Systems*, *37*. DOI: https://doi.org/10.17705/1CAIS.03709.

Wise, L. R., & Tschirhart, M. (2000). Examining empirical evidence on diversity effects: How useful is diversity research for public-sector managers? *Public Administration Review*, *60*(5), 386–394.

Wyszynski, M. (2020). *Der einfluss von framing, medienpriming, vorurteilen und debiasing auf die bewertung eines betrugs an der solidargemeinschaft* [Doctoral dissertation, Construcutor University].

From Complexity to Clarity: A Taxonomy of GovTech Startup Business Models for Public Sector Innovation

Lukas Daßler [a*], *Tessa* Ruckstuhl [b], *Andreas* Hein [c], *Helmut* Krcmar [d].

[a] KrcmarLab, School of Computation, Information and Technology, Technical University of Munich, Germany, lukas.dassler@tum.de, 0009-0006-5054-557X.

[b] KrcmarLab, School of Computation, Information and Technology, Technical University of Munich, Germany.

[c] Institute for Information Systems, University of St.Gallen, Switzerland, andreas.hein@unisg.ch, 0000-0001-9565-5840.

[d] KrcmarLab, School of Computation, Information and Technology, Technical University of Munich, Germany, helmut.krcmar@tum.de, 0000-0002-2754-8493.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. Digital transformation in public administration is increasingly driven by GovTech startups, which leverage innovative technologies to address complex societal and administrative challenges. Despite their growing importance, the business models underlying these startups remain poorly understood, limiting their effective integration into public sector ecosystems. While existing research focuses on defining GovTech and exploring its potential, little attention has been paid to the systematic analysis of the business models that enable these startups to align technological innovation with the unique requirements of public administration. Addressing this gap, our study develops a taxonomy of GovTech business models to provide clarity and actionable insights for stakeholders. Our research identifies 11 dimensions and 55 characteristics that structure the business models of GovTech startups, emphasizing meta-dimensions such as value proposition, value creation and delivery, and value capture. These insights offer a comprehensive framework to classify and analyse the diverse approaches within the GovTech sector. By analysing 85 GovTech startups in Germany through an iterative taxonomy development process, we reveal distinct patterns in areas such as funding strategies, stakeholder alignment, technological enablers, and operational scope. The taxonomy highlights how GovTech startups address key challenges like citizen engagement, operational efficiency, and compliance assistance, providing practical examples of successful implementations. This study contributes to both theory and practice by offering a structured understanding of GovTech business models. For researchers, the taxonomy provides a foundation for further exploration of this emerging field. For practitioners and policymakers, it serves as a strategic tool to foster public-private collaboration, optimize innovation adoption, and address public sector challenges in a dynamic environment.

Keywords. GovTech. Business Models. Taxonomy. Design Science Research.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.971

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1. Introduction

Governments play a central role in addressing complex societal challenges, yet they struggle to adapt their services to the demands of an increasingly digital world. While public institutions traditionally monopolized service provision, emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain are reshaping this landscape. However, financial constraints, regulatory complexity, and a lack of technical expertise hinder their adoption (Bharosa, 2022). As standardized IT solutions often fail to meet the public sector's evolving needs, governments increasingly rely on GovTech startups to drive digital transformation. These startups offer agile, tailored solutions for key challenges such as digital identity management, smart infrastructure, and real-time data processing (Mergel et al., 2022). With a rapidly growing market—valued at 19.8 billion euros in Germany and 411 billion euros globally in 2021 (Public, 2021)—GovTech has become a key driver of public sector modernization, as demonstrated by successful innovations like *Vialytics'* smart road damage detection system (Stuck & Dieke, 2023).

Despite the growing importance of GovTech, successful collaborations between startups and government institutions remain limited, largely due to the uncertainty of GovTech business models. Unlike industry firms, startups in this sector face complex procurement processes, rigid regulatory frameworks, and long decision cycles, making it difficult to establish sustainable revenue streams (Hoekstra et al., 2023). Bureaucratic hurdles and varying digital maturity among public institutions further hinder scalability, leaving many promising innovations unable to gain traction (Kuziemski et al., 2022; Mergel et al., 2022). Without a clearer understanding of how GovTech startups can structure viable business models, governments risk missing out on critical technological advancements (Bharosa, 2022).

While existing research provides valuable insights into the technological applications, regulatory landscape, and ecosystem dynamics of GovTech, it falls short in addressing the business models that enable startups to navigate this complex sector. Studies on AI and blockchain in public administration highlight technological capabilities but overlook the structural barriers that GovTech startups face in scaling their solutions (Androutsopoulou et al., 2019; Engin & Treleaven, 2018). Research on GovTech ecosystems and their relationship to CivicTech (Yoshida & Thammetar, 2021) provides a macro-level perspective but lacks granularity in explaining how startups establish viable revenue models and sustain long-term collaborations with government institutions. While regulatory and market studies (Kuziemski et al., 2022; Mergel et al., 2022) acknowledge institutional constraints, they do not systematically classify the strategies startups use to overcome them. This disconnect underscores the need for a structured framework that captures the defining characteristics of GovTech startup business models. Without such an understanding, both academic research and policy discussions risk remaining too abstract to inform actionable strategies for fostering startup-driven public sector innovation.

While GovTech is gaining significance, research has yet to systematically classify the business models that enable startups to navigate technological innovation, regulatory requirements, and government procurement processes. Existing studies provide insights into ecosystem dynamics, regulatory challenges, and technological applications but do not comprehensively analyse the structural characteristics that shape GovTech business models (Bharosa, 2022). Given the sector's distinct challenges, including long procurement cycles, fragmented public sector demand, and reliance on public funding (Filer, 2019; Mergel et al., 2022), a deeper understanding of how these startups establish and sustain operations is necessary. Clarifying the key components of GovTech business models can enhance both academic inquiry and practical decision-making, supporting more effective collaborations between startups and government institutions. Against this backdrop, this study answers: *what conceptually grounded and empirically validated characteristics structure the business models of GovTech startups?*

To investigate this research question, we conduct a case-based analysis of GovTech startups in Germany, examining their business models to identify key characteristics. A case study approach captures the complexity of GovTech operations, while a purposive sampling strategy ensures diversity in sectors, technologies, and collaboration models. Data is drawn from company reports, industry analyses, and specialised databases, providing a comprehensive foundation. To structure findings, we apply an iterative taxonomy development approach (Nickerson et al., 2013), integrating theoretical insights with empirical observations.

The final taxonomy of GovTech startup business models consists of three meta-dimensions—*value proposition, value creation and delivery,* and *value capture*—covering 11 dimensions and 55 characteristics. It highlights the diversity of GovTech models and their strategies for public sector collaboration. In value proposition, startups focus on areas such as data-driven decision support and compliance, exemplified by *GovShare's* knowledge exchange and *Trail's* AI-powered automation. Value creation and delivery shows varying technological adoption, from established solutions to advanced AI and blockchain, with integration levels ranging from independent providers like *Breeze Technologies* to co-created solutions like *Convaise*. Value capture reflects financial constraints, with many startups relying on mixed funding and subscription models, while others lack clear revenue structures. This taxonomy offers a structured framework to analyse how GovTech startups develop, deliver, and sustain their services.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This study advances the understanding of GovTech startup business models by providing a structured taxonomy across value proposition, value creation and delivery, and value capture. It extends existing research on public sector innovation (Bharosa, 2022; Mergel et al., 2022) by identifying structural barriers such as limited openness, reliance on basic technology, and challenges in public sector integration. The findings refine business model frameworks for regulated environments (Wirtz et al., 2016) and offer practical insights for policymakers to foster startup-government collaboration. For entrepreneurs, the taxonomy provides strategic guidance on aligning business models with government needs and funding structures.

2. Theoretical Background

2.1 GovTech

GovTech, an acronym for "government" and "technology," (Bharosa, 2022) represents an emerging wave of digital transformation aimed at modernizing public sector operations through innovative socio-technical solutions. Unlike traditional e-government initiatives, which often rely on in-house development or large vendors, GovTech emphasizes the agility and innovation of startups and small and medium-sized enterprises (SMEs) to address public sector challenges (Mergel et al., 2022). The core technological competencies encompass AI, blockchain, big data analytics, cloud computing, predictive analytics, and the IoT (Dener et al., 2021; Engin & Treleaven, 2018). GovTech startups utilize these technologies to create public value by improving administrative processes, promoting citizen participation, enabling transparent governance, and contributing to the reduction of corruption risks (Santiso, 2022). A key characteristic of GovTech is its collaborative nature, where private organizations work closely with public sector entities to co-create value. This collaboration leverages the technological agility of private firms and aligns it with the mission-oriented focus of government agencies, enabling innovations that address complex societal needs (Bharosa, 2022).

GovTech has been defined in various ways (Mergel et al., 2022), highlighting different aspects such as collaboration with startups and SMEs (e.g., Filer, 2019), the use of innovative technology (e.g., Accenture & Public, 2018), and the improvement of efficiency in public administration (e.g., Yoshida & Thammetar, 2021). To navigate this conceptual variety, we follow the definition by Bharosa (2022, p. 3): "GovTech refers to socio-technical solutions – that are developed and operated by private organisations – intertwined with public sector components for facilitating processes in the public sector." This definition is particularly suitable for our purposes as it captures both the technological and organizational dimensions of GovTech and emphasizes the interdependence of public and private actors.

Despite its potential, the adoption of GovTech solutions faces several challenges. Public sector organizations often operate within rigid bureaucratic structures and stringent regulatory frameworks, making it difficult to implement agile and innovative solutions (Bharosa & Janowski, 2024). Additionally, traditional procurement processes are not well-suited for engaging startups, limiting governments' access to cutting-edge technologies (Filer, 2019; OECD, 2019). This "paradox of high potential but low adoption" underscores the importance of addressing barriers such as risk aversion, technical expertise deficits, and regulatory constraints (Hoekstra et al., 2023).

2.2 Business Models

The concept of the business model has been extensively explored in academic and practical domains since the 1990s, serving as both a theoretical framework and a practical tool for analysing and guiding business practices (Massa et al., 2017; Zott et al., 2011). Despite its widespread adoption, there remains a lack of consensus on its precise definition, leading to a variety of interpretations and frameworks. Scholars have proposed both simplified and comprehensive definitions, aiming to either focus on specific aspects or encompass the intricate interdependencies within business model elements (Foss & Saebi, 2017; Wirtz et al., 2016).

One of the earliest and most influential definitions by Chesbrough and Rosenbloom (2002) conceptualizes the business model as a mechanism for transforming technological potential into economic value by mediating between technological inputs and market demands. This perspective underscores the centrality of the business model in translating innovation into market success. Similarly, Teece (2010) defines a business model as a coherent framework that articulates the logic and evidence demonstrating how value is created, delivered, and captured. This widely accepted definition emphasizes three core components:

- **Value Proposition:** Identifies the problems a company solves for its customers and the needs it satisfies (Osterwalder & Pigneur, 2010; Wirtz et al., 2016).
- **Value Creation and Delivery:** Describes the organization of resources and key activities necessary to realize the proposed value (Teece, 2010).
- **Value Capture:** Focuses on how revenue is generated and managed alongside the associated cost structure (Teece, 2010; Wirtz et al., 2016).

The interconnected nature of these elements underscores the dynamic interdependencies within business models,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

where changes in one dimension can significantly affect the others (Johnson et al., 2008).

With the rise of digital technologies, the concept of digital business models has gained increasing attention in Information Systems (IS) research (Sawy & Pereira, 2013). Digital business models leverage technological advancements to reshape how businesses operate and generate revenue. A defining feature of digital business models is their scalability and minimal reliance on physical assets, enabling businesses to offer highly personalized and efficient services at low marginal costs (Remane et al., 2022).

These advancements are especially relevant in sectors like GovTech, where digital tools enable more efficient governance, better public service delivery, and improved citizen interaction (Bharosa, 2022; Mergel et al., 2022). By facilitating innovative approaches to public sector modernization, digital business models play a pivotal role in addressing evolving societal needs.

3. Method

To ensure both practical relevance and scientific rigor, we employed design science research and utilized it as a guideline to elaborate further details of this research (Hevner, 2007; Hevner et al., 2004). Design science research is particularly well-suited for research aimed at developing and evaluating artifacts that address real-world challenges while contributing to the theoretical knowledge base (Hevner et al., 2004). This approach is applied to guide the iterative development of a taxonomy of GovTech startup business models, integrating insights from theoretical and empirical sources.

Taxonomy development is operated through three interrelated cycles: the rigor cycle, the relevance cycle, and the design cycle. The rigor cycle provides the theoretical foundation for the research by synthesizing existing literature and leveraging prior knowledge. The relevance cycle ensures the practical grounding of the research by testing the developed knowledge in real-world contexts. The design cycle serves as the iterative core of the research, where artifacts are continuously evaluated and refined based on inputs from both the rigor and relevance cycles. These three cycles are interconnected and ensure that the research process is both comprehensive and aligned with the study's objectives. Figure 1 illustrates these cycles and their respective activities.

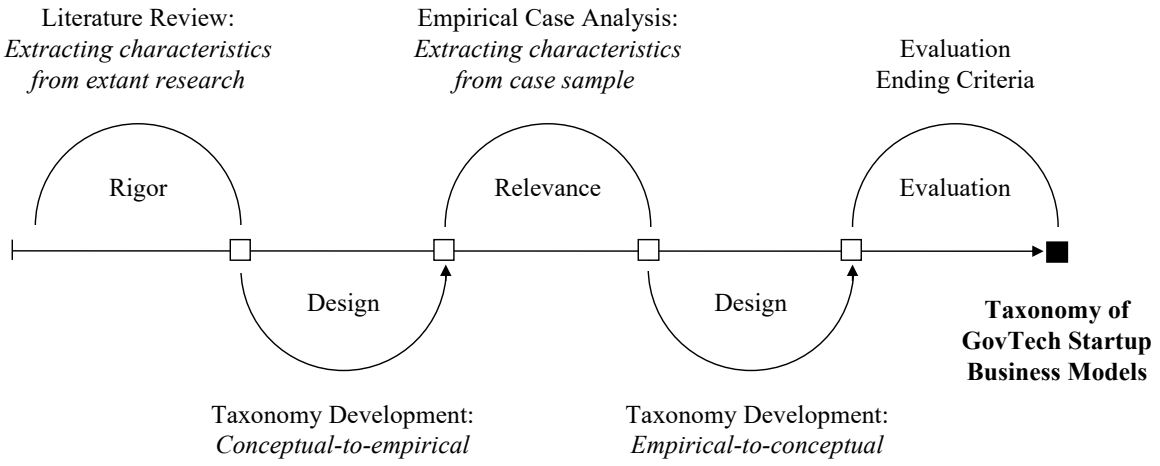


Fig. 1 - Iterative Design Science Cycles and Activities for Taxonomy Development.

The core of the design cycle is the taxonomy development method by Nickerson et al. (2013). This process develops a taxonomy with iterations from empirical-to-conceptual or conceptual-to-empirical until predefined ending-conditions are met. Nickerson et al. (2013) emphasized the importance of defining meta-characteristics at the very beginning since it eases the avoidance of examining many unrelated characteristics. The choice of meta-characteristics should be profoundly correlated with the taxonomy's purpose (Nickerson et al., 2013). In our case, the research purpose is to distinguish between various GovTech startup business models.

The **meta-characteristics** serve as the foundation for guiding the iterative development of the taxonomy and ensuring a structured and purpose-driven approach. As outlined by Nickerson et al. (2013), the meta-characteristic must represent the most comprehensive feature that aligns with the taxonomy's purpose and the needs of its users. For this research, the taxonomy is designed to assist stakeholders, including investors, public sector representatives, entrepreneurs, and researchers, in identifying, categorizing, and differentiating GovTech startups based on their business models. Accordingly, the meta-characteristic was defined as the identification of distinctive features within GovTech business models, encompassing universal business model components value proposition,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

value creation and delivery, and value capture (Wirtz et al., 2016). This focus ensures that the taxonomy remains relevant to its primary users' needs, such as evaluating growth potential and scalability for investors, identifying tailored solutions for public sector challenges, and facilitating strategic differentiation for entrepreneurs. Grounded in prior studies across domains like AI startups (Weber et al., 2022), FinTech (Eickhoff et al., 2017), and blockchain startups (Weking et al., 2019), the meta-characteristic provides a universal framework for refining subsequent dimensions and characteristics, ensuring all elements logically stem from this foundational principle.

Ending conditions determine the point at which the taxonomy can be considered complete, providing clear criteria for concluding the iterative refinement process. Following Nickerson et al. (2013), this research adopts a dual approach by integrating both objective and subjective ending conditions. Objective criteria evaluate the taxonomy's structural integrity, ensuring that all objects can be classified, no dimensions or characteristics were added, merged, or split in the last iteration, and each dimension and characteristic is unique and relevant. Subjective conditions, on the other hand, focus on the taxonomy's utility, assessing its conciseness, robustness, comprehensiveness, extendibility, and explanatory power. By meeting these conditions, the taxonomy achieves a balance between structural rigor and practical relevance. Notably, this study incorporates universal business model components—value proposition, value creation and delivery, and value capture—as guiding principles throughout the iterative cycles. By doing so, the taxonomy avoids neglecting critical dimensions or characteristics, particularly those relevant to the physical environment of the public sector, ensuring a robust and contextually appropriate framework for GovTech startup classification.

The **rigor cycle** begins with a systematic literature review to provide a robust theoretical foundation for the taxonomy development. Following the methodology by Webster and Watson (2002), the literature review focuses on two key domains: GovTech and business model theory. The first step involved keyword-based searches in prominent academic databases, including Scopus, Web of Science, and IEEE Xplore. To ensure high-quality results, we targeted articles ranked as A+, A, or B in the VHB-JOURQUAL3 classification (VHB, 2022) and included relevant contributions from the Association for Information Systems (AIS) Special Interest Group on E-Government (AIS, 2011). The search string combined the keywords: "business model" AND ("digital government" OR "GovTech" OR "e-government" OR "government technology" OR "public sector"). This broad query minimized the risk of overlooking critical contributions and enabled a comprehensive understanding of the literature. Given the emerging nature of the GovTech field, grey literature sources such as industry reports and white papers were also included to supplement academic insights. This approach allowed for a more nuanced exploration of practical and theoretical dimensions in the domain. The initial search yielded 275 articles matching the search string in their title, abstract, or keywords. To refine this dataset, duplicate entries were first removed. Next, the titles and abstracts of the remaining articles were screened for relevance to the research domains. This process resulted in 41 articles. Further refinement through full-text screening reduced this number to 21 articles. In the subsequent step, a backward search was conducted, which involved reviewing the references cited in the selected articles, and a forward search, identifying articles that cited the selected publications. These efforts added 13 additional articles to the dataset. Therefore, the input of our rigor cycle was based on 34 journal articles or conference papers. The rigorous search and selection process ensured the inclusion of high-quality, relevant sources, providing a balanced mix of theoretical insights and practical applications.

In the **relevance cycle**, we extracted knowledge from real-world data and enhanced the practical consistency of our artifact. To achieve this, we followed a case survey guideline to ensure the sampling process is systematic, comprehensive, and theoretically sound (Larsson, 1993). For data collection, we selected Crunchbase as our initial data source, a widely recognized and comprehensive database with a focus on startups and innovative companies (Marra et al., 2015). Crunchbase has proven particularly useful for research on business model innovation in emerging markets, as it includes startups at all funding stages. Previous studies on successful taxonomy development have demonstrated the utility of Crunchbase data for similar research objectives (Weking et al., 2019). Using Crunchbase's filtering tools, we queried companies headquartered in Germany and tagged as GovTech under the Industries category, resulting in an initial list of 28 companies.

To enhance representativeness and address potential selection bias, we extended our search using multiple supplementary sources. These included blogs, articles, and reports identified via systematic web searches with keywords like "GovTech Startup." A key resource in this effort was the Berlin Startup Map, a dealroom-based platform that provided a list of 179 startups categorized as GovTech or CivicTech. Additionally, we identified 22 startups through participation in GovTech-specific events, such as the GovTech Tag 2022. Combining all sources, we compiled a preliminary sample of 209 startups headquartered in Germany.

We applied stringent inclusion criteria to this sample to ensure alignment with the research objectives. Verification involved a detailed examination of publicly available information, including startups' websites, press releases, and other supporting materials. This step confirmed the startups' classification as GovTech entities and verified their operational status and location in Germany. Further criteria included assessments of the startups' founding year, growth potential, and innovation in technology or business model to validate their classification as startups.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Following this rigorous screening process, 85 startups met all criteria and were included in the final sample. The substantial reduction in sample size was primarily due to entries from the Berlin Startup Map that did not meet the inclusion criteria. In rare instances, specific criteria, such as age limits, were relaxed when a startup's business model demonstrated strong alignment with GovTech, and its classification as a startup was consistently confirmed across multiple sources. These exceptions were applied sparingly and with careful consideration to preserve the theoretical integrity of the GovTech sector.

The final sample, along with links to their websites, is listed in Table 3 in the appendix. This structured and multi-sourced approach ensured a solid and representative sample for the development of our taxonomy. These empirical data served as input for the iterative refinement of the taxonomy.

The **design cycle** is the core of the research and follows the taxonomy development methodology by Nickerson et al. (2013). This iterative refinement process was initiated following the definition of meta-characteristics and termination conditions. This involved alternating between conceptual-to-empirical (deductive) and empirical-to-conceptual (inductive) approaches to develop a taxonomy of GovTech business models. The deductive approach leveraged insights from existing literature to propose new dimensions and characteristics, while the inductive approach derived dimensions and characteristics through the analysis of empirical objects, in this case, GovTech startups. Each iteration evaluated the taxonomy against the defined termination conditions to ensure its progressive refinement (Nickerson et al., 2013).

In the first iteration, we employed a conceptual-to-empirical approach grounded in the presented literature review in the rigor cycle. To garnish the business model aspect of the taxonomy, we appended the following four dimensions: *proposed solution, key channels, revenue model*, and *target customer* that originated in Osterwalder and Pigneur (2010) and are frequently discussed by other researchers. Additionally, we added dimensions like *key technology* (Amit & Zott, 2010). GovTech-specific dimensions, including *solution domain* (Stuck & Dieke, 2023), *public sector integration, data activity, operational scope* (Bharosa, 2022), and *funding sources* (Mergel et al., 2022), were also introduced.

Using these insights, we developed the initial dimensions and characteristics for the taxonomy, resulting in a preliminary, purely conceptual taxonomy. The identified dimensions were mapped to overarching meta-dimensions based on the meta-characteristic of identifying distinctive features of GovTech startup business models. This structure encapsulated the key elements of GovTech startup business models, including *value proposition, value creation and delivery*, as well as *value capture*. Several dimensions were enriched with specific characteristics. For instance, the *solution domain* dimension included characteristics such as *smart urban infrastructure, environmental monitoring, civic engagement, health and social services,* and *internal administration* (Stuck & Dieke, 2023). The *data activity* dimension featured characteristics like *personalized service delivery* and *data-driven decision support* (Bharosa, 2022).

In subsequent iterations, an empirical-to-conceptual approach was adopted, involving the sequential analysis of 85 GovTech startups. The sample was divided into multiple phases, with each phase introducing new startups to validate and refine the taxonomy. An overview of a selection of the startups analysed is provided in Table 1.

Tab. 1 - Analysed GovTech Startups (Excerpt).

Startup	Description	Website
Convaise	Converts form-based communication between citizens and public authorities into intuitive chat interactions using conversational AI, thereby optimising administrative processes and improving accessibility of public services.	www.convaise.com
GovShare	It facilitates municipal climate protection by enabling local governments to exchange practical solutions and experiences on an open platform.	www.govshare.org
Vialytics	An AI-powered system that uses smartphone technology to help local governments better manage infrastructure by assessing road conditions and planning efficient maintenance.	www.vialytics.com

During the empirical analysis, several refinements were made to enhance the taxonomy. For example, the *collaboration level* dimension was reinterpreted as *public sector integration*, providing a clearer description of the degree of integration with public systems and workflows. Additionally, new dimensions were introduced, such as *openness*, which encompasses open data and open-source initiatives, and *key technology*. At the same time, less relevant dimensions, such as *cost structure,* were removed to streamline the taxonomy. Some existing dimensions were consolidated to improve the taxonomy's usability and relevance. For instance, the *product/service offering* and *sector focus* dimensions were merged into a broader *solution domain* dimension. These adjustments significantly improved the taxonomy's practical applicability for classifying GovTech startups.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

By the final iteration, all 85 startups had been analysed, and the taxonomy met all termination conditions. The finalized taxonomy successfully classified all startups, with every dimension and characteristic represented by at least one object. The iterative development process concluded once all objective and subjective termination conditions (Nickerson et al., 2013) were satisfied. The finalized taxonomy of GovTech startup business models is presented in detail in the results section.

4. Results

The final taxonomy of GovTech startup business models is presented in Table 2, visualized as a morphological box. In this framework, combinations of characteristics define the business model of a GovTech startup. The taxonomy comprises three meta-dimensions, eleven dimensions, and three to seven distinct characteristics per dimension, resulting in a total of 55 characteristics. Each dimension captures critical and distinctive elements of GovTech startup business models, structured around the overarching meta-characteristic that organizes business model components into the meta-dimensions of *value proposition*, *value creation and delivery*, and *value capture*. Selecting one characteristic from each dimension generates a unique profile for a GovTech startup's business model. The numbers in parentheses indicate the number of startups in our sample that exhibit the respective characteristic.

Tab. 2 – Taxonomy of GovTech Startup Business Models.

Meta-charact.	Dimension	Characteristics						
Value Proposition	Proposed Solution	Data-Driven Decision Support (22)	Collaboration and Knowledge Sharing (6)	Citizen Engagement (22)	Operational Efficiency (17)	Compliance Assistance (2)	Safety and Risk Management (6)	Data Control and Security (10)
	Solution Domain	Internal Admini-stration (18)	Citizen Services (25)	Education and Workforce Development (5)	Health and Social Services (2)	Smart Urban Infrastructure (18)	Defence and Safety (4)	Environ-mental Monitoring (13)
Value Creation and Delivery	Key Technology	AI and Advanced Analytics (24)	Blockchain (3)	IoT and Smart Sensors (10)	Cloud Computing (2)	Digital Twins (6)	Digital Identity (5)	Basic Technology Stack (33)
	Data Activity	Data Collection and Integration (19)	Personalized Service Delivery (27)	Data Analysis and Automation (26)	Data Sharing and Accessibility (10)	Data Governance and Security (3)		
	Key Channel	APIs and Modular Software (10)	Physical Devices (11)	Digital Platforms (64)				
	Public Sector Integration	Independent (36)	Partially Integrated (35)	Fully Customized (14)				
	Openness	Open Source (9)	Open Data (4)	Open Source and Open Data (2)	Proprietary (70)			
	Target Customer	B2G (42)	B2B (3)	B2C (8)	B2G and B2B (32)			
	Operational Scope	Municipal (38)	State (36)	International (11)				
Value Capture	Funding Sources	Private (28)	Public (13)	Mixed (8)	None or Undisclosed (36)			
	Revenue Model	Subscriptions and Licensing (31)	Non-Profit (2)	Transaction-based (3)	One-time Payment (6)	Consulting and Implementation Fees (4)	Undisclosed (39)	

Following Nickerson et al.'s (2013) recommendations, all dimensions are mutually exclusive to ensure clarity and applicability. For example, a startup cannot simultaneously be classified as leveraging *blockchain* and *digital twins* as its *key technology*.

Although multiple characteristics may theoretically apply to a single startup, each startup is assigned only one characteristic per dimension that fits best. This approach guarantees distinct classification within the taxonomy. Some dimensions, such as *funding sources*, are exhaustive and encompass all possible options for GovTech startups, while others, like *key technology*, reflect the most used technology.

The following sections detail each meta-dimension, its respective dimensions, and their defining characteristics, supplemented by examples from our empirical case sample.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4.1 Value Proposition

The first meta-dimension, *value proposition*, explores the benefits that GovTech startups deliver to their stakeholders. This meta-dimension is captured through two distinct dimensions: *proposed solution* and *solution domain.*

The *proposed solution* dimension outlines the core benefits GovTech startups aim to provide, driving the digital transformation of the public sector by addressing specific stakeholder needs. These benefits include the leveraging *data-driven decision support* that enable public agencies to effectively analyse large amounts of data to make informed decisions. *Collaboration and knowledge sharing* enable stakeholders to exchange information and work together on governance challenges. *Citizen engagement* focus on improving the quality and ease of public interactions with governments. *Operational efficiency* help optimize resources and reduce expenditures in public services. *Compliance assistance* supports organizations in adhering to regulations and standards. *Safety and risk management* enhance the protection of public resources and infrastructure. Lastly, *data control and security* ensure that sensitive data is controlled and protected within legal frameworks. For example, *GovShare* facilitates intergovernmental knowledge sharing by offering a platform for best practice exchange, while Trail automates regulatory compliance processes through an AI-powered copilot.

The *solution domain* dimension categorizes the operational focus of GovTech startups, emphasizing the primary areas where solutions are applied. *Internal administration* streamlines internal processes within governmental organizations. *Citizen services* enhance public-facing services such as healthcare or transportation. *Education and workforce development* improve access to learning and employment opportunities. *Health and social services* address public health challenges and social welfare. *Smart urban infrastructure* focuses on optimizing city management and infrastructure development. *Defence and security* improve security measures and emergency response capabilities. *Environmental monitoring* addresses sustainability and ecological concerns. For instance, *JobKraftwerk* connects job seekers with employers via a digital platform, supporting workforce development, while *SONAH* uses sensor-based technology to provide actionable data for urban planning.

4.2 Value Creation and Delivery

The second meta-dimension, *value creation and delivery*, examines the mechanisms through which startups generate and deliver value. This meta-dimension is comprised of seven dimensions: *key technology, data activity, key channel, public sector integration, openness, target customer,* and *operational scope.*

The *key technology* dimension identifies the primary technologies that drive GovTech solutions. *AI and advanced analytics* enable predictive insights and process automation. *Blockchain* provides secure and distributed systems based on blockchain technology. *IoT and smart sensors* gather real-time data from physical environments. *Cloud computing* offers scalable storage and processing capabilities. *Digital twins* simulate and analyse spatial data. For example, *Edgeless Systems* uses cloud computing to protect sensitive data, while *Natix* incentivizes users to collect geospatial data via smartphones for real-time applications. *Digital identity* refers to secure and verifiable online identification solutions that enable citizens and businesses to authenticate themselves for government and private sector services, thereby improving security, accessibility, and compliance with legal frameworks. One example is *Verimi*, which offers a secure digital identity platform for storing and verifying ID documents and facilitates digital signatures, logins, and payments. At the same time, most of the startups (33) leverage a *basic technology stack*, utilizing established and widely adopted technologies without incorporating advanced or disruptive elements–e.g., basic web applications.

Data activity captures how startups engage with data. *Data collection and integration* involve aggregating information from diverse sources, such as sensors. *Personalized service delivery* tailors services to individual users. *Data analysis and automation* streamline processes through advanced analytics. *Data sharing and accessibility* improve collaboration across stakeholders. *Data governance and security* ensure compliance with data protection standards. For example, *Brifle* provides a personalized digital mailbox service, while *Natix* focuses on integrating and monetizing geospatial data.

The *key channel* dimension explores how GovTech startups deliver their solutions. *Application Programming Interfaces (APIs) and modular software* enable seamless integration with existing digital infrastructures by facilitating interoperability between different systems. *Physical devices* combines hardware solutions with software functionalities. *Digital platforms*, such as web and mobile applications, provide user-friendly interfaces for accessing services. For instance, *Green City Solutions* offers physical air purification devices, which use moss filters to bind particulate matter and provide real-time air quality data through IoT sensors.

Public sector integration highlights the extent of collaboration with government workflows. *Independent* startups operate without direct involvement from public sector entities. *Partially integrated* startups utilize public sector data or systems. Customized solutions are developed in close collaboration with government agencies. The

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

independent *Breeze Technologies* provides standardized air quality monitoring solutions, whereas *Convaise* collaborates with public entities to transition citizen communication into an individualized chat-based system.

Openness reflects the degree to which startups adopt open principles. *Open source* and *open data* promote transparency and collaboration, while *proprietary solutions* protect intellectual property. For example, *HeiDi* offers modular applications for municipalities based on open-source principles, enabling easy customization and integration with existing systems. The software is developed collaboratively with 334 municipalities and cities, making it cost-effective, efficient, and strengthening communities.

Target customer and *operational scope* examine the stakeholders served by GovTech startups. As *target customers,* GovTech startups address governments *(B2G)*, businesses *(B2B)*, or individual citizens *(B2C)*. Most of the GovTech startups in our sample target government intuitions. While 42 operate as a pure B2G business, another 32 have a mixed business and also address business customers *(B2G and B2B)*.

The *operational scope* dimension further explores at which scale their solutions apply, distinguishing between *municipal*, *state*, and *international* levels. For example, a startup might operate nationally but their solutions only apply to cities on a municipal level. With 38, most startups operate at the local level in communities, closely followed by the state level with 36 startups. *FixMyCity*, for example, exemplifies a municipal-level B2G startup enhancing public services for the general population by providing a platform for citizens to report and track the resolution of urban issues such as potholes or broken streetlights. Only 11 startups operate internationally.

4.3 Value Capture

The final meta-dimension, *value capture*, focuses on how GovTech startups sustain their operations and generate income. This meta-dimension includes two dimensions: *funding sources* and *revenue model*.

Funding sources refer to the mechanisms by which financial support for startups is provided. *Private funding*, the most frequently mentioned category with 28 startups, includes investments from individuals, institutions or organizations, including venture capitalists or crowdfunding efforts. *Public funding*, on the other hand, consists of government grants or subsidies aimed at promoting innovation and growth. *Mixed funding* represents a combination of different funding sources, reflecting a diversified approach to securing resources. Most startups did not disclose their funding details or did not receive any funding (36), making *none or undisclosed* the most common funding source observed in our sample.

Revenue model describes how startups generate income. *Subscription and licensing models*, which involve recurring payments for service access, are the most disclosed revenue models used by 31 startups. *Transaction-based models* charge customers per usage, while *one-time payments* are single transactions for specific services. *Consulting and implementation fees* generate income through expertise or service deployment. Some startups operate under a *non-profit model*, focusing on creating value without direct profit, often relying on grants, donations, or other funding sources to sustain their activities. The largest group comprises startups with *undisclosed* revenue models, accounting for 39 startups.

5. Discussion

Understanding the business models of GovTech startups is key to driving the modernization of the public sector in an increasingly complex and technology-driven era. GovTech ecosystems have emerged as disruptive forces, with startups tackling critical public challenges such as administrative inefficiencies, regulatory complexity, and citizen engagement (Bharosa, 2022; Mergel et al., 2022). Despite their transformative potential, governments often face significant barriers to adopting these innovations due to strict procurement processes, complex legal frameworks, and an overall reluctance to embrace novel business models (Filer, 2019; OECD, 2019). However, countries like Germany, which boasts a rapidly growing GovTech market, show how customized digital solutions can effectively meet specific governmental needs. This highlights the importance of matching technological capabilities with the unique requirements of public institutions (Stuck & Dieke, 2023).

Our taxonomy provides a systematic framework for understanding how digital technology is implemented in various aspects of GovTech startup business models. By synthesizing research findings with empirical observations, the taxonomy reduces the complexity of the GovTech landscape and offers a clear, structured overview (Nickerson et al., 2013). Within the frame of business models, it articulates how startups can leverage digital technologies across three key dimensions: value proposition, value creation and delivery, and value capture (Wirtz et al., 2016).

For the dimension of *value proposition*, our research reveals that in the *solution domain,* 25 startups focus on *citizen services*, making it the most prominent domain in the GovTech landscape. These startups aim to improve citizen communication, enhance access to digital public services, and offer personalized solutions. For instance, *TaxFix*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

simplifies tax returns, making the process faster, more accessible, and user-friendly. Similarly, *FixMyCity* enables citizens to report urban issues, such as potholes or broken streetlights, directly to local governments, fostering more efficient resolution mechanisms. Solutions targeting *internal administration* and *smart urban infrastructure* follow closely, with 18 startups each addressing these domains. For example, *GovRadar* streamlines public procurement through AI-powered vendor matching, while *Smart City Systems* optimizes urban infrastructure with automated parking management systems. This distribution reflects a dual intent: startups aim to enhance citizen-centric service delivery while governments seek to improve operational efficiency and engagement. Conversely, sectors like *defence and security*, as well as *health and social services* remain underrepresented, likely due to their heightened organizational complexity and reliance on sensitive data. These underrepresented areas underscore the need for targeted initiatives to reduce barriers to innovation and broaden GovTech's scope in addressing public-sector challenges (Bharosa & Janowski, 2024).

Value creation and delivery is substantially characterised by their key technologies, openness, and the degree of public sector integration in their business models. Among the 85 startups analysed, 33 employ a basic technology stack as *key technology,* such as simple web applications, rather than advanced innovations like AI or blockchain. This reliance points to persistent gaps in the public sector's digital infrastructure, where foundational technological needs remain unmet (Dener et al., 2021). Consequently, startups prioritize addressing these deficiencies to create immediate value. For instance, *Vilisto* offers straightforward scheduling software to help local governments manage resources more effectively, bridging critical operational gaps (Stuck & Dieke, 2023). These findings emphasize the urgent need for public administrations to invest in digital infrastructure and workforce training, creating a supportive environment where advanced technologies can flourish. A stepwise, incremental approach to technological transformation appears more feasible in the short term, allowing governments to address fundamental needs before adopting more complex innovations.

Another noteworthy finding is the limited *openness* of GovTech startup business models with the dominance of proprietary solutions. A clear majority of startups (70) offer proprietary solutions, with only nine startups applying open-source principles and four utilizing open data. An example of a startup with an open-source approach is *HeiDi*, which develops open-source municipal tools, enabling cost-efficient customization of digital services for local governments. *Geospin*, on the other hand, leverages open geodata alongside proprietary datasets to provide predictive analytics and geospatial insights for smarter urban planning and optimized business decisions. The overwhelming reliance on proprietary software highlights a missed opportunity for fostering openness and reducing vendor dependency. Governments must actively promote the development and procurement of open-source solutions to foster competition, enhance transparency, and build internal expertise (Yoshida & Thammetar, 2021). By encouraging the use of open-source technologies, public institutions could strengthen their resilience, reduce long-term costs, and establish a more diverse and competitive market ecosystem.

Public sector integration influences the success and adaptability of GovTech startups by affecting the alignment of their business models with government systems. Startups with high integration, such as *Vialytics*, which works with over 200 municipalities on AI-powered road maintenance, demonstrate the viability of deeply integrated models. These startups often adopt co-creation-based business models and work closely with public agencies to deliver *customized solutions* for specific needs such as administrative efficiency or infrastructure management (Bharosa, 2022; Stuck & Dieke, 2023). By embedding their services in public authority workflows, these startups ensure higher adoption rates and sustainable value creation, establishing themselves as indispensable partners. By contrast, *independent* startups with lower integration offer generic solutions such as web applications. While these solutions address immediate needs, their limited integration limits their systemic impact and long-term scalability (Mergel et al., 2022). Barriers to greater integration, such as rigid procurement processes, outdated IT systems, and cultural resistance, have direct implications for GovTech business models. Startups that focus on open innovation ecosystems and use open-source models could reduce these barriers by promoting adaptability and cost efficiency (Yoshida & Thammetar, 2021). In addition, startups can rely on platform-based models that enable modular integration and allow for a phased roll-out without overhauling existing systems. This highlights the need for business models that can be adapted to different levels of public sector readiness. Ultimately, prioritizing a public sector integration not only improves the alignment of startup solutions with public sector needs but also ensures the scalability, resilience, and broader adoption of public sector innovation.

For *value capture*, our results underscore the crucial role of *funding sources* in shaping the GovTech landscape. Of the startups that disclosed their funding, 28 rely on *private capital*, while only 13 startups benefit from *public funding*. GovTech startups often rely on venture capital funding, which can clash with the slower, fragmented nature of public procurement, limiting their scalability and growth (Mergel et al., 2022). This limited public investment reflects a missed opportunity to strategically support startups that address pressing government challenges. Scaling up public funding programs could significantly accelerate the growth of the GovTech sector and ensure that startups with tailored solutions receive the resources they need. Aligning public funding with modernization goals would also improve the sector's ability to deliver sustainable innovation.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Limitations

We must acknowledge two limitations of this study. First, taxonomies are inherently iterative and cannot claim to be complete or final (Nickerson et al., 2013). In developing our taxonomy, we specifically focused on the characteristics of business models that distinguish GovTech startups in Germany. While this approach ensures the clarity and relevance of the taxonomy, it may exclude certain characteristics that could be relevant in other geographic or regulatory contexts. This trade-off was made to strike a balance between comprehensiveness and parsimony, ensuring that the taxonomy remains both actionable and understandable for the target audience.

Secondly, our empirical data is mainly drawn from publicly available information on 85 GovTech start-ups in Germany, supplemented by secondary sources such as Crunchbase. While this approach provides a solid foundation, the sample is inherently skewed towards start-up business models and may not fully capture the strategies of larger, more established technology providers or innovations originating from the public sector. Nevertheless, the iterative process of taxonomy development mitigates this limitation by integrating conceptual insights from the literature to ensure broader applicability. Given the central role of start-ups as drivers of innovation in the GovTech sector (Bharosa, 2022). the taxonomy remains a valuable tool for researchers and practitioners seeking to promote digital transformation in public administration.

Practical Implications

First, the taxonomy of GovTech startup business models presented in this study equips public administrators, startup founders, and policymakers with a robust framework to navigate the complexities of GovTech ecosystems. Specifically, it allows stakeholders to identify strategic opportunities and challenges across the value proposition, value creation and delivery, as well as the value capture dimensions. For example, public sector organizations can utilize the taxonomy to prioritize engagement with startups offering tailored solutions for more citizen-centred services or operational efficiency, as these domains demonstrate significant potential for value creation. Simultaneously, startup founders can adopt the taxonomy to align their offerings with the needs of public institutions, improving the scalability and adoption of their innovative solutions. This structured approach supports both proactive planning and reactive decision-making, enabling more resilient and adaptive public sector modernization.

Second, our taxonomy highlights the necessity of fostering partnerships and open innovation practices to overcome systemic barriers such as procurement inefficiencies and rigid regulatory frameworks. Public administrators are encouraged to explore collaborations with startups that embrace open data and open-source technologies, reducing vendor dependency and promoting adaptability. Similarly, GovTech startups can leverage the taxonomy to refine their strategies for public sector integration, ensuring their solutions are not only innovative but also practical and implementable within government systems. By bridging the gap between technological capabilities and public sector readiness, the taxonomy facilitates a co-creative ecosystem conducive to sustained innovation and efficiency.

Theoretical Implications

The taxonomy extends existing literature on digital transformation in the public sector by introducing a structured framework that emphasizes the interplay between technological innovation and public sector constraints. Unlike prior studies that focused predominantly on technological capabilities or ecosystem dynamics, this research provides a granular analysis of business model components tailored to GovTech startups. It contributes to the understanding of how value proposition, value creation and delivery, and value capture dimensions are interrelated and how these interrelations drive innovation in regulated environments. This framework enriches theoretical discussions on digital government by offering new perspectives on how startups navigate and mitigate the unique challenges of public sector ecosystems.

Furthermore, the study advances business model theory by illustrating how contextual factors such as regulatory complexity, public funding dynamics, and citizen-centric goals shape the design and evolution of business models in the GovTech sector. By integrating empirical data with theoretical constructs, the taxonomy offers a foundation for comparative analyses across different domains and geographies, shedding light on the universal and context-specific characteristics of GovTech startup business models. This theoretical contribution not only fills a critical gap in the literature but also opens new avenues for interdisciplinary research on public-private innovation in digital government.

Future Research

Our taxonomy provides a foundation for studying transitional pathways between different GovTech business models. Future research could investigate how startups evolve their business models in response to changes in regulatory environments, technological advancements, or public sector demands. For instance, analysing the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

transition from proprietary to open-source models or from independent solutions to fully integrated public sector systems could shed light on the antecedents and enablers of successful GovTech scaling. Such research could also examine how specific dimensions of the taxonomy, such as public sector integration or funding sources, influence the scalability and sustainability of GovTech innovations.

Another promising avenue for future research lies in exploring the performance implications of different business model designs within the GovTech sector. By leveraging the taxonomy as a coding scheme or survey instrument, scholars can compare the economic, social, and operational outcomes of various GovTech models. For instance, researchers could analyse whether startups focusing on citizen engagement outperform those targeting operational efficiency in terms of public value creation or long-term adoption. These insights could help refine the taxonomy further and provide actionable guidance for both academics and practitioners seeking to optimize GovTech innovations.

6. Conclusion

The growing importance of GovTech startups highlights their critical role in driving digital transformation in public administration, addressing complex challenges such as regulatory constraints, operational inefficiencies, and citizen engagement. This study aimed to systematically explore the business models of these startups, providing clarity on how they align technological innovation with the unique needs of the public sector. By developing a taxonomy structured around value proposition, value creation and delivery, and value capture, we offer a comprehensive framework that classifies and analyses diverse approaches within the GovTech sector. The findings underscore the importance of tailoring business models to overcome public sector constraints while leveraging opportunities for co-creation and innovation. Moreover, our taxonomy advances theoretical understanding of business models in regulated environments and offers practical guidance for fostering collaboration between startups and public institutions. In doing so, it equips stakeholders with actionable insights for fostering innovation and modernizing public services, ultimately contributing to a more agile and responsive public sector.

Acknowledgement

- **Contributor Statement**:
  Lukas Daßler: Conceptualization, Methodology, Visualization, Writing – Original Draft
  Tessa Ruckstuhl: Investigation, Writing – Original Draft
  Andreas Hein: Supervision, Writing – Review & Editing
  Helmut Krcmar: Supervision
- **Use of AI**: During the preparation of this work, the authors used Grammarly and DeepL in order to support grammar checking, language refinement, and translation. After using these tools, the authors reviewed, edited, made the content their own, validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

(* included in the literature review)

Accenture & Public. (2018). GovTech: Europe's next opportunity. https://www.accenture.com/content/dam/accenture/final/a-com-migration/manual/r3/pdf/pdf-90/Accenture-GovTech-POV.pdf

AIS. (2011). *Senior Scholars' Basket of Journals*. https://aisnet.org/general/custom.asp?page=SeniorScholarBasket

*Al-Debei, M. M., & Avison, D. (2010). Developing a unified framework of the business model concept. *European Journal of Information Systems*, *19*(3), 359-376.

*Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic Management Journal*, *22*(6-7), 493-520.

*Amit, R., & Zott, C. (2010). Business Model Innovation: Creating Value In Times Of Change. *SSRN Electronic Journal*, *23*. https://doi.org/10.2139/ssrn.1701660

Androutsopoulou, A., Karacapilidis, N., Loukis, E., & Charalabidis, Y. (2019). Transforming the communication between citizens and government through AI-guided chatbots. *Government Information Quarterly*, *36*(2), 358-367. https://doi.org/10.1016/j.giq.2018.10.001

*Baden-Fuller, C., & Haefliger, S. (2013). Business models and technological innovation. *Long Range Planning*, *46*(6), 419–426. https://doi.org/10.1016/j.lrp.2013.08.023

*Bharosa, N. (2022). The rise of GovTech: Trojan horse or blessing in disguise? A research agenda. *Government Information Quarterly*, *39*(3). https://doi.org/10.1016/j.giq.2022.101692

Bharosa, N., & Janowski, T. (2024). *The GovTech Challenge – GovTech and Public Value Creation* Digital Government Research (DGO 2024), Taipei, Taiwan.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

*Bock, M., & Wiener, M. (2017). *Towards a taxonomy of digital business models - conceptual dimensions and empirical illustrations* International Conference on Information Systems (ICIS), Seoul, South Korea.
*Chesbrough, H., & Rosenbloom, R. (2002). The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin-Off Companies. *Industrial and Corporate Change*, *11*. https://doi.org/10.1093/icc/11.3.529
*Davydova, M. L. (2013). Govtech and smart regulation in election law. *Universidad y Sociedad*, *14*(1), 205–211. https://doi.org/10.1016/j.lrp.2013.08.023
*de Magalhães Santos, L. G. (2024). *Dynamic Capabilities in the Public Sector to Deal with GovTech* Electronic Government (EGOV 2024),
*Dener, C., Nii-Aponsah, H., Ghunney, L. E., & Johns, K. D. (2021). *GovTech Maturity Index: The State of Public Sector Digital Transformation*. The World Bank. https://doi.org/10.1596/978-1-4648-1765-6
Eickhoff, M., Muntermann, J., & Weinrich, T. (2017). *What do FinTechs actually do? A Taxonomy of FinTech Business Models*.
*Engin, Z., & Treleaven, P. (2018). Algorithmic Government: Automating Public Services and Supporting Civil Servants in using Data Science Technologies. *The Computer Journal*, *62*. https://doi.org/10.1093/comjnl/bxy082
Filer, T. (2019). *Thinking about GovTech A Brief Guide for Policymakers*.
Foss, N. J., & Saebi, T. (2017). Fifteen Years of Research on Business Model Innovation. *Journal of Management*, *43*(1), 200-227.
Hevner, A. (2007). A Three Cycle View of Design Science Research. *Scandinavian Journal of Information Systems*, *19*.
Hevner, A., R, A., March, S., T, S., Park, Park, J., Ram, & Sudha. (2004). Design Science in Information Systems Research. *Management Information Systems Quarterly*, *28*, 75.
*Hoekstra, M., Chideock, C., Bodea, G., Bharosa, N., Cave, J., Kokkeler, B., Oomens, I., Berg, A., Veenstra, A., & Alleweldt, F. (2022). *The digital single market and the digitalisation of the public sector – govtech and other innovations in public procurement*. European Parliament. https://doi.org/10.2861/830794
*Hoekstra, M., Veenstra, A. F. V., & Bharosa, N. (2023). *Success Factors and Barriers of GovTech Ecosystems: A case study of GovTech ecosystems in the Netherlands and Lithuania* Proceedings of the 24th Annual International Conference on Digital Government Research, https://doi.org/10.1145/3598469.3598500
*Johnson, M., Christensen, C. C., & Kagermann, H. (2008). Reinventing your business model. *Harvard Business Review*, *87*, 52–60.
*Kuziemski, M., Ulrich, P., Martinez, A., & Mergel, I. (2022). *GovTech practices in the EU – A glimpse into the European GovTech ecosystem, its governance, and best practices*. Publications Office of the European Union. https://doi.org/doi/10.2760/74735
*Labanava, A., Liiv, I., & Pappel, I. (2023). *Capacity Building in GovTech for Measuring and Achievement of Sustainable Development Goals*. https://doi.org/10.54941/ahfe1003888
Larsson, R. (1993). Case Survey Methodology: Quantitative Analysis of Patterns across Case Studies. *The Academy of Management Journal*, *36*, 1515-1546.
*Lukkien, B., Bharosa, N., & Reuver, M. D. (2023, July 11–14, 2023). *Barriers for developing and launching digital identity wallets* 24th Annual International Conference on Digital Government Research (DGO 2023), Gdańsk, Poland.
Marra, A., Antonelli, P., Dell'Anna, L., & Pozzi, C. (2015). A Network Analysis Using Metadata to Investigate Innovation in Clean-Tech – Implications for Energy Policy. *Energy Policy*, *86*, 17.
Massa, L., Tucci, C. L., & Afuah, A. (2017). A Critical Assessment of Business Model Research. *Academy of Management Annals*, *11*(1), 73-104.
*Mergel, I., Ulrich, P., Kuziemski, M., & Martinez, A. (2022). *Scoping GovTech dynamics in the EU*. Publications Office of the European Union. https://doi.org/doi/10.2760/700544
*Morris, M., Schindehutte, M., & Allen, J. (2005). The entrepreneur's business model: Toward a unified perspective. *Journal of Business Research*, *58*(6), 726–735. https://doi.org/10.1016/j.jbusres.2003.11.001
Nickerson, R. C., Varshney, U., & Muntermann, J. (2013). A method for taxonomy development and its application in information systems. *European Journal of Information Systems*, *22*(3), 336-359.
OECD. (2019). Embracing Innovation in Government: Global Trends 2019. https://trends2019.oecd-opsi.org/embracing-innovation-in-government-global-trends-2019.pdf
*Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. John Wiley & Sons.
*Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying business models: Origins, present, and future of the concept. *Communications of the Association for Information Systems*, *16*. https://doi.org/10.17705/1CAIS.01601
*Public. (2021). *The State of European GovTech*. https://www.public.io/researchreports/the-state-of-european-govtech
*Remane, G., Schneider, S., & Hanelt, A. (2022). Digital Business Model Types: Understanding Their Mechanisms As Recipes To Commercialise Digital Technologies. *International Journal of Innovation Management*, *26*.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://doi.org/10.1142/S1363919622400199
*Santiso, C. (2022). Govtech against corruption: What are the integrity dividends of government digitalization? *Data & Policy*, *4*, e39, Article e39. https://doi.org/10.1017/dap.2022.31
*Sawy, O., & Pereira, F. (2013). VISOR: A Unified Framework for Business Modeling in the Evolving Digital Space. In (pp. 21-35). https://doi.org/10.1007/978-3-642-31765-1_3
*Stuck, J., & Dieke, A. K. (2023). *GovTechs in Germany, France and the UK*. https://www.wik.org/en/publications/publication/govtechs-in-deutschland-frankreich-und-grossbritannien-nr-507
*Svahn, M., Larsson, A., Macedo, E., & Bandeira, J. (2023). *Construct hunting in govtech research: An exploratory data analysis* Electronic Government (EGOV 2023),
*Teece, D. J. (2010). Business Models, Business Strategy and Innovation. *Long Range Planning*, *43*(2-3), 172-194.
*Veit, D., Clemons, E., Benlian, A., Buxmann, P., Hess, T., Spann, M., Kundisch, D., Leimeister, J. M., & Loos, P. (2014). Business models: An information systems research agenda. *Business & Information Systems Engineering*, *6*, 45–53. https://doi.org/10.1007/s12599-013-0308-y
*Vendrell-Herrero, F., Parry, G., Bustinza, O., & Gomes, E. (2018). Digital business models: Taxonomy and future research avenues. *Strategic Change*, *27*, 87–90. https://doi.org/10.1002/jsc.2183
VHB. (2022). *Verband der Hochschullehrer für Betriebswirtschaft e. V.: Alphabetische Gesamtliste der Fachzeitschriften in VHB-JOURQUAL3*. Retrieved July 2, from http://vhbonline.org/service/jourqual/vhb-jourqual-3/gesamtliste/
Weber, M., Beutter, M., Weking, J., Böhm, M., & Krcmar, H. (2022). AI Startup Business Models. *Business & Information Systems Engineering*, *64*(1), 91-109. https://doi.org/10.1007/s12599-021-00732-w
Webster, J., & Watson, R. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, *26*. https://doi.org/10.2307/4132319
Weking, J., Mandalenakis, M., Hein, A., Hermes, S., Böhm, M., & Krcmar, H. (2019). The impact of blockchain technology on business models – a taxonomy and archetypal patterns. *Electronic Markets*, *30*(2), 285-305. https://doi.org/10.1007/s12525-019-00386-3
*Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business Models: Origin, Development and Future Research Perspectives. *Long Range Planning*, *49*(1), 36-54. https://doi.org/https://doi.org/10.1016/j.lrp.2015.04.001
*Yoshida, M., & Thammetar, T. (2021). Education Between GovTech and Civic Tech. *International Journal of Emerging Technologies in Learning (iJET)*, *16*(04), pp. 52-68. https://doi.org/10.3991/ijet.v16i04.18769
*Yoshida, M., & Theeraroungchaisri, A. (2021). Socialised creation literacy appeared during the covid-19 emergency: A case report. *International Journal of Information and Education Technology*, *11*(2), 96–101. https://doi.org/10.18178/ijiet.2021.11.2.1495
*Zott, C., Amit, R., & Massa, L. (2011). The Business Model: Recent Developments and Future Research. *Journal of Management*, *37*(4), 1019-1042. https://doi.org/10.1177/0149206311406265

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Appendix A

Tab. 3 – Analysed GovTech Startups.

No.	Startup	Website	No.	Startup	Website
1	&effect	www.and-effect.com	46	JobKraftwerk	www.jobkraftwerk.com
2	Academa	www.academa.de	47	Komuno	www.komuno.de
3	Agvolution	www.agvolution.com	48	Leistungslotse	www.leistungslotse.com/en
4	Aleph Alpha	www.aleph-alpha.com	49	LiveEO	www.live-eo.com
5	Ankaadia	www.ankaadia.com	50	Locaboo	www.locaboo.com
6	Ark Climate	www.ark-climate.de	51	MeinBafög	www.meinbafoeg.de
7	AUTHADA	www.authada.de	52	Natix	www.natix.network
8	Bable	www.bable-smartcities.eu	53	NECT	www.nect.com/en
9	Better@Home	www.behome.info/	54	NETQUES	www.netqu.es
10	Breeze Technologies	www.breeze-technologies.de	55	Nextcloud	www.nextcloud.com
11	Brifle	www.brifle.de/en	56	Ororatech	www.ororatech.com
12	Brighter AI	www.brighter.ai	57	Plan4 Software	www.plan4software.de
13	Bundle	www.bundleregional.com	58	Plan4Better	www.plan4better.de
14	Certif-ID	www.certif-id.com	59	Polyteia	www.polyteia.com
15	Civocracy	www.civocracy.org	60	Preventio	www.preventio.de
16	codefy	www.codefy.de/en	61	Senf.app	www.senf.app
17	Comuneo	www.comuneo.org	62	ShiftDigital	www.shift-studio.de
18	Constellr	www.constellr.com	63	Silberfluss	www.silberfluss.io
19	Convaise	www.convaise.com/en	64	Smart City System	www.smart-city-system.com
20	Credium	www.credium.de	65	SONAH	www.sonah.tech
21	CrowdInsights	www.crowdinsights.de	66	SpotAR	www.spotar.io
22	Deine Studienfinanzierung	www.deinestudienfinanzierung.de	67	Stadt.Land.Netz	www.stadtlandnetz.de
23	DKSR	www.dksr.city/en	68	Summ AI	www.summ-ai.com/en
24	Door2door	www.door2door.io/en	69	Syte	www.syte.ms
25	Edgeless Systems	www.edgeless.systems	70	talent::digital	www.talentdigital.eu
26	Enclaive	www.enclaive.io	71	TaxFix	www.taxfix.de/en
27	ENEKA	www.eneka.de	72	Trail	www.trail-ml.com
28	famigo	www.famigo.info	73	TreeSense	www.treesense.net
29	FixMyCity	www.fixmycity.de	74	Tucan.ai	www.tucan.ai
30	Förderfunke	www.foerderfunke.org	75	Urbanistic	www.urbanistic.de
31	Geospin	www.geospin.de/en	76	Verimi	www.verimi.de/en
32	Global Goals Directory	www.globalgoals.directory	77	Vialytics	www.vialytics.com
33	GovMind	www.govmind.tech	78	Vianova	www.vianova.io
34	GovRadar	www.govradar.net	79	Viind	www.viind.com
35	GovShare	www.govshare.org	80	Vilisto	www.vilisto.de
36	Green City Solutions	www.greencitysolutions.de/en	81	VISARIGHT	www.visaright.eu
37	green gis	www.green-gis.de	82	Vote Rookie	www.voterookie.org
38	Groundkeeper	www.groundkeeper.net	83	Votebase	www.votebase.com
39	Hawa Dawa	www.hawadawa.com	84	XignSys	www.xignsys.com
40	HeiDi	www.heimat-digital.com	85	zdov	www.zdov.de
41	Helsing AI	www.helsing.ai			
42	hro.solar	www.hro.solar			
43	IDLoop	www.idloop.com			
44	Immovativ	www.immovativ.de			
45	Integreat	www.integreat-app.de/en			

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Move Fast and Break Things? Barriers to GovTech Procurement in the United Kingdom

Nathan Davies [a*], *Keegan* McBride [b], *Moritz* Kleinaltenkamp [c]

[a] Oxford Internet Institute, University of Oxford, Oxford, United Kingdom, nathan.davies@oii.ox.ac.uk, https://orcid.org/0009-0000-8940-4471 .

[b] Oxford Internet Institute, University of Oxford, Oxford, United Kingdom, https://orcid.org/0000-0002-9081-7529 .

[c] NEOMA Business School, Reims, France, https://orcid.org/0000-0002-6184-1140 .

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 20 May 2025

Abstract. Governments depend on procurement to help them achieve their digital transformation goals. Historically, public sector technology contracts have overwhelmingly flowed to large technology firms. However, governments have begun to explore opening up the procurement process to GovTech startups to drive innovation. Yet, this policy goal has proved challenging to implement. This paper explores why this is the case by presenting the case study of GovTech startup procurement in the United Kingdom. By focusing on the role of temporal dynamics in shaping procurement processes and drawing on 32 primary interviews with stakeholders across the UK GovTech ecosystem and supplementary archival data, this study identifies how the financial, staffing, and strategic processes within public sector bureaucracies enact an erratic and unpredictable procurement rhythm. It further demonstrates the challenges startups face when encountering this rhythm, struggling to predict or synchronise with it. Startups who are successful face new challenges from managing multiple rhythms. While conventional discourse often frames this procurement challenge as a mismatch between the "slow" public sector and "fast" startups, this paper instead reveals the complex and contradictory rhythms that frustrate GovTech procurement.

Keywords. GovTech, Public Procurement, Temporality, Digital Government, Startups.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.972

1. Introduction

Policymakers understand that digitalisation is a key component of building a strong and effective public sector. As a result, governments around the world are racing to digitalise their often crumbling, outdated, and legacy information systems. Getting this right requires key decision-makers to navigate an increasingly complex environment defined by rapid technological innovation and change. As most governments are likely to lack the necessary internal capabilities to build and innovate state-of-the-art technological solutions, procurement serves as a key mechanism of digitalisation. While many governments have experience procuring technology from large "primes" (Margetts & Dunleavy, 2024), there is a growing interest in opening the procurement process to the broader "GovTech" ecosystem. As defined in the European Interoperability Act, GovTech "means technology-based cooperation between public and private sector actors supporting public sector digital transformation" (EU, 2024, Article 2). The same act provides specific provisions dedicated to "facilitating the development of an open European GovTech ecosystem, including cooperation with SMEs, research and educational institutions, and start-ups" (EU, 2024, Article 11). The potential, according to a recent World Economic Forum article, is large, with the GovTech industry representing a "$9.8 Trillion Opportunity" (World Economic Forum, 2025). Yet, despite the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

importance ascribed to GovTech and its potential to drive governmental innovation, governments face challenges in realising this potential (Bharosa & Janowski, 2024). In particular, they have struggled to maximise procurement from small GovTech providers (Bharosa, 2022; Filer, 2019; Mergel et al., 2022; Taylor & Viner, 2021).

This dichotomy represents a clear opportunity for academic research. Interestingly, despite recommendations to focus on the role of procurement in GovTech innovation (Bharosa, 2022; Hoekstra et al., 2023), there is still a general lack of empirical studies exploring how procurement practices are preventing GovTech suppliers from working with the public sector. Although GovTech innovation does not necessitate a specific type of supplier, startups, as a specific type of small and medium-sized enterprise (SME), are often the particular focus of attention. Unlike larger and more established technology primes, GovTech startups are viewed as more innovative due to their ability to work in an agile fashion, rapid prototyping, and lower costs (OECD, 2024). Notwithstanding some vital public policy reports (Filer, 2018, 2019), and some pioneering early studies (De Coninck et al., 2018; Hoekstra et al., 2023), more empirical work is needed to understand how GovTech startups interact with other suppliers, investors, buyers, and intermediaries in governmental procurement processes.

This paper represents an initial attempt at providing empirical evidence on the barriers that impact the involvement of GovTech startups and SMEs in governmental procurement processes. To do this, the paper focuses on a single case study: the United Kingdom's GovTech ecosystem. The UK case is interesting in that the country has long understood the importance of procurement for digitalisation and it has faced several scandals involving procurements from large technology firms. However, despite its pronouncements to increase procurement from GovTech startups and SMEs, it has had limited success to date (British Chamber of Commerce, 2024; Cabinet Office, 2020).

In the UK, efforts at fostering innovation through public sector digitalisation have often been criticised for being too slow. Increased collaboration with startups is presented as having the ability to help the public sector speed up. This context was well articulated during a 2017 meeting at the House of Lords Select Committee on Artificial Intelligence, when Matt Hancock—then Secretary of State for Digital, Culture, Media and Sport—was questioned on the NHS's "very slow" record of innovation and the "GovTech Catalyst" scheme, a programme designed to harness startup innovation to solve challenges across government. Hancock responded, "Most of GovTech is about procurement […] Getting procurement rules right is one of the most important parts of driving improvements in technology through government" (House of Lords, 2017). However, while GovTech startups may move fast, the assumed slowness of government processes is often seen as a fundamental barrier to increasing procurement from startups, with time-consuming procedures and slow sales cycles. In surveys of UK and US public-sector-facing startups, 61% of respondents identified procurement as their most significant barrier, calling out its "time-consuming" procedures (Taylor & Viner, 2021, p. 25) and the time taken to secure government contracts (Orazem et al., 2017). In a sector where "innovation" equals "competitive advantage", companies whose products "have a nine-month 'shelf life' before the competition catches up […] fear their technology will be obsolete" by the time the government resolves its decision (ibid.). The notion of "speed", with government assumed to be "slow", and startups "fast", can be observed across government policy documents, academic literature, and the broader grey literature. This appears to suggest the importance of temporal dynamics in governmental procurement processes. Yet, these "mismatched time frames" (Filer, 2019) remain un-theorised and empirically untested in Digital Government and Procurement scholarship. Thus, this paper asks the question: How is public procurement from GovTech startups complicated by temporal dynamics? While procurement challenges relating to time (e.g. payment timelines) have been noted in previous scholarship (Loader, 2013), a more comprehensive investigation of temporal dynamics leveraging more recent advances from wider management research has not yet been conducted. Such research emphasises that surface-level issues such as slow processes or payment timelines may stem from underlying dynamics in the (mis)alignment of rhythms of organisational processes.

Methodologically, the paper relies on evidence gathered from 32 primary interviews conducted with multiple stakeholder groups across the UK, as well as supplementary archival documents. Drawing on this empirical material, the research explores the barriers that are impeding the UK's efforts to procure from GovTech startups. As a result of this research, this paper makes several contributions. It addresses the need for research on public procurement barriers to GovTech start-ups and provides empirical evidence to show that temporal dynamics play an important role. Examining these temporal dynamics in depth, the paper offers novel theoretical contributions that show how Public Sector Buyers' (PSBs) organisational processes enact an erratic and unpredictable procurement rhythm that is both too slow and too rushed for startup suppliers to engage with effectively. Startup suppliers encountering this procurement rhythm face a sequence of challenges – predicting, synchronising, and managing the rhythms of multiple internal and external processes. Thus, the paper challenges the dominant, simplified understanding that GovTech procurement issues can be ascribed to a simple clash of 'slow' bureaucracies and 'fast' startups, pointing instead to the complex temporality that arises when different organisational forms interact. Overall, the findings broaden our understanding of procurement barriers, contextualising systemic constraints and conflicting policy objectives as part of organisational processes and conflicting rhythms.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2. Theoretical Background

In an attempt to overcome the failings that accompanied earlier New Public Management approaches to digital transformation, many governments have embarked on a "comprehensive public administration reform agenda" (Boots et al., 2024, p. 300). This transformation has been a gradual process, manifesting in several waves (Dunleavy & Margetts, 2006b, 2006a; Margetts & Dunleavy, 2013, 2024). The most recent wave has been associated with calls for improved state capacity, particularly when it comes to digital technologies and data analytic capabilities (Mazzucato & Kattel, 2020). As the public sector is still often believed to have fallen behind technologically (Clarke, 2020; Clarke & Margetts, 2014; Dunleavy & Margetts, 2006a), governments have sought to modernise their approach to IT procurement: making contracts smaller and shorter (particularly for software), building more in-house expertise, buying from varied supplier sizes, and choosing open-source solutions (Boots et al., 2024). Though procurement plays a critical role in most governmental digital transformation initiatives, and there is substantial research on the procurement of technology and procurement of research, its role in Digital Government is often surprisingly "overlooked" (Boots et al., 2024, p. 297). This is unfortunate, as the history of digital transformation can only be understood in relation to procurement practices. However, recent research is now beginning to pay specific attention to how governments can better procure important emerging technologies, such as Cloud Computing (Jones, 2015) or Artificial Intelligence (McBride et al., 2021; Sanchez-Graells, 2024), as well as the role of new technologies in E-Procurement processes (Chen et al., 2021).

Focus has also begun to move beyond exploring the procurement of specific technologies necessary for digitalisation, looking into the broader procurement ecosystem and how the procurement process itself could be innovated upon (Boots et al., 2024; House of Lords Defence Committee, 2023). Of particular note, many policymakers have started to look to 'GovTech' as a means of improving their digital capabilities. It is argued that collaborating and procuring from GovTech startups would help to reduce dependence on legacy IT suppliers, support local firms to stimulate growth, and increase innovation in the public sector (Bharosa, 2022). Governments worldwide have implemented new measures to foster GovTech ecosystems that they can procure from (Hoekstra et al., 2022). However, progress has been slower and patchier than expected (Taylor & Viner, 2021), with procurement from startups hindered by barriers (Bharosa, 2022; Filer, 2019; Hoekstra et al., 2023). Existing work into why this is the case has predominantly focused on the technical barriers—such as interoperability and data security—inhibiting procurement from startups. These explanations are insufficient (Barcevičius et al., 2019). However, one potentially interesting dimension of barriers, which remains underexplored in the literature, is temporality. In their exploratory case study of GovTech ecosystems in the Netherlands and Lithuania, Hoekstra et al. reference the potential role of temporal dynamics as one of the barriers, highlighting that the pace of the private sector is perceived as "too slow for a startup or scale-up" (Hoekstra et al., 2023, p. 283). This barrier merits a more systematic exploration.

While theories of time and temporality are often discussed in management research, there is significantly less usage of this work in digital government studies. In management research, temporality continues to become a well-established "research lens" (D. G. Ancona et al., 2001; Blagoev et al., 2023), as more and more management scholars have found their focal phenomena – such as organisational change, conflict, identity, and strategy – to be underpinned by actors' subjective experience of speeds, rhythms, and time horizons. Digital government research can now leverage and apply these theoretical advancements. For scholars of digital government, several temporal contributions are especially relevant. First, cultural practices within organisations shape how individuals experience and conceptualise time (Orlikowski & Yates, 2002). Second, the stories actors tell can shape temporal norms, determining if, when, and how an organisation might decide to act (Wood et al., 2021). This enables and precludes strategic possibilities (Kaplan & Orlikowski, 2013). Third, multiple rhythms and tempos exist within and across organisations (D. Ancona & Chong, 1996; Bluedorn, 2002). Fourth, when organisations with different temporal dynamics "collide", this can cause tensions (Reinecke & Ansari, 2015). Finally, organisations can "adjust the pace or cycle of [one] activity to that of another" (D. Ancona & Chong, 1996, p. 253) as they try to synchronise to dominant cycles (Pérez-Nordtvedt et al., 2008; Sandra et al., 2023). However, synchronising to one cycle can lead to misalignment with others, creating new conflicts (Bluedorn, 2002). Given that Digital Government discourse is often framed as a way to speed up "slow bureaucratic machines" (Bharosa, 2022, p. 4)", and that GovTech ecosystems involve multiple types of organisations interacting, Digital Government scholars could likely benefit from existing theoretical tools for analysing organisational rhythms, processes, and interactions.

3. Research Methods

3.1 Research Design

Following Yin's single case-study approach, this paper looks at the UK GovTech ecosystem as the 'unit of analysis' (Yin, 2013, p. 31). The UK GovTech ecosystem comprises diverse stakeholders such as Public Sector Buyers (PSBs) in central government, local government, and healthcare; suppliers, including large incumbent suppliers, startups, and investors; and intermediaries, such as consultants and lawyers. Collectively, these organisations constitute an organisational field (DiMaggio & Powell, 1983), shaping institutional norms, practices, and procurement dynamics

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

within GovTech innovation. This ecosystem constitutes a revelatory case (Eisenhardt & Graebner, 2007) for understanding GovTech procurement dynamics for five reasons. (1) The UK is heralded as a global leader in many international digital government rankings (OECD, 2019). (2) Its public sector relies heavily on procurement (NAO, 2011, 2025); (3) but has been criticised for its reliance on large technology providers (Bracken, 2020; Greenway, 2020). (4) It has implemented a series of programmes and policy postures to promote innovation and diversity in technology procurement (e.g. GovTech Catalyst, Spark). (5) These attempts have had limited success (Science and Technology Committee - House of Commons, 2019). These factors mean that stakeholders acutely understand both the drivers and barriers to increased procurement from startups, rendering it particularly susceptible to this study.

The UK government spends an estimated £14 billion on digital programmes and technology annually (NAO, 2025). Historically, attempts at transforming UK digital government have been linked to procurement reforms, with the creation of the Government Digital Service (GDS) in 2011 linked in part to numerous expensive technology contracting failures. To counteract these failures, GDS enacted several reforms: developing spend controls and digital service standards, simplifying information classification levels, and building internal digital capabilities across government (Clarke, 2020). The following year, procurement procedures were streamlined with the introduction of G-Cloud, which enabled companies to list their offerings without a full tender or competition process (Science and Technology Committee - House of Commons, 2019, p. 51). The goal of this reform was, in part, to reduce costs and increase innovation by including more SMEs and startups. At the beginning, GDS's reforms did have success in diversifying procurement spending, with the market share of the top ten ICT suppliers falling from 53% to 39% (Kotecha & Desmond, 2017, p. 5). However, startups (as opposed to all SMEs) still only won less than 3% of government procurement spending between 2012 and 2014 (Spend Network, 2015). In 2018, a new "GovTech Catalyst" fund was created and provided £20 million to support the procurement of innovative solutions to several 'public sector challenges' from GovTech startups. However, Select Committee evidence from a roundtable of startups suggested that the programme was undermined by insufficient funding and cumbersome processes (Science and Technology Committee - House of Commons, 2019, p. 54). The new Labour government that came into power in 2024 has made reforming procurement, and increasing GovTech startup procurement in particular, an explicit policy goal.

3.2 Data Collection

Collecting and engaging with archival data provided foundational context. It informed our sampling strategy and helped interpret the primary data, which consisted of 32 expert interviews conducted between May and July 2024, each lasting approximately one hour. Participants were selected using purposive sampling based on their experience in the UK GovTech ecosystem. We identified potential interviewees—across public sector organisations, startups, investment bodies, and intermediary roles—by reviewing grey literature, government websites, and relevant programme listings. Given the difficulty of accessing senior decision-makers, we also employed convenience and snowball sampling. According to the inclusion criteria, all participants had direct or indirect experience with public procurement. While we considered providing further detail on participants' roles, we avoided role-specific identifiers due to the risk of de-anonymisation in a small and interconnected ecosystem. Participants are categorised by stakeholder type, and the sample reflects a wide range of seniority and sectoral experience (see Table 1).

As the final column shows, many participants had additional experience in other stakeholder groups that informed their experiences. For example, many investors had experience in startups and many GovTech founders had experience in government. The sample likely skews towards those already interested in procurement reform and those who agreed to be interviewed may be further self-selecting, biasing towards an extreme (Collier & Mahoney, 1996). However, the research design was oriented towards an "information-oriented selection," prioritising information richness over representativeness (Flyvbjerg, 2006).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 – Participant Sample

Stakeholder Type	Stakeholder Group	# Participants currently in group	#Additional Participants with experience in group
PSB	Civil Servant	2	10
	Government Advisor	1	0
	Procurement Official	1	1
		4	
Mediator	E-Procurement Startup	3	0
	Lawyers	2	1
	Procurement Consultants	3	1
		8	
Supplier	Startup	9	6
	Digital Consultants	3	9
	Large Corporates	1	2
		13	
Investors		**7**	2
Experts		**3**	1
TOTAL		**32**	

A semi-structured interview approach was employed, with protocols tailored to each stakeholder group (see Appendix), enabling flexible responses to new information. Interviews focused on procurement experiences, challenges, and organisational processes, encouraging detailed accounts of recent cases (e.g., tendering, bidding, investing). Temporal dynamics were explored indirectly through follow-up questions when raised organically, to reduce priming and social desirability bias.

3.3 Data Analysis

Data analysis took place concurrently with data collection, ensuring that emerging insights informed subsequent interviews. All interviews were recorded and transcribed, and an initial round of open coding (Gioia et al., 2013) was conducted by MAXQDA. Initial coding rounds produced 658 codes, many of which related to systemic constraints in GovTech procurement for both Public Sector Buyer (PSB) and startup supplier barriers. A breakthrough moment came in one of the earliest interviews when a startup lobbyist remarked: "With procurement, the number one issue, along with speed and stuff—it's not actually the rules that are the problem, it's the interpretation of the rules… they interpret rules in a really conservative way and sort of fuck over startups that way" (P1). This offhand reference to "speed and stuff" might appear insignificant at first. However, as more interviews were conducted, similar temporal analysis emerged, with participants discussing the "speeds", "rhythms", "cadences", and "cycles" of GovTech procurement. Recognising the significance of temporality, subsequent rounds of analysis linked first-order constructs into both systemic constraints and rhythms, together constituting organisational processes that were related to finance, staffing, or strategy (Table 2).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 2 –Example Data Structure: PSB Organisational Processes

Category	Theme	Codes	Exemplar Quote
PSB Organisational Processes: Financial	Shrinking Budgets	Economic Climate	*"The macroeconomic trend of government having less and less money to go around" (P6)*
		Budgetary Pressures	*"as always, there are budgetary pressures, you want the middle manager to say, no, this is indispensable" (P17)*
	Financial Rhythm	Spending Reviews	*"[Annual] Spending Reviews […] make it very difficult for you to commit to contracts that run beyond twelve months"* (P7)
		Financial Year	*"It's to do with budget allocations in a year. Departments are held accountable for going over budgets, but they're also held accountable for going under budget. So as you get towards the end of the financial year there's lots of scrapping around" (P8)*
PSB Organisational Processes: Staffing	Lacking Knowledge	Information Asymmetry	*"Not knowing what's out there in the market" (P4)*
		Technology Knowledge Gaps	*"Technology feels like a bit of an outlier" (P7)*
		Ignorant of Startups	*"So, in terms of a lack of understanding or empathy, I think I think there is that barrier there; to be honest, a lot of civil servants have only been in the civil service. They've never seen it from the startup perspective" (P26)*
	Staffing Rhythm	Churn	*"Churn happens because the mechanics of the system aren't set up to allow continuity of longer than a year"* (P5)
		Losing Institutional Knowledge	*"You've just got to know startups, and now you're gone" (P3)*
PSB Organisational Processes: Strategy	Avoiding Failure	Bigger as Safer	*"Nobody is gonna give you a prize for excluding G4S" (P24)*
		Fearing legal challenge	*"So, all these things are driven by, if you like risk that arrives from the rights of any supplier to claim that public sector buying decision over 140 grand has been distorted in some way." (P12)*
		Avoiding Media	*"If you waste a bit of money in failure, you will have to explain that to the public. If you wasted a lot of many on shit programs, that slow shitness doesn't get in the news" (P16)*
		Misaligned Incentives	*"It' s not that the individuals are shit but they're not incentivised to…do anything better. Their incentive is to find something safe*" (P5).
	Strategy Rhythm	Short-termism	*" I don't commit to a very long procurement" (P27)*
		Disjointedness	"*Current procurement processes are like a poor relay race" (P18)*

Subsequent rounds of axial coding (Strauss & Corbin, 1990) identified the processes connecting these categories, surfacing how PSB organisational processes enacted the procurement process rhythm and how startup organisational processes determined how they encountered this rhythm (Figure 1). This allowed us to connect otherwise distinct systemic constraints, verifying that temporal dynamics were an important explanatory factor.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

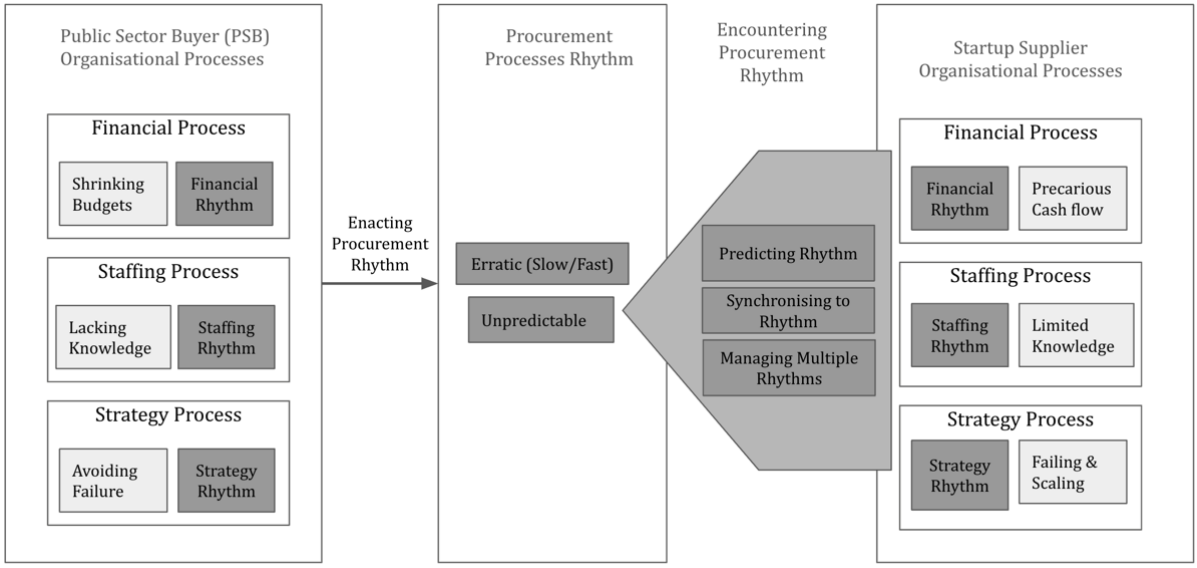


Fig. 1 – Data Structure of Axial Coding Categories and Themes

4. Results

From the interviews, participants with experience in both PSBs and startups described their organisation's systemic constraints that prevented increased procurement from startups. In both types of organisations, participants described constraints relating to financing, staffing, and strategic goals. Our analysis helps explain these experienced procurement challenges by pointing to the temporality of their underlying organisational processes. As the following results section will demonstrate, throughout each of these processes, distinct rhythms compound and exacerbate systemic constraints in GovTech procurement.

4.1 Organisational Processes of Public Sector Buyers (PSBs)

Financial Processes: Participants discussed the challenges of limited and often decreasing budgets (P5, 6, 9, 13, 17, 25). Limited budgets encourage buyers to focus more on cost and less on innovation. Across the public sector, there is "*the macroeconomic trend of government having less and less money to go around*" (P6), creating "*budgetary pressures*" (P17). These constraints are acutely felt by local government (P6, 9, 13). Two interviewees highlighted the trend of many councils declaring bankruptcy (P6, 25), despite the "*risk-averse*" and "*tightly controlling*" policies of procurement officials (P25). Other participants challenged the public narrative of shrinking budgets, offering examples of considerable funding that was allocated to local government. However, in these examples, the funding either had to be returned to the central government when it expired, or startups were late to hear about it (P9, 20).

Temporal dynamics help explain these financial processes. Across government, the financial rhythms of budgets exacerbate challenges for GovTech procurement. Many civil servants raised that the combination of Treasury Accounting and the recent succession of annual spending reviews led to a pattern in the fiscal year of hesitant spending in the first half and a "*rush to march*" in the latter half, to avoid underspending (P8, 13, 20). These budget cycles had further impacts on both staffing and strategy processes.

Staffing Processes: PSBs lack knowledge about technology and startups (P8, 16, 26, 24). As one former civil servant reflected, "*within the procurement service…additional technology feels like a bit of an outlier*" (P28). Another described the daily routine of their colleagues as "*procuring pens in the morning and scooters in the afternoon*" (P24). As such, there is little specialist knowledge regarding technology within many commercial functions. Participants acknowledged that this was slowly changing and there were highly skilled individuals (P17, 25). However, buyers with technological skills were described as "*peripheral figures*" who often struggled to "*properly embed new technology*" (P17).

This systemic constraint can only be understood in relation to the compounding rhythms within PSBs. Under-resourced and under-skilled PSBs are further undermined by the nature of budget cycles, which contributes to high churn in the lower levels of the civil service. Consequently, startup suppliers described how buyers "*always changed*" (P1). An ex-civil servant frustratedly explained, "*Churn happens because the mechanics of the system aren't set up to allow continuity of even longer than a year…this is a very big problem*" (P27). Others reiterated that even in public sector organisations that were explicitly focused on startups and innovation, high churn had

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

detrimental effects on knowledge (P16).

Strategy Processes: PSBs are, understandably, risk-focused; particularly given the high stakes involved in many procurement decisions (P8). Legal constraints are designed to mitigate risks: of being sued, of malfunctioning technology, or of suppliers going bust. Other goals, such as avoiding public failure and media attention, create further constraints that prevent collaboration with startups (P14, 27). One participant with experience in large-scale health technology procurement characterised the risk position as "*extremist*". He continued, "*this survival mode" is "the total opposite of a transformation program", which ought to "throw it up in the air and make change happen*" (P27). Participants tended to agree that the strategic process was undermined by misaligned incentives (P5, 11, 12, 13, 14, 16, 18).

These persistent challenges are easier to understand when situated in the context of the 'Strategy Rhythm'—the temporal dynamics that underpin decision-making and goal setting. The siloing of teams creates a disjointed working rhythm, undermining the ability for joined-up thinking. Throughout the interviews, participants used verbs that imply a lack of intention or even carelessness, such as "*lobbing*" and "*chucking*" (P5, 13, 18). Reflected on their time in a PSB, one participant explained that performance management does not facilitate "*the next person down the chain to actually add value*" (P18). Another with similar experience offered a memorable metaphor—procurement processes as a "*relay race*", where each actor focuses on working as quickly as possible without considering the handover between different stages of the procurement process (P18). Budget cycles further undermine attempts at implementing strategic processes. One civil servant remarked that a budget "*is not a real budget*" because it must be agreed by the department annually. He continued, "*I don't commit to a very long procurement, and I don't necessarily get value because I don't know if I've got the money in year two, three, and four. And this is bad for public sector value*" (P27).

4.2 PSBs Enacting Procurement Process Rhythm

Our results further demonstrate how PSBs' interrelated organisational processes are enacted in the temporal dynamics of the procurement process itself (Figure 2). This process is erratic, both too rushed and too slow, and unpredictable.

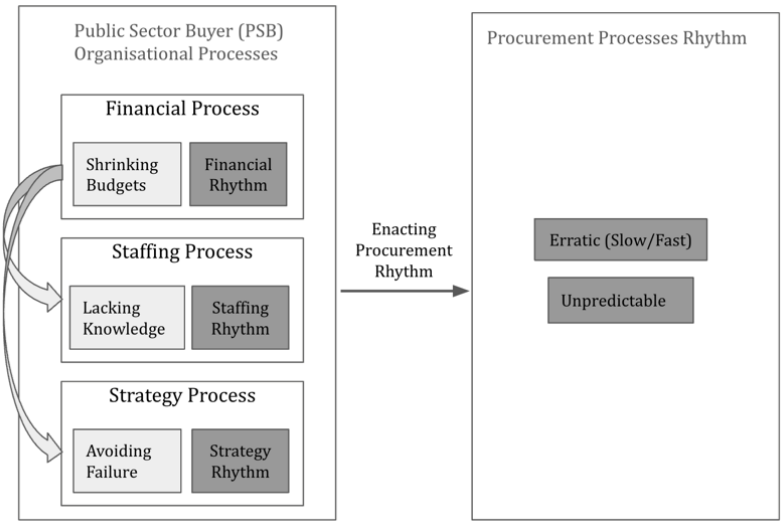


Fig. 2 – PSB Organisational Processes Enacting Procurement Rhythm

Erratic (rushed): PSBs often rush through improper pre-market engagement. Participants described how commercial teams focus on the contracting phase of procurement (P18, 25, 27, 32). An experienced buyer described how "*all the efforts go into the procurement phase. They really should go into the pre-procurement phase, the dialogue phase, the signal-to-market phase…The procurement, by the time you get there, should be the least intense part of the process*" (P27). Pre-market engagement is particularly important for suppliers who are less likely to have established connections with the public sector. Hurried pre-procurement and post-procurement phases reflect a broader phenomenon of rushed processes. Commercial teams rush to address expiring contracts and issue "*irregular contract extensions*" (P2). Local councils discover available project funding at the last minute and rush to meet deadlines (P9, 20). Civil servants acknowledged the increased use of frameworks (closed groups of pre-approved suppliers) because in many cases, "*there simply isn't the time*" to run formal procurements (P8). While frameworks are not inherently problematic, their current usage disadvantages smaller suppliers. Finally, buyers and suppliers alike discussed the impact of the financial year (P5, 13, 20). Buyers described a "*flurry to purchasing*", causing a "*mad scramble*" (P8). Likewise, suppliers described the "*frantic*" and "*crazy deadlines*" (P20).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Erratic (slow): At other points, procurement rhythms were described as too slow by all types of stakeholders (P16, 26, 27, 31). Formal procurement processes, unlike direct awards, can take "*six to eight months*" (P13) with multiple "*different hoops*" for suppliers (P20). Involving multiple departments or teams can slow things down (P12, 20, 26). One local authority supplier described the "*luck*" necessary to have the "*right stakeholders*" simultaneously aligned, particularly during holiday periods (P20). "*Little redundancy*" means that "*when things don't go to plan, there are delays everywhere*" (P24). Another startup similarly described how overworked staff members in local authorities realised they had holiday to take at the end of the fiscal year when extra staffing was needed to meet rushed deadlines, with conflicting financial and staffing rhythms further slowing procurement processes (P20). Corroborating existing research, the slow sales cycle was a repeated feature of interviews (P8, 9, 16, 17, 21, 31).

Unpredictable: This erratic rhythm—lurching between slow and rushed—combined with an opaque procurement process makes the process hard to predict (P24). While suppliers could anticipate some patterns in government sales cycles—for example, noting more tenders during summer and winter holidays (P2, 4, 8, 15)—in other ways, the procurement process was much harder to predict. One senior civil servant acknowledged this, describing, perhaps hyperbolically, that procurement was "*an uncertain process that could take three months or three years*" (P8). This uncertainty was exaggerated by political cycles, with suppliers "*relying on cash for the next couple of years of work*" that "*could evaporate*" with a General Election (P8). Another senior civil servant with experience in startups and investing described a broader, cultural "*tension*" between suppliers and buyers, who "*operate in a certain way, knowing that: governments only have a certain lifespan, a programme is never really a programme, timescales are never timescales*" (P27). These tensions from contrasting cultures are manifested in unpredictable procurement processes that make it difficult for suppliers to plan.

4.3 Organisational Processes of Startup Suppliers

Those with experience working in startups also discussed how their experience of procurement complications related to financial, staffing, and strategy processes. As in the case of PSBs, startup suppliers' temporal dynamics also compounded systemic challenges, albeit in different ways (Figure 3). These results were predominantly informed by those working in GovTech startups. Analysing the perspectives of those who had experience in other types of organisations, including PSBs and larger technology suppliers, served as additional data to confirm our results.

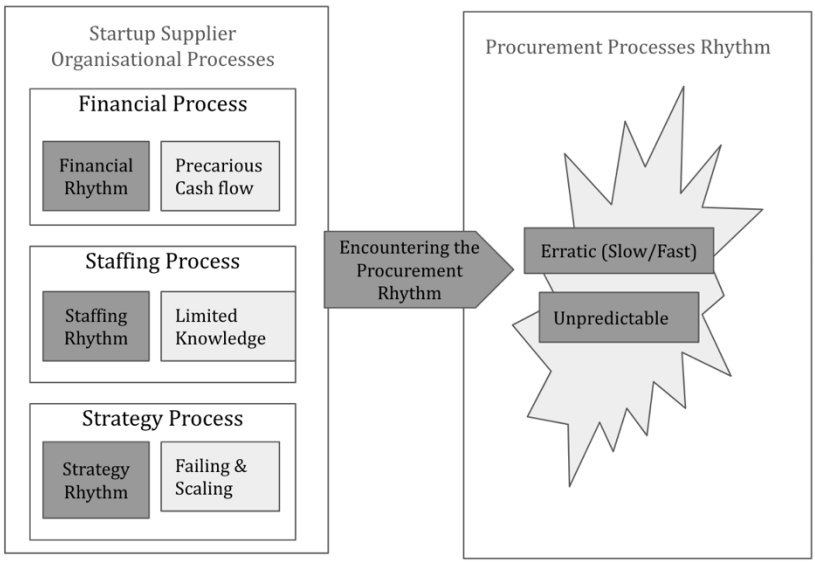


Fig. 3 – Startup Supplier Organisational Processes Encountering Procurement Rhythm

Financial Processes: Startups face challenges of constrained financial resources compared to larger suppliers. The temporal dynamic—of founders balancing their funding and revenue, on the one hand, and their expenses, notably paying employees and developing technology, on the other—was encapsulated by one supplier as "*cash flow is king*" (P16). In part because of limited financial resources and the strategic goal of scaling quickly, many startups seek external funding, often in the form of Venture Capital (VC). This imposes a financial rhythm of raising every 12 to 18 months, which can further complicate temporal dynamics. As we will see in subsequent sections, this creates challenges for startups encountering the rhythm of procurement.

Staffing Processes: Many startups discussed the challenge of lacking dedicated expertise in public sector sales, compared to larger companies who had bidding teams (P4, 5, 13, 21). Due to financial processes, many startups without large VC funding must retain staff on short-term contracts. One founder explained: "*We make do with*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

subcontractors, and we can't really build a proper team" (P6). This staffing rhythm was compared to consulting firms by participants with experience in both types of companies, where "*the beauty of a human consulting service model is you can move to [government as a secondee] and you don't lose things when the winds have slowed down… If you're selling a technology product you can't. The IP is the thing, and the thing can't move with you*" (P31).

Strategy Processes: Participants discussed the systemic constraints for startups that necessarily have to try and scale. Compared to the United States' large internal market for the public sector (P21) or the consortium buying of Norway (P24), the UK's market is smaller and more fragmented. This creates challenges for suppliers trying to scale by selling to multiple public sector customers because the "*route to market is a sort of jigsaw puzzle*" (P1). Conversely, large technology suppliers benefit from their scale to "*absorb the instability*" (P27). However, temporal dynamics frustrate startups' capacity for long-term planning. "*Time to market is the critical thing for a startup*", both to develop technology, find product-market fit, and avoid running out of resources.

4.4 Challenges for Startups Encountering Procurement Process Rhythm

Startups that seek to sell to the public sector encounter the erratic and unpredictable procurement process rhythm. As they do so, their organisational processes create challenges in predicting this rhythm (Figure 3). Those who overcome the prediction challenge face further difficulties synchronising with the procurement rhythm. Finally, those who synchronise successfully face tensions in managing multiple rhythms.

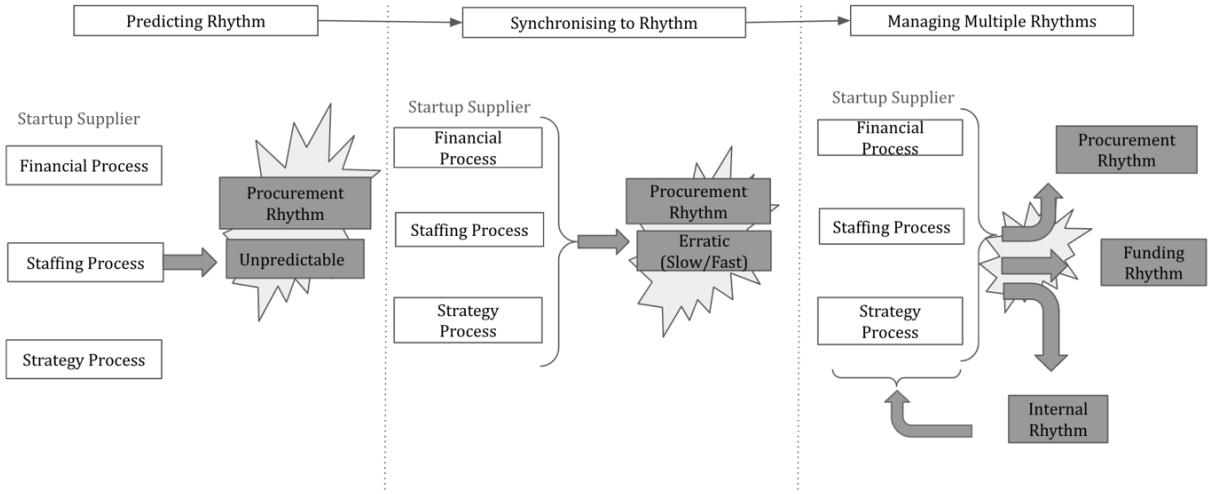


Fig. 4 – Challenges for Startup Suppliers Encountering Procurement Rhythm

Predicting Rhythm: As Figure 4 shows, to successfully bid, suppliers must navigate identifying relevant opportunities and frameworks. Joining most frameworks is time-consuming and uncertain, and they re-open for new entrants infrequently. Finding bidding opportunities was described by one as a "*waste of time*". Another claimed, "The system favours the incumbents who are happy to let things happen slowly". Many suppliers also discussed finding opportunities late. The rise of new e-procurement startups further reinforces the view that temporal dynamics disadvantage some suppliers. These mediators have built fast-growing businesses addressing these pain points. One successful e-procurement startup brands itself as enabling users to "*keep a pulse on their market and the opportunities that they should be chasing down*" and stay "*proactive*" (P22).

Synchronising with Rhythm: Given these temporal dynamics, there are challenges around government sales cycles. Startups "*try and offer purpose-built stuff for the public sector, but nine times out of ten get killed by the long sales cycles*". Short contracts exacerbate slow processes. One startup founder described their attempts to align various short-term contracts and maintain cash flow. Startups on short-term contracts "*don't know if it's going to continue*" (P9). This is further aggravated by high churn. A former startup CEO noted that the combination of slow sales cycles and fast turnover is "*completely deadly*" (P21). This combination was also noted by a former founder whose startup had gone bankrupt. He explained, "*People move on so fast… If you're dealing with early-stage tech companies, two-year postings are not very helpful*" (P16). An experienced civil servant explained how this temporal misalignment is "*Bad for startups or anyone trying to innovate... We end up with those that are the most stable companies with the deepest pockets becoming the easy buys*" (P27). Startups "*wade*" through the time-consuming bidding process under rushed deadlines (P25). This raises the question articulated by one interviewee – "*how can people pace themselves and move in a way that aligns with government cycles* (P31)?" The difficulties in aligning internal rhythms with the public sector go some way in explaining why many startups fail when selling to government, and why others never try to begin with.

Other participants described adapting their behaviour to align with the public sector. One digital consultant who

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

worked closely with startups explained startups' varying levels of success in "*pacing*" themselves to "*align*" to these cycles (P15). They explained that for many smaller suppliers, "*bidding doesn't come naturally*". Others "*know how to bid [and] have their own rhythm*". Those with bidding teams "*have their own cadence of how they do things*". Reflecting on their firms' success selling products and services to the public sector, they described how "*unlike a lot of other SMEs, we are quite in tune to what those rhythms look like*". Another former employee of the same firm mirrored this sentiment. The firm's "*evolution is a story of reacting to the signals being sent in the dance that we do with government. As they sort of slow... you kind of cue each other's movements*" (P31).

Managing Multiple Rhythms: While some startups struggle to synchronise to government cycles altogether, others face difficulties because they synchronise to these same cycles. As Figure 3 shows, startups can face tensions between procurement rhythms and their internal rhythms. For example, startups can become "*addicted to grant funding*" (P16) – dependent on a succession of precarious short contracts. This creates problems in retaining permanent staff and developing technology (P6, 32). "*User input is crucial*" for technological development as it enables startups to "*learn something and iterate from it*". However, in GovTech there are often "*less opportunities for…internal feedback*" (P31). These barriers are amplified by small, short-term contracts because "*Startups can't build products because the contracting mechanisms and what government is asking for don't correlate with the cost of developing technology*" (P32). A succession of short-term contracts creates challenges for intellectual property and hiring staff.

A second tension arises between the procurement and funding rhythm. As GovTech startups try and scale, many face barriers from investors sceptical about government customers. Due to the speed of procurement sales cycles, many Venture Capital Investors (VCs) see startups selling to government as "*un-investable*" (outside of Defence) (P30). For those who can attract external investment, the cadence of fundraising every eighteen to twenty-four months clashes with government sales cycles. Startups expressed an awareness that they will "*die if they don't raise again*" (P17). VC timelines are, therefore, a source of further tensions for public-sector-facing startups. These barriers have a cascade of disincentivising effects. Eight interviewees discussed startups bankrupting themselves when trying to sell to PSBs.

5. Discussion

Based on this single explorative case in the UK, our findings make a series of empirical and theoretical contributions with implications for policymakers and practitioners.

5.1 Empirical Contributions

First, we address calls for further research into the role of public procurement as a barrier for GovTech and the need for empirical case studies (Bharosa, 2022; Hoekstra et al., 2023). We identify barriers that prevent increased procurement from startups. In doing so, we nuance previous studies of public procurement from SMEs (Loader, 2013), disaggregating the specific experiences of GovTech startups due to their characteristic goals of developing novel technologies, disrupting markets and scaling quickly (Hoffman & Yeh, 2018). Second, we provide rigorous empirical evidence to demonstrate the role temporal dynamics play in GovTech barriers (Figure 1), confirming previously anecdotal evidence in the grey literature and further developing lines of argument in recent work (Hoekstra et al., 2023).

5.2 Theoretical Contributions

This paper makes two distinct theoretical contributions: (1) a general contribution to procurement theory and public sector innovation by illuminating underlying temporal dynamics beneath surface-level issues like perceived slowness, suggesting systemic rather than simplistic 'speed-up' solutions; and (2) a specific contribution to GovTech scholarship by revealing the unique temporal tensions faced by startups due to their position at the intersection of innovation, scaling pressures, and public sector processes.

Conventional understandings of the procurement barriers have focused on the systematic constraints that PSBs and startup suppliers face. By using "time as a research lens" (Ancona et al., 2001; Blagoev et al., 2023), we elucidate the complex temporal dynamics of GovTech procurement. While confirming that time plays an important role, our contributions challenge the assumption that underpins much of the GovTech discourse – that the conflict can be reduced to a heuristic of government being slow, startups being fast. Our research also surfaces the role that rushed government processes play in limiting GovTech procurement, "precluding strategic possibilities" (Kaplan & Orlikowski, 2013). We show that there are multiple conflicting rhythms within PSBs (D. Ancona & Chong, 1996; Bluedorn, 2002). These enact a procurement rhythm that is erratic and unpredictable. This may explain irrational-seeming procurement processes that procurement scholars have primarily attributed to conflicting policy objectives (Lember et al., 2014, 2015).

Rather than a uniform slow pace, the varied and erratic rhythm of PSBs creates challenges for the GovTech startups

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

that encounter them. Startups struggle to predict the rhythm of buyers and to subsequently synchronise with them. Nuancing more simplistic accounts that can be found in individual interviews with startups or in the grey literature, procurement challenges cannot be attributed solely to an incompatibility between 'fast' startups and 'slow sales cycles'. This is just one challenging temporal dynamic among many as startups attempt to manage multiple rhythms.

5.3 Implications for Practitioners and Policymakers

The findings of this research provide several practical insights for policymakers and practitioners aiming to enhance GovTech procurement from startups. Rather than solely focusing on simplifying procurement rules or enhancing buyer capacity, it is crucial to also develop a deeper understanding of how temporal dynamics and rhythms across the public sector and GovTech ecosystems align or misalign. Policymakers should look beyond simply accelerating procurement processes and instead improve how procurement rhythms are communicated and managed, helping startups better predict and synchronise their internal processes with public sector cycles. For instance, the recent introduction of pipeline notices under the new UK Procurement Act represents a promising initiative. If effectively implemented, these notices could greatly enhance suppliers' ability to anticipate procurement rhythms and better prepare their bidding and financing strategies accordingly. Improving transparency around procurement timings and rhythms could thus significantly mitigate the temporal barriers identified in this research. Additionally, addressing temporal misalignments not only facilitates greater involvement of innovative suppliers but also helps avoid problematic dependency on large incumbent providers. In light of unfolding geopolitical developments, this could also positively impact digital autonomy by promoting a more diversified and resilient supplier ecosystem within the public sector.

5.4 Limitations and Future Research

As a single case study, more work is required to validate these findings and test their applicability to other contexts. The findings are primarily based on experts' perceptions of barriers and would benefit from alternative methods, including quantitative research. Specific boundary conditions, such as the UK's distinct administrative, budgetary, and legal environment, limit the direct generalisability of our findings to other national contexts. We recommend future research pursue some of the lines of inquiry opened by this case study and continue to explore the fruitful cross-pollination of temporality and digital government.

Future research should examine how specific policy interventions could help address these temporal misalignments whilst supporting greater strategic autonomy in government technology procurement. This might include studying how procurement vehicles could be redesigned to better balance the competing needs for innovation, stability, and sovereign control; investigating how successful GovTech startups navigate competing timeframes whilst building sustainable public sector solutions; or exploring how digital technologies themselves might help bridge these temporal gaps without creating new dependencies. There is also scope for comparative studies examining how different jurisdictions manage temporal dynamics in their GovTech ecosystems whilst maintaining appropriate levels of digital autonomy. Given the growing importance of GovTech in public sector digital transformation, understanding and addressing these temporal barriers will be crucial for fostering more effective and sustainable public-private collaboration in government technology innovation.

6. Conclusion

Commentators often claim that public procurement is broken. This study has shown how temporal dynamics play a critical role in frustrating the stated policy goal of increasing public procurement from GovTech startups. While conventional wisdom frames the challenge as a clash between "slow" government and "fast" startups, our findings suggest a more complex and patterned problem: the erratic and contradictory procurement rhythms enacted by public sector organisations. Startups struggle not only with delays but with unpredictability and misalignment with multiple rhythms. Fixing procurement will require more than government moving faster—it will require learning to better move together. To do so, researchers must continue to explore time as a structural feature of governance—and policymakers must begin to take time seriously.

Acknowledgement

- **Contributor Statement***: Author contributions were assigned according to the CRediT (Contributor Roles Taxonomy) system.
    - Nathan Davies: Conceptualisation, Methodology, Investigation, Data Curation, Formal Analysis, Validation, Writing – Original Draft, Writing – Review & Editing, Visualisation, Project Administration, Funding Acquisition, Resources
    - Keegan McBride: Validation, Writing – Review & Editing, Supervision, Funding Acquisition, Resources

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- Moritz Kleinaltenkamp: Methodology, Formal Analysis, Validation, Writing – Review & Editing, Visualisation, Supervision

- **Use of AI***: During the preparation of this work, the author(s) used Claude (Anthropic) in order to proofread. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Ancona, D., & Chong, C.-L. (1996). *Entrainment: Pace, cycle, and rhythm in organizational behavior*.

Ancona, D. G., Goodman, P. S., Lawrence, B. S., & Tushman, M. L. (2001). Time: A New Research Lens. *The Academy of Management Review*, *26*(4), 645. https://doi.org/10.2307/3560246

Barcevičius, E., Cibaitė, G., Codagnone, C., Gineikytė, V., Klimavičiūtė, L., Liva, G., Matulevič, L., & Misuraca, G. (2019). *Exploring digital government transformation in the EU: Analysis of the state of the art and review of literature.* (G. Misuraca, Ed.). Publications Office. https://data.europa.eu/doi/10.2760/17207

Bharosa, N. (2022). The rise of GovTech: Trojan horse or blessing in disguise? A research agenda. *Government Information Quarterly*, *39*(3), 101692. https://doi.org/10.1016/j.giq.2022.101692

Bharosa, N., & Janowski, T. (2024). The GovTech Challenge ?V GovTech and Public Value Creation. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 1043–1045. https://doi.org/10.1145/3657054.3659125

Blagoev, B., Hernes, T., Kunisch, S., & Schultz, M. (2023). Time as a Research Lens: A Conceptual Review and Research Agenda. *Journal of Management*, 01492063231215032. https://doi.org/10.1177/01492063231215032

Bluedorn, A. C. (2002). *The human organization of time: Temporal realities and experience* (pp. xii, 367). Stanford University Press.

Boots, S., Clarke, A., Brousseau, C., & Lajoie, A. (2024). Breaking All the Rules: Information Technology Procurement in the Government of Canada. *Canadian Public Administration*, *67*(3), 297–325. https://doi.org/10.1111/capa.12577

Bracken, M. (2020). *The sad tale of Britain's Government Digital Service—Public Digital*. https://public.digital/pd-insights/blog/2020/11/the-sad-tale-of-britains-government-digital-service

British Chamber of Commerce. (2024). *SME Procurement Tracker (2024)*. https://www.tussell.com/gov/blog/sme-procurement-tracker-2024

Cabinet Office. (2020). *Transforming Public Procurement*. https://assets.publishing.service.gov.uk/media/5fd77b11e90e076630958ecc/Transforming_public_procurement.pdf

Clarke, A. (2020). Digital government units: What are they, and what do they mean for digital era public management renewal? *International Public Management Journal*, *23*(3), 358–379. https://doi.org/10.1080/10967494.2019.1686447

Clarke, A., & Margetts, H. (2014). Governments and Citizens Getting to Know Each Other? Open, Closed, and Big Data in Public Management Reform. *Policy & Internet*, *6*(4), 393–417. https://doi.org/10.1002/1944-2866.POI377

Collier, D., & Mahoney, J. (1996). *Insights and Pitfalls: Selection Bias in Qualitative Research* (SSRN Scholarly Paper 1540881). https://papers.ssrn.com/abstract=1540881

De Coninck, B., Leysen, J., & Leysen, V. (2018). *Public Procurement of Innovation Through Increased Startup Participation: The Case of Digipolis (Research-in-progress)*.

DiMaggio, P, & Powell, W.W. (1983). "The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields". American Sociological Review. 48: 148. doi: 10.2307/2095101

Dunleavy, P., & Hood, C. (1994). From old public administration to new public management. *Public Money & Management*, *14*(3), 9–16. https://doi.org/10.1080/09540969409387823

Dunleavy, P., & Margetts, H. (2006a). *Digital era governance: IT corporations, the state, and E-government*. Oxford University Press.

Dunleavy, P., & Margetts, H. (2006b). New Public Management Is Dead—Long Live Digital-Era Governance. *Journal of Public Administration Research and Theory*, *16*(3), 467–494. https://doi.org/10.1093/jopart/mui057

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building From Cases: Opportunities And Challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Filer, T. (2018, September 25). In Govtech Investment, Patience is a Virtue. *Bennett Institute for Public Policy*. https://www.bennettinstitute.cam.ac.uk/blog/govtech-investment-patience-virtue/

Filer, T. (2019). Thinking about GovTech: A Brief Guide for Policymakers. *Bennett Institute for Public Policy*.

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, *12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Gil-Garcia, J. R., Dawes, S. S., & Pardo, T. A. (2018). Digital government and public management research: Finding the crossroads. *Public Management Review*, *20*(5), 633–646. https://doi.org/10.1080/14719037.2017.1327181

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods*, *16*(1), 15–31. https://doi.org/10.1177/1094428112452151

Greenway, A. (2020, September 24). The Government Digital Service truly was once world-beating. What happened? *The Guardian*. https://www.theguardian.com/society/2020/sep/24/government-digital-service-truly-was-once-world-beating-what-happened

Hoekstra, M., Chideock, C., Bodea, G., Bharosa, N., Cave, J., Kokkeler, B., Oomens, I., Berg, A. V. D., Veenstra, A. F. V., & Alleweldt, F. (2022). *The Digital Single Market and the digitalisation of the public sector*.

Hoekstra, M., Van Veenstra, A. F., & Bharosa, N. (2023). Success Factors and Barriers of GovTech Ecosystems: A case study of GovTech ecosystems in the Netherlands and Lithuania. *Proceedings of the 24th Annual International Conference on Digital Government Research*, 280–288. https://doi.org/10.1145/3598469.3598500

Hoffman, R., & Yeh, C. (2018). *Blitzscaling: The Lightning-Fast Path to Building Massively Valuable Companies* (1st edition). HarperCollins.

Hood, C. (1995). Contemporary public management: A new global paradigm? *Public Policy and Administration*, *10*(2), 104–117. https://doi.org/10.1177/095207679501000208

House of Lords. (2017, December 12). *Oral evidence—Artificial Intelligence Select Committee*. https://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/artificial-intelligence-committee/artificial-intelligence/oral/75736.html

House of Lords Defence Committee. (2023). *It is broke—And it's time to fix it: The UK's defence procurement system*.

Kaplan, S., & Orlikowski, W. J. (2013). Temporal Work in Strategy Making. *Organization Science*, *24*(4), 965–995. https://doi.org/10.1287/orsc.1120.0792

Kotecha, B., & Desmond, J. (2017). *State of the UK GovTech Market: Unlocking the Potential of Startups to Solve Public Problems.* PUBLIC.

Lember, V., Kattel, R., & Kalvet, T. (Eds.). (2014). *Public Procurement, Innovation and Policy: International Perspectives*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-40258-6

Lember, V., Kattel, R., & Kalvet, T. (2015). Quo vadis public procurement of innovation? *Innovation: The European Journal of Social Science Research*, *28*(3), 403–421. https://doi.org/10.1080/13511610.2015.1043245

Loader, K. (2013). Is Public Procurement a Successful Small Business Support Policy? A Review of the Evidence. *Environment and Planning C: Government and Policy*, *31*(1), 39–55. https://doi.org/10.1068/c1213b

Margetts, H., & Dunleavy, P. (2013). The second wave of digital-era governance: A quasi-paradigm for government on the Web. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *371*(1987), 20120382. https://doi.org/10.1098/rsta.2012.0382

Margetts, H., & Dunleavy, P. (2024). The political economy of digital government. *Public Money and Management*. https://ora.ox.ac.uk/objects/uuid:f337829e-ad2b-47ee-a87e-e8875849c74e

Mazzucato, M., & Collington, R. (2023). *The Big Con: How the Consulting Industry Weakens Our Businesses, Infantilizes Our Governments, and Warps Our Economies*. Penguin Press.

Mazzucato, M., & Kattel, R. (2020). COVID-19 and public-sector capacity. *Oxford Review of Economic Policy*, *36*(Supplement_1), S256–S269. https://doi.org/10.1093/oxrep/graa031

Meier, K., & Hill, G. (2005). Bureaucracy in the Twenty-First Century. In *The Oxford Handbook of Public Management* (pp. 51–71). https://scholarworks.boisestate.edu/pubadmin_facpubs/40

Meijer, A. (2015). E-governance innovation: Barriers and strategies. *Government Information Quarterly*, *32*(2), 198–206. https://doi.org/10.1016/j.giq.2015.01.001

Mergel, I., Ulrich, P., Kuziemski, & Martinez, A. (2022). *Scoping GovTech dynamics in the EU.* European Commission. Joint Research Centre. https://data.europa.eu/doi/10.2760/700544

Milward, H. B., & Provan, K. (2003). Managing the hollow state: Collaboration and contracting. *Public Management Review*, *5*(1), 1–18. https://doi.org/10.1080/1461667022000028834

NAO. (2011). *Information and Communications Technology in government. Landscape Review—NAO report*. https://www.nao.org.uk/reports/information-and-communications-technology-in-government-landscape-review/

NAO. (2025). *Government's approach to technology suppliers: Addressing the challenges*. https://www.nao.org.uk/insights/governments-approach-to-technology-suppliers-addressing-the-challenges/#downloads

OECD. (2019). *Digital Government Index: 2019 results* (OECD Public Governance Policy Papers 03; OECD Public Governance Policy Papers, Vol. 03). https://doi.org/10.1787/4de9f5bb-en

OECD. (2024). *Enabling Digital Innovation in Government: The OECD GovTech Policy Framework*. OECD. https://doi.org/10.1787/a51eb9b2-en

Orazem, G., Mallory, G., Schlueter, M., & Werfel, D. (2017). *Why Startups Don't Bid on Government Contracts*. 16.

Orlikowski, W. J., & Yates, J. (2002). It's About Time: Temporal Structuring in Organizations. *Organization Science*, *13*(6), 684–700. https://doi.org/10.1287/orsc.13.6.684.501

Pérez-Nordtvedt, L., Payne, G. T., Short, J. C., & Kedia, B. L. (2008). An entrainment-based model of temporal organizational fit, misfit, and performance. *Organization Science*, *19*(5), 785–801. https://doi.org/10.1287/orsc.1070.0330

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Reinecke, J., & Ansari, S. (2015). When Times Collide: Temporal Brokerage at the Intersection of Markets and Developments. *Academy of Management Journal*, *58*(2), 618–648. https://doi.org/10.5465/amj.2012.1004
Rhodes, R. a. W. (1994). The Hollowing Out of the State: The Changing Nature of the Public Service in Britain. *The Political Quarterly*, *65*(2), 138–151. https://doi.org/10.1111/j.1467-923X.1994.tb00441.x
Sandra, D., Segers, J., & Giacalone, R. (2023). How organizations can benefit from entrainment: A systematic literature review. *Journal of Organizational Change Management*, *36*(2), 233–256. https://doi.org/10.1108/JOCM-01-2022-0023
Science and Technology Committee - House of Commons. (2019). *Balance and effectiveness of research and innovation spending: Government and UK Research and Innovation Responses to the Committee's Twenty-First Report of Session 2017–19 -*. https://publications.parliament.uk/pa/cm5801/cmselect/cmsctech/236/23602.htm
Spend Network. (2015). *A hard sell—Why does less than 3% of government procurement spend go to startups?* https://www.nesta.org.uk/blog/a-hard-sell-why-does-less-than-3-of-government-procurement-spend-go-to-startups/
Strauss, A., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques* (p. 270). Sage Publications, Inc.
Taylor, H., & Viner, Z. (2021). *The State of European GovTech*. PUBLIC.
Wood, M. S., Bakker, R. M., & Fisher, G. (2021). Back to the Future: A Time-Calibrated Theory of Entrepreneurial Action. *Academy of Management Review*, *46*(1), 147–171. https://doi.org/10.5465/amr.2018.0060
World Economic Forum. (2025). *The Global Public Impact of GovTech*. https://reports.weforum.org/docs/WEF_The_Global_Public_Impact_of_GovTech_2025.pdf
Yin, R. K. (2013). *Case Study Research: Design and Methods* (Fifth edition). SAGE Publications, Inc.

Appendix

Below is a sample protocol used for interviews with public sector buyers. Similar structures were used for other stakeholder groups (e.g., startup founders, intermediaries), with content tailored accordingly. All questions were followed by flexible prompts depending on interviewee responses.

Core Question	Associated Prompts & Follow Ups
1. Can I confirm you understand and agree with the informed consent procedures?	
2. Could you describe your current role and how you got there?	Perceptions of UK procurement; motivation for working in procurement.
3. In what ways do you interact with procurement in your work?	Organisational context; specific responsibilities; constraints.
4. Can you walk me through the process of recent procurement decision you were involved with in detail?	Specific hurdles; supplier engagement; interdepartmental coordination.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 12: Increasing citizen engagement and active citizenship through digital government

Track Description

Citizen engagement has been identified as a crucial factor in several studies seeking to derive benefits from digital government strategies. Making public institutions open and transparent, and generating public value, is a massive challenge that cannot prescind from citizens' participation in the process of thinking, discussing, modeling, approving, implementing, and evaluating public services and solutions. Consultation and participation processes have brought governments and society closer together. However, new challenges await, particularly as society's trust in governments is compromised in many parts of the world, and misinformation and disinformation emerge. Consequently, it is paramount to advance understanding of engagement as an institutional, structural, social, cultural, and political phenomenon, as well as the individual cognitive process of deciding to get involved at all levels, from town to nationwide public management discussion. This track focused on citizen engagement and digital citizenship through active citizen participation in public discourse, aiming to improve digital public services and the impact of digital government.

Track Chairs

E. M. Luciano, Pontifical Catholic University of Rio Grande do Sul, Brazil
G. V. Pereira, University for Continuing Education Krems, Austria
C. Bianchi, Università degli Studi di Palermo, Italy

Contents

Child-focused challenges in the digital transformation of government services.....744
M. M. Erhi

Fast Track for Collaborative Solutions: A Methodology for Public Service Design Workshops Supported by LLMs 757
W. C. M. P. da Silva, E. D. Canedo, G. M. Correa, H. G. de Moura, P. E. D. Franco, G. G. N. Santana, and R. M. da C. Figueiredo

Game elements enabling citizens' engagement: an integrative literature review into elements, motivations, drivers and barriers 772
B. Satrio, F. Kleiman, and M. Janssen

How Could Public Libraries Empower Communities to Participate in Government AI Initiatives? A Practical View of Benefits and Challenges 787
Z.-X. Huang, M. Gascó-Hernandez, and J. R. Gil-Garcia

What do we know about E-participation at the Local Level? 797
C. P. Faganello, E. M. Luciano, and G. V. Pereira

Child-focused challenges in the digital transformation of government services.

Makpor Mercy Erhi [a*]

[a] United Nations University Operating Unit on Policy-Driven Electronic Governance, Guimaraes, Portugal, makpor@unu.edu, ORCID 0000-0001-6044-0575.
Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. The digital transformation of government services fundamentally reshapes how citizens engage with public institutions and services, creating new opportunities and challenges for inclusive governance in the digital age. Amongst the most critical yet often overlooked stakeholders in this transformation process are children, who represent a significant portion of the global population and the future drivers of digital innovation and civic participation. As digital platforms become central to service delivery, children's unique needs, rights, and vulnerabilities must be explicitly addressed to ensure equitable access, protection, and empowerment. This paper examines the implications of government digital services for children in some selected countries. The paper focuses on governments' role as stakeholders in shaping public services and the importance of contributing to digital literacy, safeguarding privacy, and promoting child-friendly participation mechanisms. Drawing on five-country case studies – Bangladesh, Brazil, Ghana, Sweden, and Timor-Leste - the paper highlights the challenges and opportunities associated with integrating child-sensitive approaches into digital governance. The cases provide insights into how digital government services can increase active citizenship and civic engagement among children and their families while addressing disparities in access and usage. The findings build on a collaborative study conducted in 2021 by the United Nations Children's Fund (UNICEF) and the United Nations University Operating Unit on Policy-driven Electronic Governance (UNU-EGOV). The study underscores the transformative potential of child-sensitive digital government initiatives in promoting early civic participation and empowering marginalized communities. The analysis emphasizes the need for a nuanced understanding of age-specific requirements, improved data collection mechanisms, and a coordinated whole-of-government approach to digital transformation. By integrating child-sensitive practices into digital governance, children's rights are not only safeguarded by governments but also spurs a generation of digital literates, active citizens who are empowered to impact their communities and futures. This paper calls for a concerted effort to prioritize children in digital governance strategies, ensuring that no child is left behind in the digital era. Key contributions include the identification of best practices in inclusive ecosystems, the articulation of a holistic framework for digital service delivery and online safety, as well as the enhancement of strategies for bridging digital divides for marginalized children.

Keywords. Children, COVID-19 Era, Digital transformation, Government digital services, Inclusivity.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.975

1. Introduction

Digital technologies, through rapid advancement, are fundamentally reshaping economies and societies, presenting the potential to permanently transform the nature of modern governance (UNICEF & UNU-EGOV, 2021) and public service delivery. Societal transformations driven by digital technologies have reshaped how individuals interact with governments globally (Van Veldhoven & Vanthienen, 2022). Moreso, it has offered transformative opportunities to improve the efficiency, reach, and quality of government services (Nagy, 2017; UNICEF & UNU-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

EGOV, 2021) for citizens. The advent of the 'digital evolution' holds the promise of enhanced governance, more inclusive service delivery, and increased responsiveness through the utilization of information and communication technologies (ICT) (Nagy, 2017). Therefore, digital government services have emerged as critical tools for enhancing citizen engagement, streamlining bureaucratic processes, and addressing complex societal challenges (Nagy, 2017; Van Veldhoven & Vanthienen, 2022). Governments worldwide have embraced this transition to e-government, with a central focus on digitizing sectors such as public health, education, social services, and identity management.

During the COVID-19 pandemic, the adaptation of digital solutions accelerated globally (Van der Voort, 2020), demonstrating the potential to maintain essential public services in times of crisis (Amankwah-Amoah, Khan, Wood & Knight, 2021; Janssen & Van der Voort, 2020). However, the accelerated pace of digital transformation also brought to the forefront existing inequalities and created new challenges, particularly for marginalized and vulnerable populations, including children (Ranganai, Muwani, Zivanai, Munyoro & Sakadzo, 2022). Children, as a demographic group, are distinctively positioned in the digital transformative narrative (Keeley & Little, 2017; Livingstone & Third, 2017) as both active users of digital services, particularly in education, healthcare, and social protection and passive recipients of the broader public policies that increasingly rely on digital tools and technologies (UNESCO, 2016; Van Veldhoven & Vanthienen, 2022). Despite their critical significance as stakeholders, children's specific needs and rights are often overlooked in digital governance strategies. Issues such as access disparities, digital literacy gaps, online safety, data privacy, and age-appropriate service design remain underexplored and inadequately addressed in many countries (Fosch-Villaronga, Van der Hof, Lutz, C., & Tamò-Larrieux, 2023; Livingstone & Third, 2017).

Globally, disparities in digital inclusion persist, shaped by socioeconomic inequalities, infrastructural limitations, and governance frameworks (Helsper, 2021). These challenges are majorly present in low-middle-income countries, where children face intense barriers to accessing digital services (UNICEF & UNU-EGOV, 2021). For instance, children in rural areas often struggle with limited internet connectivity, while those in urban poor communities may lack access to affordable digital devices or adequate digital literacy training. In high-income countries with advanced digital infrastructures, gaps in child-focused policies and practices persist, which may undermine the potential benefits of digital government services (Livingstone, Stoilova & Nandagiri, 2019). Addressing these challenges requires a nuanced understanding of the socio-economic, cultural, and institutional contexts that shape digital service delivery for children (Hammond, Polizzi & Bartholomew, 2023).

Furthermore, the rapid digitization of government services raises critical questions about equity and inclusivity (Latupeirissa, et al., 2024; Ranchordas, 2022). Are these services designed to accommodate children from diverse backgrounds, including those with disabilities, those from minority groups, and those living in fragile contexts? Are the risks associated with increased online engagement, such as cyberbullying, exploitation, and exposure to harmful content, adequately reduced? While digital technologies offer transformative potential, their benefits cannot be fully realized without addressing these pressing challenges. Consequently, digital services have become increasingly common in the 21st century; their significance has been magnified during the global COVID-19 pandemic, especially for children and their families (Robinson, et al., 2020; Mok, Xiong & Bin Aedy Rahman, 2021). This presents a pressing need to ensure digital services align with inclusivity, child rights, and safety. Despite the potential of digital services to improve the relevance and accessibility of services for children, there is a lack of systematic comprehension regarding available service types and the facilitating factors that guarantee their alignment with inclusivity, child rights, and safety (Latupeirissa, et al., 2024). The need for systematically exploring the discourse and the practices that ensure government digital services advance and protect the rights of children and young adults cannot be overemphasized (Hammond, Polizzi & Bartholomew, 2023; Ranchordas, 2022). Governments must enhance their capacity to secure data and address the demands of parents and society in ensuring inclusivity, online safety and delivering improved services.

The article critically examines the challenges and opportunities of digital government services for children across five diverse countries: Bangladesh, Brazil, Ghana, Sweden, and Timor-Leste. These countries were selected as they represent a broad spectrum of socio-economic development, different levels of government maturity, and digital infrastructure; providing valuable insights into how digital transformation impacts children in varied contexts. Bangladesh and Ghana, for instance, highlight the barriers faced by low-income nations with limited resources (Graham, 2019), while Brazil showcases a middle-income country's efforts to balance rapid urbanization with digital inclusion (Mazzucato, 2024). In contrast, Sweden exemplifies the approach of a high-income nation with advanced digital systems (Ericsson & Mealy, 2019), and Timor-Leste offers a unique perspective as a post-conflict country striving to build a resilient digital future (McWilliam, 2020). An in-depth study analysis was conducted on the countries' government and norm-setting institutional websites (UNICEF & UNU-EGOV, 2021). Explorative interviews were also conducted in 2021 to complement the data collected from the respective government repositories. The findings of this study underscore the urgent need for child-sensitive digital government strategies that prioritize inclusivity, equity, and the protection of children's rights.

This article adds to the extant literature and makes key contributions, including a holistic framework for online

safety and advancing strategies for bridging digital divides for marginalized children. It extends theoretical discussions by linking digital government services to active citizenship and early civic engagement. Practical and actionable recommendations for creating a safer, more inclusive digital future for children are proposed for policymakers, educators, and technologists. By integrating child-centric perspectives with strategies for inclusion and equity, the study provides a roadmap for creating safer and more inclusive digital ecosystems for children globally. The remaining part of the paper is structured as follows: Section 2 describes the research methodology used to conduct the study. Section 3 discusses the findings relating to the key issues and challenges raised in the study, and proposes a holistic whole-of-government framework for delivering government digital services. Sections 4 and 5 conclude with the article's conclusion and recommendations for ways forward and further analysis.

2. Methodology

2.1 Global survey

A comprehensive global survey of government and norm-setting institutional websites was conducted (UNICEF & UNU-EGOV, 2021) to address the persistent issues mentioned in the introduction. The survey aimed to identify the digital services available to children and their families, focusing on understanding their unique needs, rights, and vulnerabilities (Keeley & Little, 2017; Singh, et al., 2020). The survey also sought to uncover gaps in accessibility, usability, and inclusivity, highlighting areas where digital government services could be improved to better serve marginalized and underserved communities.

A thorough review of relevant academic and grey literature was conducted to complement this approach. The review provided a foundational understanding of the broader socio-political and technological contexts in which digital services are developed and implemented. It also provided insights into best practices, emerging trends, and persistent challenges in digital governance for children. Furthermore, to know citizens' perspectives, explorative interviews were conducted with 28 representatives from government institutions, civil society organizations, and international bodies (UNICEF & UNU-EGOV, 2021). These interviews provided nuanced, context-specific insights into the five countries' design, implementation, and challenges of digital government services.

2.2 Case Study Analysis

All five countries were selected based on their varied socioeconomic conditions, levels of digital infrastructure, and strategic approaches to digital governance. Bangladesh and Ghana represent low-income countries grappling with significant barriers to digital inclusion, such as limited connectivity and resource constraints (Graham, 2019). Brazil is a middle-income country demonstrating the complexities of balancing rapid urbanization with equitable digital access (Mazzucato, 2024). Sweden is a high-income country with advanced digital infrastructure and presents best practices and innovative strategies for inclusivity (Ericsson & Mealy, 2019; UNESCO, 2020). Finally, as a post-conflict state, Timor-Leste provides a unique perspective on the challenges and opportunities of building resilient digital systems in fragile contexts (Ribeiro, Clarke & O'Donoghue, 2020; Timor-Leste Ministry of Education, 2022).

The findings from the survey, literature review, and interviews have been synthesized to provide a holistic understanding of the challenges and opportunities associated with digital government services for children. Key themes explored include accessibility, digital literacy, online safety, data privacy, and the alignment of digital services with child rights and inclusivity principles. Table 1 below presents a concise overview of all five countries, highlighting their socio-economic profiles, digital maturity levels, and strategic focus areas for digital government services. This contextual information global survey and case study analysis are critical for understanding the impacts of digital transformation on children and for identifying scalable and context-sensitive solutions that prioritize equity and inclusivity.

Tab. 1 – Countries considered for the study and a brief description of each.

Country	Income group	Structural set-up	Area of interest
Bangladesh	Low-income	Federal, with central coordination of digital transformation. Federal authorities deliver the majority of services. Weak local authorities.	An emerging Asian economy where digitizing services, increased inclusion, and accessibility in rural areas is a key strategic focus (https://a2i.gov.bd/).
Brazil	Medium-income	Federal, strong state, and local government rights and autonomy. The majority of services are delivered by state and local authorities. A	An emerging Latin American economy, where the rights and well-being of minors follow a mainly classical ICT approach.

		mix of strong and weak local authorities.	
Sweden	High-income	Unitary, strong central government coordination but with decentralized implementation. Over 70% of services are delivered by local authorities.	A European country known for its innovative approaches to education (e.g., educational outcomes, blended play, and experience-based learning) and also technology.
Ghana	Low-income	Unitary, strong central government coordination. The central government delivers the majority of services. Weak local authorities.	Emerging African economy with an emerging tech scene and increased focus on public sector transformation and access to technology and government services.
Timor-Leste	Low-middle-income	Unitary, strong central government, no regions or local authorities. The central government delivers all services.	Asian and emerging within the tech scene. Beginning to aim towards public sector transformation, access to digital technology and services.

Source: Author, UNICEF & UNU-EGOV

The selection of countries also aims to provide a diverse representation, encompassing various levels of economic development, a spectrum of service portfolios, and different stages of governmental digital transformation. For instance, in Table 2 below, Timor-Leste identified as a low-middle-income country with limited public services, is in the initial phases of ICT infrastructure rollout, accompanied by comprehensive plans for e-government. In contrast, Sweden, a high-income welfare state consistently ranked amongst the top 10 countries globally in e-government development, offered a contrasting perspective with its advanced digital transformative initiatives.

Tab. 2 – Current socioeconomic indicators of case countries.

Indicator Description	**Bangladesh**	**Brazil**	**Ghana**	**Sweden**	**Timor-Leste**
Population, total (World Bank, 2023)	171.47	211.14	33.79	10.54	1.38
Percentage of the child population	38.79	32.99	47.83	23.12	59.69
Urbanization (Worldometer, 2024)	42%	91%	57.90%	87.0%	36%
GNI per capita ($) (PPP) (World Bank, 2023)	9,510	20,470	7,450	71,780	5,620
Literacy rate (% ages 15 - 24) (WB)	95% (2021)	99.28% (2022)	93.48% (2020)	99% (2023)	85.10% (2020)
Employment to population ratio (% ages 15 and above – modeled ILO estimated)	55.73%	57.9%	66.38%	62%	65.5%

(WB, 2023)					
Youth not in school or employment (% ages 15 and above) (WB, 2020)	27.39	24.16	30.50	6.13	20.95
Internet users (% of the population) (WB, 2023)	44.50%	84.15%	69.84% (2022)	95.70%	40.75% (2022)
Mobile phone subscriptions (per 100 persons) (WB, 2022)	105.26	98.89	119.62	125	110
E-Government Development Index Ranking (UNDESA, 2025)	0.6570	0.8403	0.6317	0.9326	0.4020

Source: Author. Adopted from UNICEF and UNU-EGOV, 2021, and updated to current data.

2.3 Development and preparation of semi-structured interviews

The interview guide and questions were mainly developed, drawing upon literature from government repositories, academic publications and reports. These resources provided a solid foundation for framing the questions (International Social Security Association, 2019; Neilson, 2019), ensuring they addressed the specific aspects of digital government services for children and their families. The interview was designed to explore a range of topics, including accessibility, usability, inclusivity, data privacy, and the overall impact of digital government services on children. To capture the diverse needs and experiences of children, the study focused on three distinct age groups:

- Infants and young children (ages 0-4): This group primarily relies on their parents and guardians to access government services. Questions for this group focused on the impact of digital services and the role of parents or caregivers in navigating these systems.

- School-age children (ages 5-14): As direct beneficiaries of many government services, such as education and healthcare, this group often accesses digital services through intermediaries like teachers, healthcare providers, or family members. The questions emphasized their experiences and the effectiveness of intermediaries in facilitating access.

- Adolescents (ages 15-18): This group has growing independence and, in many cases, legal rights comparable to those of adults. Questions addressed their direct use of digital services, their perspectives on accessibility and usability, and their awareness of privacy and data protection issues.

The semi-structured interview underwent multiple rounds of review and refinement to ensure cultural sensitivity and contextual relevance. It was designed to facilitate open-ended responses, encouraging interviewees to share detailed insights and personal experiences related to digital government services. The interview guide will be shared via email upon request.

2.4 Data collection and field activities

The data collection process was a collaborative effort between UNICEF and UNU-EGOV, with a focus on ensuring comprehensive and representative findings. The first step involved the careful selection of the five case countries listed in Table 1 above. The countries were chosen to reflect a diverse range of socio-economic conditions, levels, and stages of digital transformation, and their strategies for digital governance. The next phase involved identifying key stakeholders, including government agencies, non-governmental organizations (NGOs), international non-governmental organizations (INGOs), civil society organizations (CSOs), and other relevant entities. Potential interviewees were selected based on their expertise and involvement in digital service delivery, policy-making, or

advocacy relating to children's rights and digital governance.

The data collection exercise took place between February and April 2020. Semi-structured interviews were conducted using the prepared interview guide. This allowed for flexibility in probing specific themes while maintaining consistency across interviews. The interviews were carried out by team members from both UNICEF and UNU-EGOV (UNICEF & UNU-EGOV, 2021), ensuring a balanced representation of expertise and perspectives during the data collection process. Furthermore, field activities included the analysis of policy documents, government reports, and service delivery frameworks to contextualize the insights from interviewees. This multi-method approach ensured a robust understanding of the challenges and opportunities associated with digital government services for children. This systemic and collaborative process allowed the study to generate detailed context-specific findings that highlighted the transformative potential of the digital services of the case countries while also addressing the specific needs and vulnerabilities of children in the case countries.

3. Findings and Discussion

3.1 The general state of affairs of digital services for children globally

Accessing digital services in recent times has created a unique space for children, transforming them into active users of the internet and digital technology (Janssen & Van der Voort, 2020; Keeley & Little, 2017; Fosch-Villaronga, Van der Hof, Lutz & Tamò-Larrieux, 2023; Helsper, 2021). Thus, the rise in internet connectivity and the availability of digital platforms have significantly reshaped how children interact with the world (Keeley & Little, 2017). This transformation has been further accelerated by the advent of the COVID-19 pandemic, which has necessitated the shift to online spaces for education, healthcare, and various social and entertainment activities – many of which have educational components. These developments have redefined childhood experiences, creating new opportunities and challenges for minors in the digital age.

Global data highlights the pervasive reach of digital technologies, with an estimated 3.89 billion people in 2018 (Hammond, Polizzi & Bartholomew, 2023; Hernandez & Roberts, 2018). However, since COVID-19, this has increased to an estimated 5.52 billion people, which is equivalent to 67.5% of the world's total population (DataReportal, 2025). Following this new and intense era of crisis for children and recent technology trends, the potential risks for children have indeed become a continuation of the reality of the past several years. Children aged 15 years and older have emerged as the most avid subgroup of minors and young adults connected online. As of 2023, approximately 79% of children and young adults aged 15 to 24 globally are active Internet users (International Telecommunication Unit, 2023). This indicates that 21% of the age group remains unconnected (ITU, 2025).

A growing body of evidence underscores the multifaceted benefits of digital access for children (Hammond, Polizzi & Bartholomew, 2023; Keeley & Little, 2017). Access to digital services has proven instrumental in various ways, particularly in education (Haleem, Javid, Qadri & Suman, 2022; Williamson, 2017). Online school activities and out-of-school educational resources are two prominent avenues through which children leverage digital technologies (McNaughton, et al., 2022). These tools have democratized access to quality education, enabling learners to access diverse resources and engage with interactive content irrespective of geographic or socioeconomic barriers (Keeley & Little, 2017). However, the advantages of digital opportunities extend far beyond education (Parveen & Ramzan, 2024). Children engaging with digital services, particularly in the global northern hemisphere, encounter various opportunities, including developing digital literacy and communication skills and exploring creative and innovative activities (Haddock, Ward, Yu & O'Dea, 2022). For instance, digital platforms often serve as spaces for collaboration, where children can connect with peers globally, exchange ideas, and participate in social and civic initiatives and engagements.

Findings from the 2018 Programme for International Students Assessment (PISA) reveal that 95% of 15-year-olds across OECD countries have access to some form of digital services (Avvisati & Givord, 2021). This high level of connectivity suggests that digital technologies have become an integral part of young people in the global northern hemisphere. However, notable disparities exist in accessibility and usability across different demographic and geographic groups, particularly when considering children in the global south. More so, while substantial data on internet usage by adolescents aged 15 to 18 exist, there still remains a significant gap in the digital experiences of younger children aged 0 to 14 (Livingstone, Stoilova & Nandagiri, 2019).

The literature review revealed limited data on the ages of 0 to 14, leaving gaps and critical questions on their technology access and usage patterns. Furthermore, other significant indicators such as gender, age, and geographic location are often underexplored, resulting in an incomplete understanding of the state of affairs or digital landscape for children. This lack of data poses a challenge for policymakers, educators, and stakeholders aiming to ensure equitable access and address the risks associated with digital engagement (Livingstone, Stoilova & Nandagiri, 2019). To address these gaps, there is a pressing need for comprehensive research that explores the digital experiences of younger children, disaggregated by key variables such as age, gender, socioeconomic status,

and geographic location.

3.2 Accessibility

The study revealed significant disparities in children's access to digital government services, primarily driven by socioeconomic and geographic factors. In low- and middle-income countries such as Bangladesh and Ghana, inadequate infrastructure and high costs of digital devices are major barriers. For instance, recent ITU (2023) statistics show that only 40% of households in low-income countries have internet access, compared to 90% in high-income countries. More so, rural areas often lack the connectivity needed to access digital services, leaving children in these regions disproportionately disadvantaged.

In Bangladesh, programs such as "*Digital Bangladesh*" aim to improve access by providing internet-enabled education hubs and affordable devices (Digital Bangladesh Vision, 2020; United Nations Development Programme, 2021). However, logistical challenges and resource constraints often limit their reach (Dappe, Kunaka, Lebrand & Weisskopf, 2019). Ghana has made advancements with initiatives such as public-private partnerships to expand connectivity, yet progress remains slow in rural areas. Furthermore, these challenges are spurred by socioeconomic inequalities, as families in lower-income brackets often prioritize basic needs over digital resources.

In Timor-Leste, digital transformation is in its nascent stages (Timor-Leste Ministry of Education, 2022), facing unique challenges, including the lack of localized content and limited awareness of digital tools among educators and parents (Ribeiro, Clarke & O'Donoghue, 2020). Community-based approaches, such as local internet hubs and collaborative education platforms, have shown promise (Srinivasan, Jishnu & Shamala, 2021) but require scalability and sustainability to create a meaningful impact (Guglielmi et al., 2021). In contrast, Sweden exemplifies best practices through universal broadband coverage and subsidized digital services and devices for students, ensuring equitable access (Lazar, Goldstein & Taylor, 2015). However, in high-income countries, children from immigrant and minority backgrounds often encounter linguistic and cultural barriers to accessing government digital services, highlighting the need for tailored approaches and alignment to inclusion.

3.3 Online Safety

Online safety emerged as a critical concern across all case study countries. Children's increased use of digital platforms has brought about exposure to risks such as cyberbullying and identity theft, as well as exposure to harmful content. According to the UNICEF report (2021), 1 in 3 internet users globally is a child. Yet, fewer than half of all countries have implemented comprehensive online safety policies that align with the needs of children online. In Brazil, the legal framework for child protection in digital spaces includes initiatives for eliminating cyberbullying and preventing exploitation (Third, Livingstone & Lansdown, 2019). However, there are gaps in enforcing these laws (Brazilian Internet Steering Committee, 2021), leaving children vulnerable, especially children in underserved regions where digital literacy remains low.

In Ghana and Bangladesh, vulnerabilities are exacerbated by limited awareness among parents and educators. Thus, children are often left to navigate online spaces without adequate guidance or safeguards (Ghana Investment Fund for Electronic Communications, 2022; United Nations Development Programme, 2021). These regions urgently need structural training programs to educate stakeholders on digital safety practices engagement (Livingstone, Stoilova & Nandagiri, 2019). Sweden has proactive measures in place, such as "Digital Resilience Programs," which are integrated into school curricula (Swedish National Agency for Education, 2021). These measures ensure that children are taught how to identify and mitigate online risks. The programs also lay emphasis on parental involvement, recognizing the critical role-play of families in promoting safe online behaviors.

3.4 Inclusivity in Education

Digital education holds immense potential to bridge learning gaps, yet inequalities are often intensified (Bozkurt, et al., 2020). The COVID-19 pandemic exposed the fragility of digital education systems, particularly in low-income countries (Srinivasan, Jishnu & Shamala, 2021; West, Kraut & Ei Chew, 2019). In Ghana, only 20% of students had access to online learning platforms during school closures (Agormedah, Henaku, Ayite & Ansah, 2020; GIFEC, 2022; Owusu-Fordjour, Koomson & Hanson, 2020), compared to almost universal access in Sweden (Pramling Samuelson, Wagner & Eriksen Ødegaard, 2020; SNAE, 2021). These disparities showcase the urgent need for targeted intervention to ensure inclusivity.

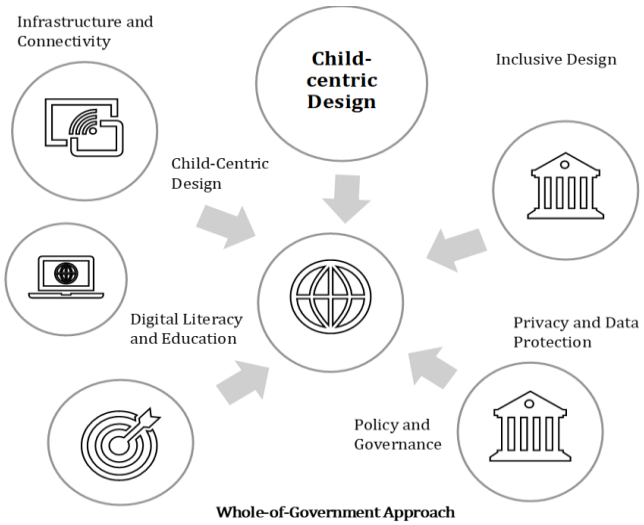
Innovative solutions, such as mobile-based learning platforms and community internet hubs, have shown possibilities in improving access in resource-constrained settings (Srinivasan, Jishnu & Shamala, 2021). For instance, Brazil has presented programs that use television and radio to deliver educational content to students without internet access, ensuring a broader reach (Brazilian Network Information Center, 2021). More so, partnerships with technology companies have enabled the distribution of low-cost tablets and preloaded educational content to underserved communities (NIC.Br, 2021; Third, Livingstone & Lansdown, 2019).

Sweden's inclusive education model incorporates assistive technologies for children with disabilities and multilingual platforms for immigrant students, ensuring no child is left behind (Tajic & Bunar, 2023; UNESCO, 2020). The findings emphasize the significance of integrating digital literacy into school curricula, providing teacher training on digital tools, and ensuring that digital platforms are accessible to children from diverse socioeconomic backgrounds. Furthermore, creating partnerships between public institutions and private organizations can help fund innovative solutions for inclusive education ((Tajic & Bunar, 2023).

3.5 Government digital services for increased citizens' engagement

This section presents a holistic framework to illustrate some of the key components and interconnections required to design and deliver inclusive and effective government digital services for children in all five case study countries.

Fig. 1 – Framework for Government Digital Services



Source: Author

Elements in the framework play a critical role in ensuring that services are accessible, equitable, and responsive to citizens' needs, especially children. The infrastructure and connectivity pillar presents the foundational layer of digital services (Camarinha-Matos, Fornasiero, Ramezani & Ferrada, 2019; Serrano, 2018). It focuses on ensuring that the physical and technological infrastructure, such as broadband networks, mobile towers, satellite coverage and electricity are readily available and accessible, especially in the underserved and remote areas. Thus, without robust connectivity, citizens in marginalized regions risk being excluded from accessing government digital services.

The digital literacy and education component presents the capability of citizens to effectively use digital technologies. Programs within this area must push for the use of digital skills among children, educators, parents and communities. This will help ensure that citizens are equipped to navigate digital or online government platforms, use e-learning tools, and access resources safely and effectively. The Child-centric design pillar focuses on designing digital platforms and services that align with children's unique needs and rights. Services around this pillar must feature intuitive interfaces, age-appropriate content, and tools for meaningful citizen participation. For instance, digital platforms must integrate child-friendly features, such as simplified navigations and visuals that reverberate younger users.

The privacy and data protection pillar highlights the need to safeguard sensitive data, particularly for children, as they may be conversant with the digital risks associated with online activities. It lays emphasis on implementing encryption, anonymization, and robust data protection policies to ensure users' safety (Third, Livingstone & Lansdown, 2019). Legal frameworks and monitoring mechanisms are also critical to enhancing trust in digital systems, especially for children (Felzmann, Villaronga, Lutz & Tamo-Larrieux, 2019). The policy and governance pillar provides the strategic and regulatory framework for the delivery of digital services, emphasizing cross-sector collaboration, inclusive policies, and government accountability. Thus, the governance framework ensures equitable accessibility to resources while addressing the digital divide, cybersecurity, and other challenges.

The inclusive outcomes and whole-of-government approach are the central elements of the framework. The inclusive outcomes represent the ultimate goal of digital services, which are equitable access, inclusion, and

empowerment of all citizens, especially children and marginalized communities. The whole-of-government approach highlights the need for coordination across multiple multilateral collaborators and sectors for the delivery of both unified and seamless digital services for children.

4. Conclusion

The digital transformation of government services continues to present unique opportunities for addressing systemic inequalities and empowering children. However, realizing this potential requires a sustained and strategic commitment from policymakers, educators, and technology developers. The paper examined the challenges and opportunities inherent in using digital platforms to improve accessibility, online safety, and inclusivity for children. The findings emphasize that while significant strides have been made globally, many systemic barriers persist, including infrastructure limitations, socioeconomic disparities, and gaps in online safety. Children's access to digital government services is often dictated by their geographic location, household income, and the availability of localized, culturally appropriate resources (Mathrani, Sarvesh & Umer, 2022; UNICEF & UNU-EGOV, 2021). Addressing these disparities requires efforts toward bridging the digital divide through robust infrastructure investment, affordable access to digital devices and the internet, and policies that prioritize the needs of underserved communities.

Governments must approach digital transformation through a child-centered perspective to ensure that digital services accommodate children's basic needs and actively contribute to their empowerment and protection. Thus, governments must continue adjusting their digital transformation strategies while embracing children's needs. This will require moving beyond short-term fixes to adopt long-term, sustainable strategies that address the root causes of digital exclusion. More so, ensuring that children can safely navigate digital platforms, particularly due to their high susceptibility to risks is of great significance. Governments must implement comprehensive and effective online safety frameworks that balance not only regulation with education but also empower both children and their guardians to use digital tools and technologies responsibly.

Governments must collaborate with international organizations, civil society groups, and the private sector to establish inclusive digital ecosystems. Furthermore, ensuring transparency and accountability in the implementation of digital initiatives. This is critical to building trust and achieving outcomes. Success in digital transformation efforts and initiatives will depend on adapting to evolving technologies while maintaining a persistent commitment to equity, safety, and inclusivity. Finally, the study underscores the need for international and multilateral collaborations to develop and share best practices, including tools for monitoring digital activities and implementing early warning systems and scalable frameworks for cross-border cooperation.

5. Recommendation

The study recommends the following key points:

5.1 Infrastructural expansion

Investing in robust and accessible internet infrastructure, prioritizing underserved and rural areas to bridge the digital divide. More so, governments' introduction of subsidized initiatives and programs will result in digital tools and internet accessibility that are also affordable for low-income families.

5.2 Enhancing online safety

Establishing comprehensive and effective online safety policies that include education on digital risks, implementing robust content filtering systems, and stringent penalties for cybercrimes targeting children. Also, having effective collaborations to develop a unified framework for child online protection.

5.3 Promoting inclusive education

Inclusivity in education remains a key foundation for equitable digital transformation. The integration of digital literacy into educational and school curricula, as well as the provision of continuous professional development for educators and teachers to effectively use digital tools is extremely significant. Also, expanding access to assistive technologies for children with disabilities and designing multilingual platforms to accommodate diverse linguistic needs cannot be overemphasized.

5.4 Pushing for collaboration

Develop multi-stakeholder partnerships that bring together government, non-governmental organizations (NGOs), international organizations, and the private sector to co-create solutions that address accessibility, safety, and inclusion. Making use of public-private partnerships to fund innovative projects and initiatives, and also ensuring the sustainability of these projects and initiatives are significant factors for consideration.

5.5 Implementation of data-driven strategies

Governments must regularly collect and analyze data to monitor the effectiveness of their digital initiative. The use of evidence-based research and/or data to refine strategies, identify emerging challenges, and adapt to the changing technological landscape is critical to the success of any digital transformation journey.

5.6 Encouraging civic engagement and community participation

Actively involve children, parents, and local communities in designing and implementing digital services to ensure real needs are addressed and cultural contexts are considered.

Acknowledgement

- **Funding or Grant** (if applicable)**:** The article is part of a study and rapid analysis conducted by the United Nations Children's Fund (UNICEF) and the United Nations University Operating Unit on Policy-driven Electronic Governance (UNU-EGOV) titled "Government digital services and children: Pathway to digital transformation.
- **Conflict Of Interest (COI)***: "There is no conflict of interest"

References

Agormedah, E. K., Henaku, E. A., Ayite, D. M. K., & Ansah, E. A. (2020). Online learning in higher education during COVID-19 pandemic: A case of Ghana. *Journal of Educational Technology and Online Learning*, *3*(3), 183-210.

Amankwah-Amoah, J., Khan, Z., Wood, G., & Knight, G. (2021). COVID-19 and digitalization: The great acceleration. *Journal of business research*, *136*, 602-611.

Avvisati, F., & Givord, P. (2021). How much do 15-year-olds learn over one year of schooling? An international comparison based on PISA.

Brazilian Internet Steering Committee (CGI.br). (2021). Internet sector overview in Brazil. Available at: CGI.br. Accessed on 20th December 2024.

Brazilian Network Information Center. (2021). Education and digital technologies: Challenges and strategies for the continuity of learning in times of COVID-19. Available at: sectoral-studies-education-and-digital-technologies.pdf. Accessed on 19th December 2024.

Bozkurt, A., Jung, I., Xiao, J., Vladimirschi, V., Schuwer, R., Egorov, G., ... & Paskevicius, M. (2020). A global outlook to the interruption of education due to COVID-19 pandemic: Navigating in a time of uncertainty and crisis. *Asian Journal of Distance Education*, *15*(1), 1-126.

Camarinha-Matos, L. M., Fornasiero, R., Ramezani, J., & Ferrada, F. (2019). Collaborative networks: A pillar of digital transformation. *Applied Sciences*, *9*(24), 5431.

Dappe, M. H., Kunaka, C., Lebrand, M., & Weisskopf, N. (2019). *Moving forward: Connectivity and logistics to sustain Bangladesh's success*. World Bank Publications.

DataReportal. (2025). Digital around the world. Available at: Digital Around the World — DataReportal – Global Digital Insights. Accessed on 21st January, 2025.

Digital Bangladesh Vision 2021. (2020). Government of Bangladesh. Available at: a2i – Aspire to Innovate. Accessed on 20th January 2025.

Ericsson, F., & Mealy, S. (2019). Connecting official development assistance and science technology and innovation for inclusive development: Measurement challenges from a development assistance Committee perspective.

Felzmann, H., Villaronga, E. F., Lutz, C., & Tamò-Larrieux, A. (2019). Transparency you can trust: Transparency requirements for artificial intelligence between legal norms and contextual concerns. *Big Data & Society*, *6*(1), 2053951719860542.

Fosch-Villaronga, E., Van der Hof, S., Lutz, C., & Tamò-Larrieux, A. (2023). Toy story or children story? Putting children and their rights at the forefront of the artificial intelligence revolution. *AI & society*, *38*(1), 133-152.

Ghana Investment Fund for Electronic Communications (GIFEC). (2022). Bridging the digital divide in Ghana. Available at: gifec.gov.gh. Accessed on 20th December 2024.

Graham, M. (Ed.). (2019). *Digital economies at global margins*. MIT Press.

Guglielmi, S., Jones, N., Nicolai, S., Pereznieto, P., Plank, G., Vu, N., ... & Mackintosh, A. (2021). Reimagining Girls' Education: Solutions to Keep Girls Learning in Emergencies. *UNICEF*.

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable operations and computers*, *3*, 275-285.

Hammond, S. P., Polizzi, G., & Bartholomew, K. J. (2023). Using a socio-ecological framework to understand how 8–12-year-olds build and show digital resilience: A multi-perspective and multimethod qualitative study. *Education and Information Technologies*, *28*(4), 3681-3709.

Helsper, E. (2021). The digital disconnect: The social causes and consequences of digital inequalities.
Hernandez, K., & Roberts, T. (2018). Leaving no one behind in a digital world. *K4D Emerging Issues Report. Brighton, UK: Institute of Development Studies*.

ISSA. (2019). ISSA Report: 10 Global challenges for social security. Available at: ISSA Report: 10 Global challenges for social security | International Social Security Association (ISSA). Accessed on 18th January 2025.

International Telecommunications Unit. (2025). New global connectivity data shows growth, but divides persist. Available at: Press Release. Accessed on 21st January 2025.

Janssen, M., & Van der Voort, H. (2020). Agile and adaptive governance in crisis response: Lessons from the COVID-19 pandemic. *International journal of information management*, *55*, 102180.

Keeley, B., & Little, C. (2017). *The State of the Worlds Children 2017: Children in a Digital World*. UNICEF. 3 United Nations Plaza, New York, NY 10017.

Latupeirissa, J. J. P., Dewi, N. L. Y., Prayana, I. K. R., Srikandi, M. B., Ramadiansyah, S. A., & Pramana, I. B. G. A. Y. (2024). Transforming public service delivery: A comprehensive review of digitization initiatives. *Sustainability*, *16*(7), 2818.

Lazar, J., Goldstein, D. F., & Taylor, A. (2015). *Ensuring digital accessibility through process and policy*. Morgan kaufmann.

Livingstone, S., & Third, A. (2017). Children and young people's rights in the digital age: An emerging agenda. *New media & society*, *19*(5), 657-670.

Mazzucato, M. (2024). Challenges and opportunities for inclusive and sustainable innovation-led growth in Brazil: A mission-oriented approach to public-private partnerships.

McNaughton, S., Zhu, T., Rosedale, N., Jesson, R., Oldehaver, J., & Williamson, R. (2022). In school and out of school digital use and the development of children's self-regulation and social skills. *British Journal of Educational Psychology*, *92*(1), 236-257.

McWilliam, A. (2020). *Post-conflict social and economic recovery in Timor-Leste: Redemptive legacies*. Routledge.

Mok, K. H., Xiong, W., & Bin Aedy Rahman, H. N. (2021). COVID-19 pandemic's disruption on university teaching and learning and competence cultivation: Student evaluation of online learning experiences in Hong Kong. *International Journal of Chinese Education*, *10*(1), 221258682110070.

Nagy, K. H. (2017). How can developing countries make the most of the digital revolution? Retrieved from How can developing countries make the most of the digital revolution?. Accessed on 30th December 2024.

Nielsen, M.M., 2019. Tackling identity management, service delivery, and social security challenges: technology

trends and partnership models. In *Proceedings of the 12th International Conference on Theory and Practice of Electronic Governance* (pp. 1-5).

Owusu-Fordjour, C., Koomson, C. K., & Hanson, D. (2020). The impact of Covid-19 on learning-the perspective of the Ghanaian student. *European journal of education studies*.

Parveen, D. S., & Ramzan, S. I. (2024). The role of digital technologies in education: benefits and challenges. *Int. Res. J. Adv. Eng. Manag*, *2*, 2029-2037.

Pramling Samuelsson, I., Wagner, J. T., & Eriksen Ødegaard, E. (2020). The coronavirus pandemic and lessons learned in preschools in Norway, Sweden and the United States: OMEP policy forum. *International journal of early childhood*, *52*(2), 129-144.

Ranchordás, S. (2022). The digitization of government and digital exclusion: setting the scene. In *The Rule of Law in Cyberspace* (pp. 125-148). Cham: Springer International Publishing.

Ranganai, N., Muwani, T. S., Zivanai, L., Munyoro, B., & Sakadzo, N. (2022). Challenges and Opportunities for Digital Inclusion in Marginalised Communities. *Digital Transformation for Promoting Inclusiveness in Marginalized Communities*, 72-94.

Ribeiro, S. M. B., Clarke, S., & O'Donoghue, T. (2020). *Mapping Primary School Leadership in a Post-Conflict Context: The Case of Timor-Leste*. Cambridge Scholars Publishing.

Robinson, L., Schulz, J., Khilnani, A., Ono, H., Cotten, S. R., McClain, N., ... & Tolentino, N. (2020). Digital inequalities in time of pandemic: COVID-19 exposure risk profiles and new forms of vulnerability. *First monday*, *25*(10).

Serrano, W. (2018). Digital systems in smart city and infrastructure: Digital as a service. *Smart cities*, *1*(1), 134-154.

Singh, S., Roy, D., Sinha, K., Parveen, S., Sharma, G., & Joshi, G. (2020). Impact of COVID-19 and lockdown on mental health of children and adolescents: A narrative review with recommendations. *Psychiatry research*, *293*, 113429.

Srinivasan, M., Jishnu, D., & Shamala, R. (2021). COVID-19 and online education: Digital inequality and other dilemmas of rural students in accessing online education during the pandemic. *World of Media*, *4*, 34-54.

Swedish National Agency for Education. (2021). Digitalisation strategy for education system. Available at: National Agency for Education. Accessed on 10th January 2025.

Tajic, D., & Bunar, N. (2023). Do both 'get it right'? Inclusion of newly arrived migrant students in Swedish primary schools. *International Journal of Inclusive Education*, *27*(3), 288-302.

Third, A., Livingstone, S., & Lansdown, G. (2019). Recognizing children's rights in relation to digital technologies: Challenges of voice and evidence, principle and practice. In *Research handbook on human rights and digital technology* (pp. 376-410). Edward Elgar Publishing.

Timor-Leste Ministry of Education. (2022). Digital education initiatives in Timor-Leste. Available at: Ministry of Education. Accessed on 21st January 2025.

United Nations Development Programme. (2021). Digital Bangladesh to Innovative Bangladesh: The road to 2041. Available at Digital Bangladesh to Innovative Bangladesh: The road to 2041 | United Nations Development Programme. Accessed on 20th January 2025.

United Nations Department of Economic and Social Affairs. (2025). UN E-Government Knowledgebase: E-Government Development Index(EGDI). Available at: EGOVKB | United Nations > About > Overview > E-Government Development Index. Accessed on 12th January 2025.

United Nations Education, Scientific and Cultural Organization. (2016). A policy review: Building digital citizenship in Asia Pacific through safe, effective and responsible use of ICT. Bangkok: UNESCO Asia and Pacific Regional Bureau for Education. Available at: https://bangkok.unesco.org/content/policy-review-building-digital-citizenship-asia-pacific-through-safe-effective-and. Accessed on 4th January 2025.

UNESCO. (2020). Inclusive education: Children with disabilities. Available at: Inclusive education: children with disabilities - UNESCO Digital Library. Accessed on 4th January, 2025.

United Nations Children's Fund & United Nations University Unit on Policy-driven Electronic Governance. (2021). Government digital services and children: Pathways to digital transformation. Retrieved from Government digital services and children: pathways to digital transformation | Innocenti Global Office of Research and Foresight. Accessed on 20th December 2024.

United Nations Children's Fund. (2021). The State of the World's Children 2021 – On my mind: Promoting, protecting and caring for children's mental health. Available at: The State of the World's Children 2021 | UNICEF. Accessed on 20th January 2025.

UNICEF and Bangladesh Bureau of Statistics. (2019). Progotir Pathey Bangladesh – Multiple indicator cluster Survey 2019: Survey finding report. Available at: Bangladesh 2019 MICS Report_English.pdf. Accessed on 13th January 2025.

Van Veldhoven, Z., & Vanthienen, J. (2022). Digital transformation as an interaction-driven perspective between business, society, and technology. *Electronic markets*, *32*(2), 629-644.

West, M., Kraut, R., & Ei Chew, H. (2019). I'd blush if I could: closing gender divides in digital skills through education.

Williamson, B. (2017). Big data in education: The digital future of learning, policy and practice.

Worldometer. (2025). Worldometer: World Population. Available at: Worldometer - real time world statistics. Accessed on 4th January 2025.

World Bank Group. (2023). World Bank Open Data. Available at: World Bank Open Data | Data. Accessed on 4th January 2025.

Fast Track for Collaborative Solutions: A Methodology for Public Service Design Workshops Supported by LLMs

Wander Cleber Maria Pereira da Silva[a], *Edna* Dias Canedo[b*] *George* Marsicano Correa[a], *Henrique* Gomes de Moura[a], *Paula Emilyn* Deodato Franco[a], *Giovanna* Galvão Novaes Santana[a], *Rejane Maria* da Costa Figueiredo[a]

[a]Information Technology - Research and Application Center - ITRAC, Faculty of Science and Technology in Engineering (FCTE), University of Brasilia (UnB), Brasilia, Brazil, wandercleber@unb.br, georgemarsicano@unb.br, hgmoura@unb.br, paula.franco@unb.br, giovanna.santana@unb.br, rejanecosta@unb.br, https://orcid.org/0000-0002-7060-1245, https://orcid.org/0000-0001-9212-9124, https://orcid.org/0009-0006-8749-7575, https://orcid.org/0009-0009-4821-0051, https://orcid.org/0000-0001-8243-7924.

[b] University of Brasilia (UnB), Department of Computer Science, Brasilia, Brazil, ednacanedo@unb.br, 0000-0002-2159-339X.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. Context: Innovation and agility are critical needs in the public administration, driving the development of methodologies that optimize collaborative processes. **Goal**: This study focuses on co-creating a digital solution for a Service Plan of Functions through a Service Design Workshop. We propose and apply a fast track for collaborative Solutions approach, integrating large language models (LLMs) to streamline idea consolidation and facilitate consensus in service design workshops. **Method**: We conducted a workshop aimed at rethinking an existing solution from the perspective of the service user. This involved defining personas, mapping the user journey, proposing functionalities, and aligning these functionalities with the journey stages. **Results**: The proposed methodology significantly reduced execution time and enhanced the efficiency of service design processes involving large groups, without compromising decision quality. The study provides a detailed description of the methodology, the prompts employed, and the outcomes of a case study conducted in a Brazilian public-sector state-owned enterprise.

Keywords. Service Design, Public Administration, Large Language Models (LLMs), Collaborative Methodologies, User-Centered Design
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1061

1. Introduction

The public administration is under increasing pressure to innovate and adapt to rapidly changing societal needs. Collaborative initiatives in this domain often face significant challenges, particularly when organizing ideas and reaching consensus in large, diverse groups. The complexity of these processes is further compounded by constraints on time, resources, and the need to address the interests of various stakeholders (Pajula et al., 2024; Venson et al., 2024). Collaborative decision-making in public administration frequently encounters obstacles such as fragmented communication and misaligned objectives, which can undermine the efficiency and effectiveness of innovation initiatives (**DBLP:journals/jucs/MarsicanoCPRF24**; Leonardi & Not, 2022). Similarly, (Not et al., 2024) highlighted that the growing complexity of public service design requires novel approaches to manage diverse perspectives and foster actionable outcomes.

Studies have identified several critical challenges in implementing co-production processes in public administration. Co-production is defined as a strategy that enables the production of public goods and services through the sharing of responsibilities and power among public agents, private entities, and citizens (Osborne

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

et al., 2021). There are two main types of co-production: 1) Simultaneous Co-production: This occurs when citizens actively participate during the delivery process of public services, directly collaborating in its execution; and 2) Sequential Co-production: This involves citizen participation in distinct stages of the production process, such as planning, implementation, or evaluation, but not necessarily during the direct delivery of the service. These types highlight different moments and forms of citizen engagement in the co-production of public services (Osborne et al., 2021). Among the key issues are the absence of clear theoretical frameworks to guide public managers, insufficient managerial skills, a lack of tools for effective implementation and capacity-building, and limited awareness among public managers about the concept of co-production (Figueiredo, Venson, et al., 2024), (Figueiredo et al., 2022). These challenges underscore the need for enhanced management education in this area (Pedrosa et al., 2022), (Sicilia et al., 2016). Additionally, other studies highlight that public administrations (PAs) often struggle to determine the starting point for initiating co-production efforts (Leonardi et al., 2023). They frequently lack structured approaches for managing work plans and documentation, face difficulties in overseeing tasks and handovers, and encounter challenges in sustaining processes that span months or even years. The inconsistent and unsystematic use of technology further exacerbates these issues. Public administrations often rely on a patchwork of devices and tools without a cohesive strategy, with inadequate planning for the regular and effective use of ICTs emerging as a significant challenge (Clifton et al., 2020).

Another issue is the lack of a consolidated guidelines of practices or institutional knowledge in co-production. Public administrations often need to reconfigure the process from scratch each time, as there are no established best practices or precedents to rely on (Leonardi & Not, 2022). (Leonardi & Not, 2022) also highlighted the pressing need for guidance in managing the numerosity and heterogeneity of stakeholders involved, as well as the evolving structure of collaborative networks. These challenges are compounded by bureaucratic and cross-organizational barriers that further hinder co-production efforts (Leonardi & Not, 2022). Support is also required to reduce the costs of user engagement and improve its effectiveness. Key strategies include creating collaboration settings that mitigate perceived power asymmetries between public officers and users, enabling continuous monitoring and iterative evaluation of the co-production process, and ensuring its accountability and sustainability. Together, these measures aim to foster a more structured and inclusive approach to co-production, addressing both operational and relational challenges within public administration (Loeffler, 2018).

Traditional methods for facilitating workshops in the public administration, while widely used, often fall short in addressing these challenges. Conventional workshop techniques can be time-intensive and struggle to accommodate the input of large, heterogeneous groups effectively. Furthermore, these methods may not provide the agility needed to rapidly adapt to emerging insights or unexpected constraints during the design process. This inefficiency is particularly problematic in scenarios where timely decision-making is critical (Belkacem et al., 2024). Recently, the Service Design (SD) approach has been used in the context of public services digitization to tackle some of these challenges. SD enables organizations to view their services from the perspective of citizens and those involved in delivering an innovative service (Figueiredo, Venson, et al., 2024; Trischler & Westman Trischler, 2022). It is a user-centered, collaborative, and holistic approach designed to create services that balance the needs of citizens with those of the organization, delivering seamless and high-quality experiences to improve existing services and develop new ones (Koskela-Huotari et al., 2021; Leinonen & Roto, 2023). To address these challenges, this study explores the potential of integrating large language models (LLMs) into collaborative design workshops in the public administration. LLMs, with their advanced natural language processing capabilities, have shown promise in consolidating ideas, generating insights, and facilitating consensus in various domains. However, their application in public administration contexts remains under-explored. This gap presents an opportunity to investigate how LLMs can enhance the efficiency and effectiveness of collaborative processes in this domain. The reliance on traditional methods for organizing and facilitating workshops in the public administration often hinders innovation, primarily due to their limited scalability and inefficiency in addressing the diverse inputs of participants. To overcome this challenge, this study aims to explore the following research question:

RQ.1. How can a "Fast Track for Collaborative Solutions" supported by LLMs optimize design workshops in public service?

We hypothesize that the integration of LLMs into workshop methodologies can accelerate the consolidation of ideas and facilitate consensus among participants, ultimately enhancing the outcomes of collaborative processes. This paper presents the following contributions: i) The development of specific prompts tailored for

the consolidation of ideas and the facilitation of consensus in collaborative workshops; ii) A methodology based on the concept of a "Fast Track for Collaborative Solutions," designed to enable agile and effective workshops, particularly in large and diverse groups; iii) The proposed approach is validated through a case study conducted in a Brazilian public-sector state-owned enterprise. By addressing a real-world challenge in the public administration, this study aims to provide a practical framework for improving service design processes, leveraging the capabilities of LLMs to overcome traditional workshop limitations.

2. Background and Related Work

(Stephen P Osborne & Strokosch, 2016) defined co-production as active or passive participation of public service users in activities such as the design, management, delivery, or evaluation of public services. Co-production of public services signifies that services are not solely delivered by professionals and managers from public agencies but are collaboratively created and subsequently provided to users and citizens (Brandsen & Honingh, 2016; Figueiredo, Pedrosa, et al., 2024). Additionally, (Scupola & Mergel, 2022) defined co-production as a collaborative process where multiple stakeholders (e.g., citizens, public and private organizations) work together to create public value during the digital transformation of public services. This process encompasses three main phases: 1) Co-design: Collaborative planning to address stakeholders' needs; 2) Co-development: Implementation phase where stakeholders jointly build the proposed solutions; and 3) Co-delivery: The cooperative delivery or execution of the developed solutions. This approach represents a more inclusive method for developing and delivering public goods and services, involving citizens, users, and public organization members in the entire process of creation, execution, and long-term sustainability (Sorrentino et al., 2018). Co-production highlights the role of users as active agents rather than passive beneficiaries. This alternative approach often results in better long-term outcomes. The growing interest in promoting more participatory service creation arises from the traditional challenges in delivering public goods and services. Moreover, user participation has been further driven by socio-economic crises and the challenges governments face, including increasing demand for public services, rising user expectations, and, in many cases, constrained government budgets for service provision (Bovaird & Löffler, 2013).

The distribution of power and responsibility between public and private actors can vary significantly, leading to different models of co-production. Stakeholders and users can assist the government in improving public performance and more effectively meeting the desires and needs of citizens. Additionally, the government can help citizens enhance their daily productivity, decision-making, and well-being by offering efficient and easily accessible public services (Linders, 2011). However, achieving this requires diverse collaborative processes, which can be facilitated and influenced by the introduction of ICT in various ways (Capolupo et al., 2020). According to (Not et al., 2024), co-production encompasses a wide range of practices and activities, including the use of Service Design approaches, co-design techniques (involving internal stakeholders, partners, and suppliers), and co-creation practices (with end users). These approaches may involve participants at varying levels of engagement, be applied at different stages of the creation process, and depend on the type of service, the activities, and the strategies and responsibilities involved. (Figueiredo, Venson, et al., 2024) employed a Service Design (SD) approach to foster innovation in public services through co-design and co-creation activities focused on citizen-centered solutions. The methodology was structured into four iterative phases: exploration, creation, reflection, and implementation. The authors applied SD to various government projects and concluded that using SD to co-design and implement public service solutions enhanced stakeholder engagement and contributed to service innovation. Additionally, the iterative practices of SD were found to lead to solutions more aligned with user and organizational needs, enabling the delivery of greater value to society.

Despite the benefits of co-production, it requires greater attention to governance and accountability, and relies on high levels of trust among the various parties involved to achieve successful outcomes (Not et al., 2024). To effectively implement co-production processes and impact traditional public policies and services, organizational structures must be developed with low centralization, high connectivity among actors, and an ethos of mutuality and equality among the different participants, including the end users. Therefore, co-production demands active citizen participation and a more engaged role from public organizations in service delivery (Not et al., 2024). The adoption and use of Artificial Intelligence (AI) technologies by the public administration have grown significantly. Governments have deployed AI systems for predictive policing, cybersecurity defense, regulatory enforcement, adjudicating benefits and privileges, and as chatbots to address citizen inquiries and assist with filling, searching, and drafting documents (Dunleavy & Margetts, 2023; Henman, 2020). With the rapidly increasing adoption of Generative AI (Gen AI) tools by the general public, governments have

begun experimenting with these technologies and issuing guidelines on how they could be used by public administration. Gen AI, in particular, presents opportunities for government organizations not only to enhance their interactions with citizens but also to integrate and leverage their internal knowledge assets to improve the development and delivery of public services (Dunleavy & Margetts, 2023).

AI can be leveraged to enhance government operations and services by designing systems and programs capable of solving problems, learning, perceiving, understanding, reasoning, and becoming aware of their environment (Mellouli et al., 2024). AI relies on identifying and processing data, selecting training datasets, choosing algorithms, conducting training, and evaluating outcomes. These data are often high-volume and pertain to diverse situations with varying complexity and contexts (Mellouli et al., 2024). Among these contexts, public administration stands out as a domain where AI can be applied across various sectors, including health, education, sustainable development, transportation, and the like. AI has emerged as a critical strategic element in government agendas. As public administrations strive to harness the power of AI to better serve their citizens, new opportunities for innovation and efficiency in public administration are arising. AI holds the potential to transform public services and policies, offering innovative capabilities that empower civil servants with enhanced support for decision-making processes (Mellouli et al., 2024; B. W. Wirtz & Müller, 2019). AI acts as a catalyst for creating innovative services for citizens, governments, and public organizations. By adopting AI, governments can unlock substantial benefits, such as improved service quality, increased productivity, and cost-effective service excellence (J. Wirtz, 2020). In this context, this research presents the integration of LLM tools into the design of a workshop aimed at facilitating the rapid collection and synthesis of ideas, agile consensus-building, and the generation of instant feedback and documentation to prototype the improvement of a public service.

3. Research Design

The methodology for this study was designed to evaluate the effectiveness of a fast track for collaborative solutions approach supported by LLMs in a service design workshop for the public administration. This section details the planning, execution, and tools used in the workshop, structured to facilitate rapid idea consolidation, agile consensus-building, and the prototyping of solutions. The agenda incorporated the following stages: 1. Workshop Context; 2. Integration of LLMs; 3) Deliverables; and 4) Evaluation. **1. Workshop Context** The workshop aimed to tackle inefficiencies in the submission and analysis of public service plans, focusing on co-creating a digital solution to optimize these processes. Its primary objective was to redesign the service with an end-user perspective, improving both user satisfaction and organizational efficiency. A total of 28 participants from various roles and public organizations took part in the workshop. These participants included key stakeholders, such as public servants, managers, and technical staff, ensuring a diverse range of perspectives and expertise. The workshop spanned two days, with each session designed to progressively build toward a minimum viable product (MVP) for the proposed service. The Workshop Context stage encompassed the following:

1. Introduction and Contextualization: Participants were introduced to the objectives of the workshop and the processes under analysis. Ice-breaking activities were conducted to foster a collaborative atmosphere, followed by a shared understanding of the existing challenges. The workshop aimed to co-create a digital solution based on the service design approach for the Functions Plan process. #P3 presented the process flow: a) Proposal/Amendment/Reconsideration/Start Process: The process begins when the state-owned company submits a proposal, a plan amendment, or a request for reconsideration; b) Insert Proposal Type: There are four types of analyses: a new functions plan proposal, a functions plan amendment, a request for reconsideration, and proposals with conditions; c) Insert Documentation: The state-owned company must gather all necessary documentation to support the analysis; d) Forward Proposal to Supervisory Ministry: The proposal is sent to the Supervisory Ministry, which verifies compliance with the company's policy and business guidelines; e) Receive Proposal: The proposal is received by Secretariat of Coordination and Governance of State-Owned Enterprises (SEST) (Canedo et al., 2021) to begin the technical analysis; f) Review and Forward to SEST: The proposal is forwarded to SEST for a more detailed analysis; g) Verify Complete Documentation: The first phase of SEST's analysis involves checking the completeness of the documentation; h) Request Additional Information or Proceed: If any documents are missing, SEST requests additional information; i) Merit Analysis: Once the documentation is complete, SEST conducts a merit analysis of the proposal, which involves comparing data and identifying necessary adjustments; j) Review of the

Technical Report Draft: After the analysis, a draft technical report is prepared and reviewed; k) Consolidation/Signature of the Technical Report: The final technical report is consolidated and signed; l) Send Feedback to the Company: After being signed, the technical report is sent to the company along with an official communication; m) Deadline for Compliance with Conditions: If the analysis imposes conditions, the company is given a deadline to comply with them; and n) Conclude Process: The process can be concluded when the company fulfills the conditions. If the deadline passes without compliance, the process is closed without fulfillment.

2. Problem Identification and Consolidation: Participants worked in groups to brainstorm issues related to the current process, using tools such as post-its for idea collection. These ideas were then consolidated into a unified problem statement during a plenary discussion.
   The primary focus of the workshop was the analysis of function plans by SEST, addressing the need to adapt to frequent changes in the dynamic structures of the process workflow. The majority of the workload is related to new plans or modifications to existing ones, while job and salary processes occur less frequently but are more complex. One of the key challenges is ensuring the speed of the process, which involves three main stakeholders: the state-owned enterprise, the analyzing body (such as the speaker's coordination team), and the supervising Ministry.
   #P3 detailed the documentation stages and emphasized the importance of complying with legal standards. There are four types of processes: new function plan proposals, plan modifications, reconsideration requests, and proposals requiring conditional approval. SEST's initial task is to verify the completeness of the documentation. If any documents are missing, the state-owned enterprise is notified to provide the missing items. Technical analysis is then conducted, with the possibility of requesting additional information. At the end of the process, a technical report is prepared and reviewed internally by SEST before being sent to the enterprise. This report may include conditions that the enterprise must fulfill within a stipulated timeframe.
3. Solution Exploration: Through the "Is-Is Not / Does-Does Not" framework, participants explored the characteristics and functionalities of the ideal solution. Group discussions were followed by collective consolidation of the insights.
4. User-Centered Redesign: Using design thinking principles (de Sá Araújo et al., 2019), participants defined personas (Canedo et al., 2023) representing typical users of the service, such as "Luci," a 45-year-old HR manager. Then, they mapped user journeys, identifying pain points and opportunities for improvement.
5. Journey-Based Functionality Design: Functionalities were proposed and aligned with specific stages of the user journey. This phase emphasized prioritization and feasibility, ensuring alignment with user needs and organizational goals.
6. Prototype Development: Low-fidelity prototyping methods, such as storyboards and wireframes, were employed to visualize the proposed solution. Groups collaborated to create initial designs, which were then unified into a final prototype.

2. Integration of LLMs. LLMs were used throughout the workshop to support: 1. Idea Consolidation: Synthesizing inputs from participants to create cohesive problem statements and solutions. At this stage, participants simultaneously shared their contributions through a platform integrated with the LLM. An example of the prompt used: "Group and synthesize ideas on [topic X] submitted by multiple participants, identifying key patterns and main themes." Outcome: A consolidated overview of the primary suggestions; 2. Consensus Facilitation: Summarizing group discussions to streamline decision-making processes. The LLM organized the grouped ideas into clear options for voting or discussion. An example of the prompt used: "Generate three options based on the main ideas, considering different perspectives, to facilitate group decision-making." Outcome: Concrete and structured proposals for decision-making; and 3. Feedback and Documentation: Generating instant summaries of each session, ensuring comprehensive records of insights and decisions. Real-time automated summaries of the discussions and decisions were generated. An example of the prompt used: "Create a detailed summary of the decisions made and the corresponding justifications provided by stakeholders during this session." Outcome: Comprehensive reports of the discussions and decisions finalized at the end of the workshop.

3. Deliverables. The workshop concluded with the development of an MVP (and its prototypes), outlined by a value proposition, user personas, key functionalities, and expected outcomes. This provided a tangible output for stakeholders to further refine and implement. **4. Evaluation**. The methodology was evaluated based on participant feedback, the quality of the MVP, and the efficiency of the workshop process. Metrics included the time required for each stage, the perceived effectiveness of LLM integration, and the alignment of the final prototype with user and organizational needs.

The service design workshop conducted with Startup EstataisGov provided significant insights and actionable outcomes aimed at enhancing the management and submission of public service plans. Held over two days, the workshop facilitated collaborative discussions among key stakeholders, including representatives from public enterprises, supervisory ministries, and SEST. The following section detail the main results achieved, categorized into problem identification, user journey development, functional prototyping, and recommendations for technological and procedural improvements.

4. Results

The central focus of the workshop was to systematically identify and categorize the challenges in the current system for public service plan management. Participants used tools such as post-its and facilitated group discussions to map the primary pain points, which were later consolidated into categories. During **the introduction and contextualization phase**, participants were divided into small groups to gain insights into the problem. After their discussions, they recorded their ideas about the issue on post-it notes. The participants generated 48 insights related to the problem (Function Plan), as summarized in Table 1. During the problem identification and consolidation phase, these insights were processed using a Large Language Model (LLM). The text submitted to the LLM was: *"With a specialized perspective on Service Design, analyze the texts presented in the post-its (1) and organize them into commonly practiced categories. If you cannot identify a word with more than 90% accuracy, ask me".*

In response, the LLM reported successfully analyzing the content and organizing it into categories. Some words or phrases were flagged as open for further clarification regarding their categorization. Overall, the accuracy level was high, as the categories identified by the LLM aligned closely with the responses provided by stakeholders. In addition to categorizing the insights, the LLM offered context for its decisions and highlighted the significance of each problem raised. A subsequent prompt was used to consolidate the information into seven primary problem categories. This allowed the data to be reduced without compromising quality, enabling quicker comparison with the participants' feedback. With the LLM's assistance and validation by participants, the following problem categories were established: 1. Function Plans of Companies; 2. Improvement of SEST Services;3. Processes and Analyses; 4. Challenges and Limitations; 5. Innovations and Tools; 6. Business Needs and Sustainability; and 7. Agility and Optimization. Moreover, leveraging the LLM's suggestions and further validation from participants, the core problem was defined as follows: *"The process of submitting and analyzing the function plan faces challenges related to the lack of agility, standardization, adequate information, and functionalities."*

Tab. 1 – Insights for the Functions Plan

ID	Insight
1	High demand volume: The process faces a large volume of requests.
2	Complex analysis: High quantity of documents requiring thorough review.
3	Merit analysis: Evaluation of the request's intrinsic merit.
4	Document analysis: Reviewing and validating submitted documents.
5	Order-based merit review: SEST technical merit analysis is conducted in the order of submission.
6	Document verification and checklist: Documents submitted by the supervising ministry are analyzed and checked.
7	Service automation: Automate the functions plan workflow to enhance user experiences for SEST, ministries, and state-owned enterprises.
8	Communication with supervisory authorities: Ensure effective communication within and outside the system.
9	Comparative analysis: Compare approved and proposed functions plans within the same state-owned enterprise and across others.
10	Initial submission: The process begins at the state-owned enterprise, which provides documents for analysis.

Continued on the next page

ID	Insight
11	Process agility: Accelerate the overall process to improve efficiency.
12	Guidelines and business context: Establish clear directives and align with organizational goals.
13	Technical note drafting: Prepare a technical note for review by coordinators and directors before approval by the secretariat.
14	Non-implementation of functions plan: Address instances where the enterprise fails to implement the plan.
15	Limited team: Small team available to handle the analyses.
16	Report generation: Extract reports of approved functions plans.
17	Document iteration: Revisions and resubmissions consume significant time.
18	System forms: Leverage system-based forms for data collection.
19	Procedural standardization: Establish a systematic approach to the process.
20	Legal basis review: Ensure the request adheres to legal requirements.
21	Largest requests: Prioritize significant or complex cases appropriately.
22	Improved SEST services: Enhance SEST's functions plan services for state-owned enterprises.
23	Proposal withdrawal or substitution: Determine whether ministries or enterprises can withdraw or replace proposals.
24	Modernization and simplification: Update and simplify regulatory frameworks.
25	Business needs: Address specific organizational requirements.
26	New functions plan proposals: Process new plan submissions effectively.
27	Final deliverable: Issue the technical note or official document to the state-owned enterprise.
28	Merit evaluation criteria: Define what aspects are considered in the merit analysis.
29	Reconsideration requests: Allow enterprises to submit reconsideration requests with SEST's response.
30	Functions plan scope: Evaluate and refine the functions plans of state-owned enterprises.
31	Process tracking: Enable access to the status of SEST processes.
32	Limited technical resources: Few technicians available to conduct analyses.
33	SEST role justification: Clarify why enterprises must undergo SEST's review process.
34	Information quality: Ensure accurate and comprehensive information is submitted.
35	Conditional responses: Provide responses with conditions, setting deadlines for the enterprise's reply to SEST.
36	Scope and approach review: Revise the scope and operational mode to align with goals for state-owned enterprises.
37	Alignment reviews: Use alignment sessions to complement information and enhance understanding.
38	Email communication challenges: Question the necessity of involving the supervising ministry when email suffices for enterprise communication.
39	Streamlining the process: Explore ways to make the process faster and more efficient.
40	Fast-track options: Consider "FAST-TRACK" workflows for groups of enterprises with similar characteristics.
41	Request complexity levels: Address the challenge of diverse complexity levels competing in the same workflow.
42	Risk supervision: Incorporate risk oversight mechanisms (e.g., Previc).
43	Financial sustainability: Ensure that plans are financially sustainable.
44	Participation scope: Clarify if all enterprises are required to submit these requests.
45	Transparency: Improve transparency by providing access to SEST's decisions and publishing timelines in official directives.
46	AI utilization: Implement AI tools to support analyses and decision-making.

Continued on the next page

ID	Insight
47	Excel and historical data: Use Excel spreadsheets to compare current requests with past proposals.
48	Enterprise versatility: Adapt to the unique characteristics of different enterprises.

In **the solution exploration phase**, after group discussions, participants identified the following critical points/contradictions: a) Compliance vs. User Guidance; b) Intelligent Automation vs. Analyst Replacement; c) Access Control vs. Transparency; d) Detailed Reporting vs. Merit Analysis; e) Process Standardization vs. Necessary Customization; and f) AI Usage for Analysis vs. Norm Review. Table 2 presents the results from applying the "Does" and "Does Not Do" technique. We asked the LLM to create a persona and a user journey representing an average Brazilian individual who uses the services presented during the workshop, focusing on the following information: Name, Age, Questions, Tasks, Feelings, Motivations, and Objectives. The LLM generated a persona that could potentially be used in the development of the workshop. However, the information was not directly presented to the group of participants. Instead, it was compared with the personas created by the participants themselves. During this comparison, some differences were identified, particularly concerning the "pain points" highlighted by more experienced stakeholders. Nevertheless, the prompt proved effective and has potential for improvements in future applications. To enhance the process, future iterations of the prompt should focus on prioritizing the "pain points" and "critical demands" raised by the participants, while maintaining the necessary randomness and divergence for problem exploration.

Tab. 2 – Solution Exploration with the Does and Does Not Do Technique

Does	Description
Receives and Categorizes Requests	Receives and categorizes user requests and processes.
Generates Reports	Provides detailed reports on the status and progress of requests.
Compliance	Assists in meeting norms and regulations.
User Guidance	Provides automated instructions and help to facilitate usage.
Uses AI for Analysis	Analyzes data using artificial intelligence, improving accuracy and efficiency.
Access Control and Security	Manages who can access specific information and functionalities.
Generates Indicators	Provides insights and performance metrics for users and managers.
Standardizes Requests	Defines a standardized workflow for handling different types of requests.
Intelligent Automation for UX	Automates processes to ensure a better user experience.
Communication and Integration	Serves as a bridge to connect information between systems and teams.
Provides Templates	Facilitates the creation and management of standardized documents.
Does Not Do	**Description**
Norms Review	Does not review or modify legal or regulatory norms.
Merit Analysis	Does not decide on the merit of issues; it only organizes the data.
Analyst Replacement	Does not replace human expertise or analysts' decisions.
Replicate Processes	Does not replicate processes without adaptations; it organizes but requires customization.
Generate Work	Does not create work automatically; it only manages and optimizes existing processes.

In **the User-Centered Redesign phase**, participants contributed to creating the persona profile. During the creation process, the workshop moderator facilitated discussions within each group, addressing their questions and providing any necessary information. Each group presented their persona's profile, including behavior and habits, pain points and frustrations, as well as needs and goals. Figure 1 illustrates the persona proposed by Group 1. We kept the image in Portuguese to preserve the authenticity and reliability of the content created during the workshop. The final persona profile was developed after extensive discussions and

comparisons of the proposals presented by all groups. The consolidated persona profile is detailed in Table 3. The first day of the workshop concluded with the definition of the persona's profile and behavior.

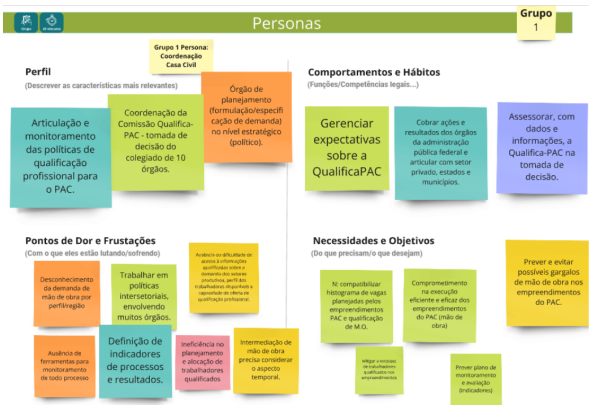


Fig. 1 – Persona Construction

Tab. 3 – Persona Profile/Behavior

Profile	Behaviors	Pain Points and Frustrations	Needs and Goals
SEST Analyst	Adds requested information, Analyzes personal files, Maintains financial health, Makes automated decisions.	Lack of understanding of requests, Incorrect demands, Distrust, Work overload.	More data and inputs, Clearer requests, Simplified communication with the company.
State-Owned Enterprise Career Analyst	Enjoys talking and discussing ideas, Promotes solutions, Open to change, Motivated by challenges.	Issues with expenses, Lack of subsidies, Conflicts of interest, Union pressures.	Autonomy in HR management, Quick information, Agility in proposal creation.
HR Manager (People Management)	Liaises with top management and SEST, Negotiates with unions.	Lack of understanding of SEST's demands, Slow analysis process.	Clear guidance, Agility, Fewer barriers in the process.
HR Competence Unit	Sense of urgency.	Delayed responses, Lack of guidance, Communication difficulties.	Faster responses, Greater autonomy, Easy-to-use and guiding system.
Public Enterprise	10,000 employees, Treasury-dependent, Aviation sector: Renewable energy production, Medium-sized company, Activation zone, Average budget.	Promotes renewable energy projects across the country, Oversees project implementation and execution, Manages federal funds allocated for its activities, Supports sustainable development in Brazil.	Lack of autonomy for independent work, Difficulty obtaining market benchmarks, Challenges filling specific roles, Incompatibility between public administration response times and market dynamics, Lack of understanding of technological evolution by SEST.

The second day of the workshop began with the definition of user journeys (**Phase: Journey-Based Functionality Design**. A total of four journeys were created: 1) Management of Job Plans; 2) Request for a New Plan; 3) Login and Plan Management via Gov.br; and 4) Process of Transfers and Plan Execution. This generic user journey integrates the main steps outlined in the four specific journeys, organizing the flow cohesively: Access and Login; Classification and Completion of the Request; Submission and Validation; Monitoring and Alerts; Completion and Notification; and Process Finalization with Accountability. It adheres to the primary

Tab. 4 – Generic User Journey

Step	Description
1. Access the System	The user accesses the system based on their profile (e.g., Gov.br system or the company's corporate system). They log in and select the type of request to be made (e.g., job plan, workload, remunerations, etc.).
2. Define the Request	The user classifies the request: it can be a new plan, an amendment to an existing plan, a reconsideration of a decision, or compliance with specific conditions. The system provides the option to consult a checklist or tailored instructions for each type of request.
3. Fill Out and Submit the Request	The user completes a smart template provided by the system, including clauses related to the request, such as: i) Remuneration value; ii) Specific assignments (e.g., FG, workloads); iii) Access requirements for the role; iv) Workload estimation; and v) General/thematic justification for the request. The system allows the inclusion of attachments and document validation before submission. After completing the template, the user submits the request, generating a protocol.
4. Validate and Forward the Request	The system performs automatic document validation. The request goes through internal reviews (e.g., legal, councils, IT, etc., as necessary). The user can forward the request to the supervising ministry or another competent authority, including a technical opinion, if applicable.
5. Monitor the Request	The user can check the real-time status of the request, accessing all company submissions via a dashboard. The system generates automatic alerts about deadlines, updates, or the need for additional adjustments. The user has access to the history of completed analyses and can track pending and new requests.
6. Conclude the Request and Notify the Supervising Ministry	The request is automatically finalized in the system, and the final document is made available to the user. The system automatically notifies the supervising ministry or competent authority of the decision regarding the request. If applicable, payment guides (e.g., GRU) or other types of documentation are generated.
7. Close the Process	The process is concluded with the implementation of the plan or the accountability procedure. The system records all stages, ensuring transparency and traceability. Control bodies can access the data to monitor and oversee the execution of planned actions.

stages, such as request classification, template completion, and document submission, enabling the execution of each type of plan or function within the system.

The Prototype Development phase was conducted using storyboards, which allow illustrating user interaction with the service. Each group created their wireframes using flip-charts, post-its and colored pens. Afterwards, all groups presented their results and collaborated to define the final unified version of the prototype. Afterwards, the solution screens were designed by design professionals, using the Figma tool. In **the Deliverables phase**, the MVP was developed, including the following elements: 1. Value Proposition: A concise description of the value the MVP will provide to users, focusing on the primary pain point or need it will address; 2. Personas: Identifies and describes the main user profiles of the MVP, including relevant characteristics, needs, and behaviors; 3. Journeys: Outlines the key steps a user will take when interacting with the MVP, focusing on the most critical interactions to deliver value; 4. Features: Lists the essential features the MVP must have, prioritizing only what is necessary to validate the main hypothesis; 5. Expected Outcomes (Prototypes): Describes the results expected from the MVP, including both business and user outcomes; 6. Metrics: Defines the key metrics that will be used to measure the success of the MVP, ensuring they align with the expected outcomes; 7. Cost and Timeline: Estimates the total cost to develop and launch the MVP, creating a high-level timeline with key stages and deadlines; and 8 Delivery Date: Sets a clear delivery date for the MVP, helping to maintain focus and prevent scope creep.

These components serve as the foundation for developing the MVP, ensuring a focused, result-driven approach that allows for quick adjustments as needed. In **the Evaluation phase**, the methodology was assessed through participant feedback, the quality of the MVP, and the overall efficiency of the workshop process. The evaluation

focused on metrics such as the time spent on each stage, the effectiveness of integrating LLMs, and how well the final prototype aligned with user and organizational needs. This feedback provided valuable insights for refining the methodology and improving future workshops.

The results of the Service Design workshop, Startup EstataisGov, provided an overview of the management and submission process for job plans in state-owned enterprises. It highlighted the main process stages and the challenges faced by public servants in these organizations. The proposed solution was developed through participant insights, presentations, and prototyping activities. The narrative focused on enhancing efficiency, transparency, and innovation in addressing the activities and challenges of the job plan process. Over the two-day workshop, several critical areas for improvement were identified, particularly the lack of standardization and speed in handling requests, as well as the need for more effective communication between state-owned enterprises and SEST. Workflow analysis emphasized how automating certain process steps could reduce response times while ensuring a better user experience. The use of generative AI across all stages helped improve the quality of analyses and discussions, ensuring responses were faster and more accurate. Thus, the outcomes achieved during the workshop were highly positive, providing a clear roadmap of current issues and challenges, as well as practical and innovative solutions. The focus on digital solutions, standardization, user experience, and the adoption of new technologies aims to create a significant positive impact on the efficiency and transparency of the job plan management process in state-owned enterprises. These results paved the way for a more agile, integrated, and effective system, capable of meeting the demands of state-owned enterprises and supervising ministries while ensuring compliance with current regulations and accelerating processes.

RQ.1 Summary: A fast track for collaborative solutions supported by Large Language Models (LLMs) can optimize design workshops in public service by automating repetitive tasks, such as data categorization and summarization, enhancing real-time collaboration, and providing instant access to relevant information. LLMs can facilitate idea generation and decision-making by analyzing vast amounts of textual data and identifying key patterns. This reduces time spent on manual processing, allowing participants to focus on high-value activities. Moreover, the integration of LLMs can improve communication and alignment between stakeholders by ensuring consistency and clarity in the shared content.

5. Discussions

This section highlights several critical challenges identified within public service workflows, including process inefficiencies, high demand and limited resources, inadequate communication, and lack of transparency. These challenges are not exclusive to this study but are consistent with those reported in other research on public sector operations. **Process Inefficiencies**: The workflow for analyzing public service plans is hindered by bureaucratic delays, lack of standardized templates, and high variability in submission quality. Participants highlighted the prolonged timelines required for document verification, merit analysis, and internal reviews. Other studies have similarly highlighted inefficiencies in governmental decision-making processes, often attributed to bureaucratic complexities (Eom & Lee, 2022; Harfianto et al., 2022).

High Demand and Limited Resources: SEST faces an overwhelming volume of requests with a limited number of technical analysts. This imbalance often results in delays and bottlenecks, especially for complex submissions. (Daßler et al., 2024) conducted 17 expert interviews to investigate the co-production process, the measures utilized, and the challenges faced. Four key challenges were identified: recruiting citizens, managing resources, navigating political hurdles, and fostering cooperation between administration and citizens. The study also highlighted that financial constraints are a common issue in collaborative projects involving citizens, with personnel shortages presenting a significant challenge. The authors emphasize the importance of adequate budgets and professional facilitation to ensure the sustainability of projects and their efficient implementation by public agencies. **Inadequate Communication**: Communication gaps between public enterprises, supervisory ministries, and SEST were noted as a major issue. Misaligned expectations and unclear guidelines exacerbate these challenges. This finding aligns with other studies in the literature (**DBLP:journals/jucs/MarsicanoCPRF24**; Androniceanu, 2021; Canedo et al., 2021; Criado & Villodre, 2022; Daßler et al., 2024; Figueiredo, Venson, et al., 2024; Venson et al., 2024), which also highlight challenges stemming from communication difficulties, particularly in maintaining consistent citizen engagement, managing diverse stakeholder interests, and aligning differing schedules.

Lack of Transparency: Stakeholders identified the need for greater visibility into the status of submissions and decisions, emphasizing that a transparent process would build trust and accountability. (Androniceanu, 2021) investigated the level of transparency in Romanian government ministries by analyzing public data and information available on the websites of 18 ministries and conducting online surveys with 45 employees from the ministries' Information and Documentation Departments. The authors concluded that administrative transparency remains a challenge for Romanian government ministries. They emphasized that access to information builds citizen trust in public agencies, enables citizens to understand government decisions, and increases their confidence and satisfaction in using public services offered by the government. This finding reinforces the results of our research. Despite identifying some challenges during the public service design workshops supported by LLMs, several key advantages were observed: **1) Time Reduction**: The implementation of the Fast Track reduced the duration of workshops by at least 30%; **2) Improved Collaboration**: Enhanced participant engagement driven by the agility and clarity of the process; and **3) More Informed Decisions**: The effective consolidation of ideas resulted in stronger and more robust proposals. The facilitation of the workshop enabled greater efficiency in handling large volumes of information and reduced fatigue during extended collaborative processes, given that the processes analyzed by SEST are complex and require the involvement of various stakeholders. However, the reliance on certain tools and the need for adequate infrastructure to conduct the workshop, as well as challenges in participants' initial adaptation to the tools used, may impose limitations on the use of the fast track for collaborative solutions. Despite these limitations, the proposed methodology for conducting workshops has the potential to transform the way workshops with Brazilian federal public administration agencies are conducted in the public sector, fostering agile and collaborative decision-making among all participants. Furthermore, the fast track can be adapted to any public service in different countries.

6. Threats to Validity

In this study, several potential threats to validity have been identified, which may influence the reliability and generalizability of the results. Following the framework of Wohlin et al. (2012), these threats can be categorized into internal, construct, external, and conclusion validity. **Internal validity** refers to the extent to which the study can establish causal relationships between the interventions (for instance, the use of AI and automation) and the outcomes (for example, efficiency improvements, decision quality). A potential threat to internal validity could be the presence of uncontrolled variables, such as external organizational changes or variations in the level of experience of the participants (for instance, technicians and managers). Additionally, biases in the selection of participants or sample sizes could influence the observed outcomes. Efforts were made to mitigate this threat by involving a diverse set of participants from various roles within the public sector companies, ensuring a broader understanding of the system's impact.

Construct validity concerns whether the measures used in the study truly represent the concepts they are intended to measure. In this study, the main constructs include process efficiency, decision quality, and user satisfaction. A potential threat is the use of subjective assessments (for instance, user feedback) to evaluate these constructs, as different participants may interpret or report their experiences differently. To mitigate this, multiple sources of data were used, including surveys, interviews, and system logs, which helped triangulate the findings and reduce the bias associated with any single source. **External validity** concerns the generalizability of the findings beyond the specific context of the study. One potential threat is that the results may not be applicable to all public sector agencies or to other governmental systems that do not use similar technologies. The study was conducted in a specific setting (state-owned companies and focused on a particular process: Function Plan). As such, caution must be exercised when generalizing the findings to other contexts. Future studies in different sectors or with larger sample sizes could help improve external validity and expand the generalizability of the results. **Conclusion validity** concerns the degree to which the conclusions drawn from the study are accurate and reliable. A possible threat to conclusion validity is the improper use of analysis, which could lead to false positive or negative results. To address this, appropriate methods were applied to analyze the data, ensuring that the results were statistically significant and reflective of the true impact of AI and automation. However, limitations in the sample size and study duration could still affect the robustness of the conclusions. Future research should focus on expanding the scope of this study, potentially involving a larger and more diverse set of public sector organizations, as well as incorporating longitudinal data to assess the long-term effects of AI and automation on process efficiency, decision quality, and user satisfaction. Additionally, further studies could explore the impact of different AI models and automation technologies on the outcomes of the process, ensuring the reliability and robustness of the findings across different contexts.

7. Conclusions

The workshop outcomes provided valuable insights into the existing challenges and opportunities for improving the management of job plans in state-owned enterprises and the SEST. The comprehensive mapping of problems revealed key issues such as delays in the analysis process, lack of standardization in documentation, and complex workflows, all of which were hindering the efficiency of the system. These findings formed the foundation for proposing practical solutions to streamline and optimize the entire process. The development of user journeys provided a deeper understanding of the different user interactions with the system. By mapping out the steps for various types of demands—such as new plans, modifications, reconsiderations, and compliance requests—participants were able to identify critical touchpoints that require optimization for improved user experience and efficiency.

Prototyping and refining system functionalities were crucial to visualizing the potential improvements, such as the use of intelligent templates, workflow automation, and automated report generation. These prototypes not only allowed for the testing and validation of ideas but also laid out a clearer path for future system implementation. The consensus around integrating advanced technologies, particularly automation and AI, was a pivotal outcome. Participants identified that automating document analysis and demand tracking could significantly reduce the time required for merit evaluations, enabling SEST technicians to focus on more complex tasks. This would also improve the accuracy and consistency of the analysis process, minimizing errors and rework. Standardization emerged as a central theme, aiming to unify demand management with clear workflows and standardized models. This approach is intended to simplify tasks for both technical staff and managers, while enhancing transparency throughout the process. It would also create a more predictable workflow, allowing for better expectations management for both state-owned enterprises and supervising ministries. Furthermore, the focus on improving user experience (UX) underscored the importance of creating an intuitive, accessible, and adaptable system that caters to the diverse needs of different user profiles. This not only involves system interface design but also emphasizes real-time communication and information sharing between all parties involved.

Several innovative ideas and simplifications were proposed, including the creation of a FAST-TRACK for less complex demands and the modernization of the regulations governing job plan processes. Simplifying workflows and granting greater autonomy to state-owned enterprises were seen as necessary measures to address the growing volume of demands. These innovations align with the need to ensure the sustainability of the process and its compliance with government policies and business directives. In conclusion, the workshop successfully provided a roadmap for creating a more efficient, transparent, and user-centered system for managing job plans in state-owned enterprises. The integration of technology, standardization, and user-focused solutions offers a promising path toward improving process efficiency and ensuring compliance with regulatory requirements. Considering the fundamental role of artificial intelligence and automation in improving the organizational efficiency of public sector companies, a future study should focus on evaluating the real impact of generative AI. This should not only include the operational efficiency of processes but also assess the impact on the quality of decisions made by technicians and managers in state-owned companies. Furthermore, it is important to evaluate the accuracy of automated analyses and how this affects the satisfaction and trust of users in government systems.

Acknowledgments

This research is part of a cooperation agreement between the Information Technology Research and Application Center (ITRAC) at the University of Brasilia (UnB) and the Ministry of Management and Innovation in Public Services (MGI), Secretariat for Digital Government (SGD), Directorate for Digital Transformation Dissemination.

References

Androniceanu, A. (2021). Transparency in public administration as a challenge for a good democratic governance. *Revista» Administratie si Management Public «(RAMP)*, *36*, 149–164.

Belkacem, I., Ciorna, V., Petry, F., & Ghoniem, M. (2024). Wow - A system for self-service collaborative design workshops. *CoRR*, *abs/2408.09926*, 1–22. DOI: https://doi.org/10.48550/ARXIV.2408.09926.

Bovaird, T., & Löffler, E. (2013). From engagement to co-production: How users and communities contribute to public services. In *New public governance, the third sector, and co-production* (pp. 35–60). Routledge.

Brandsen, T., & Honingh, M. (2016). Distinguishing different types of coproduction: A conceptual analysis based on the classical definitions. *Public administration review*, *76*(3), 427–435.

Canedo, E. D., Calazans, A. T. S., Silva, G. R. S., Costa, P. H. T., & Masson, E. T. S. (2023). Use of journey maps and personas in software requirements elicitation. *Int. J. Softw. Eng. Knowl. Eng.*, *33*(3), 313–342. DOI: https://doi.org/10.1142/S0218194023300014.

Canedo, E. D., de Alcântara, P. T. R., de Souza, L. C., Amaral, L. H. V., de Sousa Júnior, R. T., & Nze, G. D. A. (2021). People management: Modelling the work of an ICT team in a coordination and governance organisation of state-owned enterprises. *Int. J. Bus. Process. Integr. Manag.*, *10*(3/4), 213–229. DOI: https://doi.org/10.1504/IJBPIM.2021.124020.

Capolupo, N., Piscopo, G., & Annarumma, C. (2020). Value co-creation andco-production in the interaction between citizens and public administration. *Kybernetes*, *49*(2), 313–331. DOI: https://doi.org/10.1108/K-07-2018-0383.

Clifton, J., Fuentes, D. D., & García, G. L. (2020). Ict-enabled co-production of public services: Barriers and enablers. A systematic review. *Inf. Polity*, *25*(1), 25–48. DOI: https://doi.org/10.3233/IP-190122.

Criado, J. I., & Villodre, J. (2022). Revisiting social media institutionalization in government. an empirical analysis of barriers. *Gov. Inf. Q.*, *39*(2), 101643. DOI: https://doi.org/10.1016/J.GIQ.2021.101643.

Daßler, L., Hein, A., & Krcmar, H. (2024). Innovating public services: Drivers and challenges of innovation labs in the co-production of e-government services. In H. Liao, D. Dueñas-Cid, M. A. Macadar, & F. Bernardini (Eds.), *Proceedings of the 25th annual international conference on digital government research, DGO 2024, taipei, taiwan, june 11-14, 2024* (pp. 711–720). ACM. DOI: https://doi.org/10.1145/3657054.3657138.

de Sá Araújo, C. M. M., Santos, I. M., Canedo, E. D., & de Araújo, A. P. F. (2019). Design thinking versus design sprint: A comparative study. In A. Marcus & W. Wang (Eds.), *Design, user experience, and usability. design philosophy and theory - 8th international conference, DUXU 2019, held as part of the 21st HCI international conference, HCII 2019, orlando, fl, usa, july 26-31, 2019, proceedings, part I* (pp. 291–306, Vol. 11583). Springer. DOI: https://doi.org/10.1007/978-3-030-23570-3_22.

Dunleavy, P., & Margetts, H. (2023). Data science, artificial intelligence and the third wave of digital era governance. *Public Policy and Administration*, *23*, 09520767231198737. DOI: https://doi.org/https://doi.org/10.1177/09520767231198737.

Eom, S., & Lee, J. (2022). Digital government transformation in turbulent times: Responses, challenges, and future direction. *Gov. Inf. Q.*, *39*(2), 101690. DOI: https://doi.org/10.1016/J.GIQ.2022.101690.

Figueiredo, R., Gardenghi, J. L. C., de S. Santos, L., Furtado, R. A., Barbosa, R. F. P., Boaventura, L. U., Modesto, A. S. C., & Martins, L. B. (2022). The design of a public service cost model tool to evaluate digital transformation in brazilian government. In J. Filipe, M. Smialek, A. Brodsky, & S. Hammoudi (Eds.), *Proceedings of the 24th international conference on enterprise information systems, ICEIS 2022, online streaming, april 25-27, 2022, volume 2* (pp. 442–452). SCITEPRESS. DOI: https://doi.org/10.5220/0011108900003179.

Figueiredo, R., Pedrosa, G., Gardenghi, J., Venson, E., Judice, M., Judice, A., Costa, F., Silva, W., & Marsicano, G. (2024). Co-design and co-creation in digital public services: A service design approach. *Anais do XII Workshop de Computação Aplicada em Governo Eletrônico*, 87–98. DOI: https://doi.org/10.5753/wcge.2024.2505.

Figueiredo, R., Venson, E., Pedrosa, G. V., Gardenghi, J. L. C., Judice, M., Judice, A., & Costa, F. (2024). Stakeholder interaction in the redesign and creation of digital public services: A service design approach. In F. H. M. Oliveira, S. K. da Silva de Lemos Santos, I. T. Monteiro, & M. L. B. Villela (Eds.), *Proceedings of the XXIII brazilian symposium on human factors in computing systems, IHC 2024, brasília, brazil, october 7-11, 2024* (p. 60). ACM. DOI: https://doi.org/10.1145/3702038.3702107.

Harfianto, H. D., Raharjo, T., Hardian, B., & Wahbi, A. (2022). Agile transformation challenges and solutions in bureaucratic government: A systematic literature review. *ICCMB 2022: 5th International Conference on Computers in Management and Business, Singapore, January 21 - 23, 2022*, 12–19. DOI: https://doi.org/10.1145/3512676.3512679.

Henman, P. (2020). Improving public services using artificial intelligence: Possibilities, pitfalls, governance. *Asia Pacific Journal of Public Administration*, *42*(4), 209–221. DOI: https://doi.org/10.1080/23276665.2020.1816188.

Koskela-Huotari, K., Patrício, L., Zhang, J., Karpen, I. O., Sangiorgi, D., Anderson, L., & Bogicevic, V. (2021). Service system transformation through service design: Linking analytical dimensions and service design

approaches. *Journal of Business Research*, *136*, 343–355. DOI: https://doi.org/10.1016/j.jbusres.2021.07.034.

Leinonen, A., & Roto, V. (2023). Service Design Handover to user experience design – a systematic literature review. *Information and Software Technology*, *154*, 107087. DOI: https://doi.org/10.1016/j.infsof.2022.107087.

Leonardi, C., & Not, E. (2022). Challenges and opportunities for ICT in co-production: A case study of public service innovation in an italian municipality. In L. Hagen, M. Solvak, & S. Hwang (Eds.), *Dg.o 2022: The 23rd annual international conference on digital government research, virtual event, republic of korea, june 15 - 17, 2022* (pp. 322–327). ACM. DOI: https://doi.org/10.1145/3543434.3543462.

Leonardi, C., Not, E., Gerosa, M., & Lotti, R. (2023). A case study of cross-organizational co-design with public bodies: Opportunities for a collaborative platform. In A. Wolff, D. Siemon, A. D. Liddo, & G. Concilio (Eds.), *The 11th international conference on communities and technologies (c&t), lahti, finland, 29 may 2023 - 2 june 2023* (pp. 6–11). ACM. DOI: https://doi.org/10.1145/3593743.3593747.

Linders, D. (2011). We-government: An anatomy of citizen coproduction in the information age. In *Proceedings of the 12th annual international conference on digital government research, DG.O 2011, college park, md, usa, june 12 - 15, 2011* (pp. 167–176). DOI: https://doi.org/10.1145/2037556.2037581.

Loeffler, E. (2018). Providing public safety and public order through co-production. In *Co-production and co-creation* (pp. 211–222). Routledge. DOI: https://doi.org/https://doi.org/10.4324/9781315204956-33.

Mellouli, S., Janssen, M., & Ojo, A. (2024). Introduction to the issue on artificial intelligence in the public sector: Risks and benefits of AI for governments. *Digit. Gov. Res. Pract.*, *5*(1), 1:1–1:6. DOI: https://doi.org/10.1145/3636550.

Not, E., Leonardi, C., López-de-Ipiña, D., Silva-Palacios, D., Sánchez-Corcuera, R., Kazhamiakin, R., & Gerosa, M. (2024). Designing a digital environment to support the co-production of public services: Balancing multiple requirements and governance concepts. *Digit. Gov. Res. Pract.*, *5*(3), 24:1–24:30. DOI: https://doi.org/10.1145/3664612.

Osborne, S. P., Nasi, G., & Powell, M. (2021). Beyond co-production: Value creation and public services. *Public administration*, *99*(4), 641–657.

Pajula, L., Hänninen, R., Korpela, V., & Taipale, S. (2024). Exploring stakeholder perspectives on user involvement in designing digital public services for older adults. *First Monday*, *29*(9), 1–17. DOI: https://doi.org/10.5210/FM.V29I9.13330.

Pedrosa, G. V., Judice, A., Judice, M., Araújo, L., Fleury, F., & Figueiredo, R. (2022). Applying user-centered design on digital transformation of public services: A case study in brazil. In *Dg.o 2022: The 23rd annual international conference on digital government research, republic of korea, june 15 - 17, 2022* (pp. 372–379). ACM. DOI: https://doi.org/10.1145/3543434.3543493.

Scupola, A., & Mergel, I. (2022). Co-production in digital transformation of public administration and public value creation: The case of denmark. *Government Information Quarterly*, *39*(1), 101650. DOI: https://doi.org/https://doi.org/10.1016/j.giq.2021.101650.

Sicilia, M., Guarini, E., Sancino, A., Andreani, M., & Ruffini, R. (2016). Public services management and co-production in multi-level governance settings. *International Review of Administrative Sciences*, *82*(1), 8–27.

Sorrentino, M., Sicilia, M., & Howlett, M. (2018). Understanding co-production as a new public governance tool.

Stephen P Osborne, Z. R., & Strokosch, K. (2016). Co-production and the co-creation of value in public services: A suitable case for treatment? *Public Management Review*, *18*(5), 639–653. DOI: https://doi.org/10.1080/14719037.2015.1111927.

Trischler, J., & Westman Trischler, J. (2022). Design for experience – a public service design approach in the age of digitalization. *Public Management Review*, *24*(8), 1251–1270. DOI: https://doi.org/10.1080/14719037.2021.1899272.

Venson, E., da Costa Figueiredo, R. M., & Canedo, E. D. (2024). Leveraging a startup-based approach for digital transformation in the public sector: A case study of brazil's startup gov.br program. *Gov. Inf. Q.*, *41*(3), 101943. DOI: https://doi.org/10.1016/J.GIQ.2024.101943.

Wirtz, B. W., & Müller, W. M. (2019). An integrated artificial intelligence framework for public management. *Public Management Review*, *21*(7), 1076–1100.

Wirtz, J. (2020). Organizational ambidexterity: Cost-effective service excellence, service robots, and artificial intelligence. *Organizational Dynamics*, *49*(3), 1–9.

Game elements enabling citizens' engagement: an integrative literature review into elements, motivations, drivers and barriers

Budi Satrio [a*], *Fernando* Kleiman [b], *Marijn* Janssen [c].

[a] Faculty of Technology Policy and Management, Delft University of Technology, Delft, the Netherlands, b.satrio@tudelft.nl, 0000-0001-9291-2039.

[b] Faculty of Technology Policy and Management, Delft University of Technology, Delft, the Netherlands, f.kleiman@tudelft.nl, 0000-0003-3336-3484.

[c] Faculty of Technology Policy and Management, Delft University of Technology, Delft, the Netherlands, m.f.w.h.a.janssen@tudelft.nl, 0000-0001-6211-8790.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Gamification may foster citizen relationships with the government but can also result in a disinterest in participation. In the context of digital government, we do not know which game elements specifically contribute to citizen engagement. In this paper, we conduct an integrative study, drawing from existing literature on citizen engagement through gamification. We examined the citizens' motivation to engage with the government, linked it with game elements explored in the literature, and finally exhibited how these elements could support or inhibit citizens' motivation. Using self-concordance and civic engagement models, we investigated gamification focusing on individual experiences, both personally and as citizens. The findings of this research show a link of static game elements with external and introjected forms of motivation. In contrast, dynamic game elements seem more aligned with intrinsic and identified motivation. We develop a taxonomy outlining these relationships, enabling further research on game elements and their impact on citizen engagement over time.

Keywords. Gamification, Integrative Literature Review, Citizen Engagement, Civic Engagement Theory, Taxonomy, Game Elements, Motivation, Self-Concordance Model, Digital Government.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.974

1. Introduction

Involving citizens in government activities and encouraging their engagement leads to successful collective action (Firmstone & Coleman, 2015; Graham et al., 2019; Kaur et al., 2022). This engagement promotes inclusivity, addresses inequalities, and attracts citizens' interest and opportunities (Arndt et al., 2020; Lopez et al., 2024). However, in the context of digital government, traditional methods such as town hall meetings and public hearings are struggling to engage citizens effectively (Fung, 2015; Irvin & Stansbury, 2004; Kumagai & Ilorio, 2020). The main challenge is making information and opportunities accessible and enjoyable for everyone (Balestrini et al., 2017; Fung, 2015; Purwanto et al., 2020). Digital technologies offer promising solutions to this issue (Firmstone & Coleman, 2015; Geiselhart, 2004; Haro-de-Rosario et al., 2018; Mossberger et al., 2007).

Building on the potential of digital technologies to increase citizen engagement, gamification has emerged as an innovative approach in the digital government context (Van Zoonen, 2020). Gamification has been used to boost citizen participation in activities such as urban planning, public policy feedback, and civic involvement (Hassan & Hamari, 2019; Kazhamiakin et al., 2015; Schrape, 2014). Gamification makes government processes more

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

interactive and enjoyable, thus increasing engagement (Bianchini et al., 2016; Hassan, 2017; Hassan & Hamari, 2019). However, it also risks shallow engagement and may not sustain long-term involvement (Hassan et al., 2018; Raftopoulos, 2020; Steffens et al., 2017).

Given these factors, it is essential to understand the game elements that make gamification work. For example, the Mechanics, Dynamics, and Aesthetics framework defines a game's mechanics as rules, dynamics as user behavior, and aesthetics as emotional responses (Hunicke et al., 2004). Other definition focuses on motivation, goal completion, and engagement (García Iruela et al., 2019), while another delves into motivation-focused components such as flow, relatedness, purpose, autonomy, and mastery (AlMarshedi et al., 2014). Despite multiple definitions, there remains a notable lack of comprehensive overviews specifically detailing how these elements influence citizen engagement in government activities. This gap is also noted by Resek et al. (2024) and Contreras-Espinosa & Blanco-M (2022). Without a clear understanding of these elements, governments and researchers may struggle to engage citizens effectively using gamification.

This paper bridges the gap by establishing a taxonomy of these elements. We aim to open new avenues for research into citizen engagement and contribute to educational technology by providing insights into how gamification can be effectively applied in civic contexts. Academically, this study contributes to the digital government and participation literature by identifying game elements that influence citizens' engagement in government activities. Practically, it provides insights for governments on using gamification to increase citizen engagement.

In addressing these objectives, we develop a protocol to direct our study. First, we focus on understanding the motivations of citizens to participate in gamified citizens' engagement, both personal and civic motivations. Then, we examine the drivers and barriers that influence their participation. Finally, we explore the game elements that bridge these motivations, drivers, and barriers, providing a comprehensive taxonomy of game elements enabling citizens' engagement.

To present these insights effectively, this study is structured as follows: the research approach, findings, discussion, and conclusions.

2. Research Approach

This paper systematically integrates studies on game elements for citizen engagement using the PRISMA protocol due to its structured and transparent approach (Moher et al., 2009). To complement this approach, we use backwards and forward snowballing (Wohlin, 2014) and materials from Scopus and Web of Science. Then, we discuss the findings with prior studies to reflect on existing knowledge and further contextualize our results within the broader literature.

To guide our study, we formulate three research questions:

RQ1: What motivates citizens to participate in gamified citizen engagement initiatives within digital government?
RQ2: What factors enable or hinder citizen participation in gamified digital government platforms?
RQ3: What are the game elements for gamifying citizen engagement in digital government contexts?

Our search protocol follows the PRISMA phases: identification, screening, eligibility, and inclusion. In the first phase, identification, we use Scopus and Web of Science databases since they are both widely recognized databases for academic literature (Martín-Martín et al., 2018). The search strings in titles and abstracts consist of four sets of keywords: gamification, factors, interaction, and stakeholders, as depicted in Tab. 1. We include "participation" and "engagement" since they are often used interchangeably to describe citizens' involvement. Specific strings in gamification, interaction, and stakeholder sets must exist in the articles' keywords to narrow the search to gamification in government. The publication language is English because studies suggest no evidence of systematic bias in using only English (Jüni et al., 2002; Morrison et al., 2012). We limit the start year of publication to 2010 because it marks the first appearance of the word "gamification" in Google Trends (Google, 2024). During the second phase, screening, we eliminate studies that are not pertinent to the research issue. In the third phase, eligibility, we thoroughly evaluate the remaining research for their relevance and quality. Studies that do not correspond with the research aims are excluded. The rationale for exclusion is recorded to guarantee openness. In the final phase, inclusion, studies that satisfied all inclusion criteria are incorporated into the review. This phase involved a detailed examination of the selected studies to extract relevant data on the gamified citizens' engagement.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 - Search strings used in the title and abstract

Source	Search strings
Scopus	(TITLE-ABS("gami*"OR"game*") AND TITLE-ABS("drive*"OR"motiv*"OR"barrier*"OR"inhibit*") AND TITLE-ABS("engag*"OR"participat*"OR"interact*") AND TITLE-ABS("government*"OR"citizen"OR"people"OR"civic") AND KEY("gami*"OR"game*") AND KEY("engag*"OR"participat*"OR"interact*") AND KEY("government*"OR"citizen"OR"people"OR"civic")) AND PUBYEAR > 2009 AND PUBYEAR < 2025 AND (LIMIT-TO(LANGUAGE,"English"))
Web of Science	((TI=(gami* OR game*)OR AB=(gami* OR game*))AND(TI=(drive* OR motiv* OR barrier* OR inhibit*)OR AB=(drive* OR motiv* OR barrier* OR inhibit*))AND(TI=(engag* OR participat* OR interact*)OR AB=(engag* OR participat* OR interact*))AND(TI=(government* OR citizen OR people OR civic)OR AB=(government* OR citizen OR people OR civic))AND AK=(gami* OR game*)AND AK=(engag* OR participat*)AND AK=(government* OR citizen OR people OR civic))AND PY=(2010-2024)

For the backward search, we include articles authored by similar researchers within the context of gamification in citizen engagement. For the forward search, we include subsequent articles citing the current article that also focused on gamification in citizen engagement. Our inclusion criteria require that the title or abstract addresses gamification in government settings and that the article's content pertains to citizen engagement. Conversely, articles failing to meet these criteria are excluded.

We conducted our search in May 2024. Initially, we found 117 studies: 96 from Scopus and 21 from WoS, resulting in 99 papers after removing duplicates. In the screening, eligibility, and inclusion phases, we included 3 studies from backward and forward searches and excluded 24, totaling 78 studies consisting of conference papers, articles, and book chapters from 2011-2024. Our reason for exclusion is that the study should relate to citizens' engagement. The overall process is outlined in Figure 1.

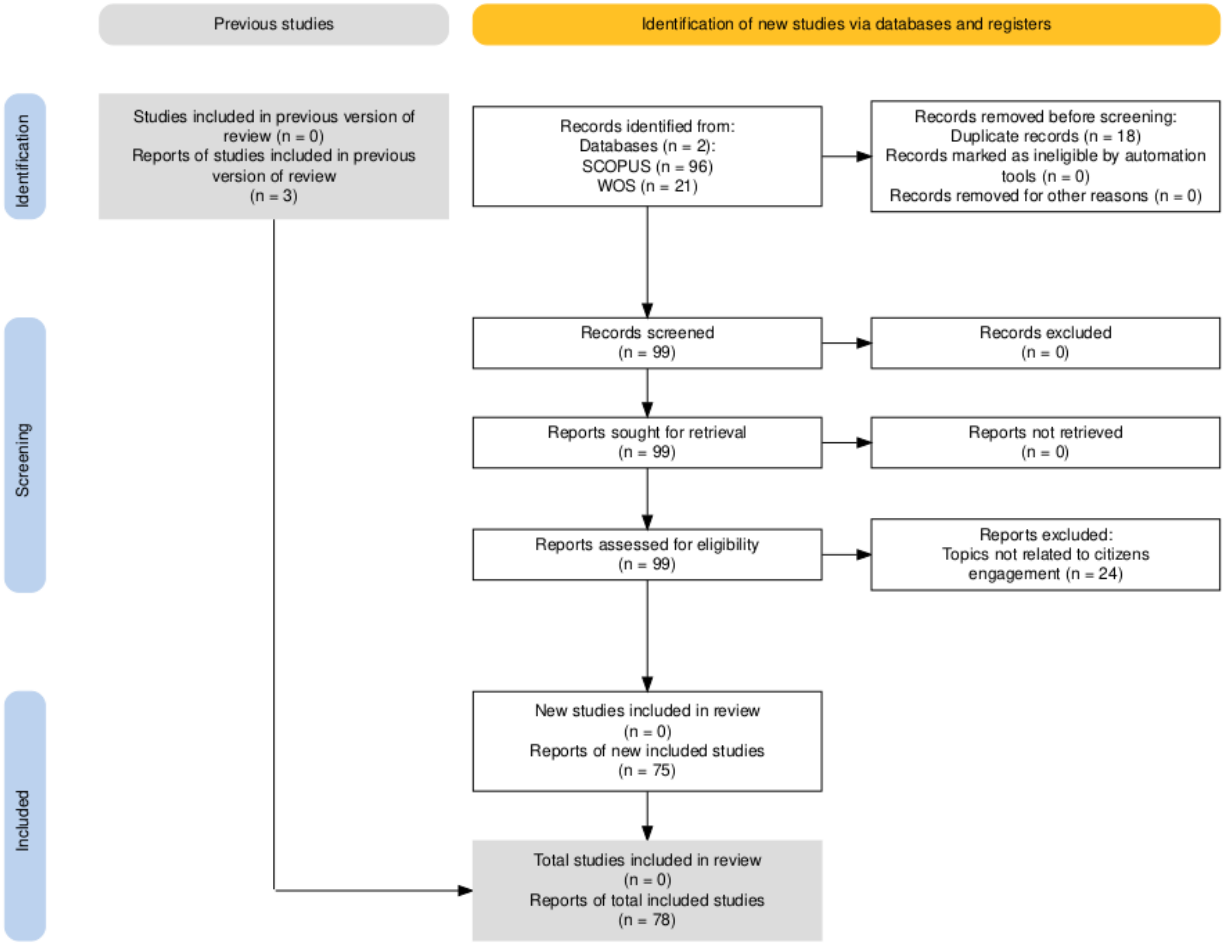


Fig. 1 - PRISMA flow diagram of citizens' motivation, drivers, and barriers of gamified citizens' engagement. This diagram was created using an online PRISMA flow diagram (Haddaway et al., 2022).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3. Findings

This section is structured based on the general findings and the research questions formulated to guide this study. First, we present the bibliometric analysis and notable discoveries. Then, we report the findings on citizens' motivations to engage, which explore individual and civic motivations. Next, we analyze the drivers and barriers of gamification, examining how these aspects influence engagement within civic contexts. Finally, we examine the game elements found in the literature. By organizing the findings in this way, we aim to provide comprehensive information before we discuss their relationship in the next section.

3.1 Bibliometric analysis

In this subsection, we examine the type of publication to understand the distribution across journals, conference papers, and book chapters. Then, we analyze the year of publication to identify the trends of studies in this context. Next, we explore the author's keywords to uncover focus areas within the literature. Finally, we assess the types of games discussed in the papers, providing insights into the specific gamification approaches applied to citizen engagement.

Over 90% of gamification studies in citizen engagement are in conference papers and articles, with few in book chapters. The limited number of studies on gamification in citizen engagement disseminated through book chapters indicates an underutilization of this publication format. This gap suggests an opportunity for researchers to explore the potential of book chapters to provide a more comprehensive analysis and to reach diverse academic audiences.

Examining the year of publication shows growing studies from 2011, a plateau since 2018, and a spike in 2023. This number indicates an ongoing discussion of gamification research since 2018 and a growing interest in recent years. The low number of publications in 2024 may be attributed to ongoing research that has yet to reach publication stages.

We notice the "science" keyword occurs often in the literature search. Further analysis showed that the "science" keyword relates to studies referencing citizen science, where gamification can help the public to contribute to collecting or analyzing the data for research (Haklay et al., 2021). In the assessment of the type of game discussed in the study, we find that 13% of the searched literature discusses evolutionary game theory (EGT), which combines evolutionary biology with game theory (Sigmund & Nowak, 1999). This type of study, funded by Chinese institutions, led to increased research in 2023. Although loosely related to gamification, EGT's focus on stakeholder motivation and interest is similar to gamification's focus, therefore we keep it for further analysis.

3.2 Citizens' motivations

Investigating citizens' motivations reveals why they choose to participate in gamified citizens' engagement. To explore these motivations in depth, we employ the Self-Concordance Model which helps differentiate between individual motivations rooted in personal goals and values, and the Civic Engagement Model which distinguishes civic motivations shaped by resources, psychological engagement, and community.

The Self-Concordance Model classifies motivation into four types: external, introjected, identified, and intrinsic (Sheldon & Elliot, 1999). External motivation, driven by outside factors, includes in-game items like Geo-coins that lead to real-world incentives (Clarke et al., 2017), recognition through scores and badges (Gicquel et al., 2019), or penalties for prolonged silences in recordings (Hantke et al., 2018). Introjected motivation is an internalized form of motivation where goals serve to maintain a certain self-image, such as a sense of ownership for cooperating in Citizen Social Lab (Vicens et al., 2018). Identified motivation occurs when goals are personally significant and driven by personal values, exemplified by users' team preferences in MTV Fantasy Election (Foxman & Forelle, 2014). Intrinsic motivation involves pursuing goals for enjoyment or stimulation as the joy users find in completing OldWeather (Eveleigh et al., 2013) or the immersive experience of Forgotten Island (N. Prestopnik & Souid, 2013). These motivations align with an individual's core values, therefore they are essential for understanding the outcomes of gamification.

The Civic Engagement Model explains citizen participation in government activities through three components: resources, psychological engagement, and recruitment networks (Verba et al., 1995). Resources refer to the necessity for citizens to have spare time, financial means, or skills to participate in gamified citizen engagement. For example, the lack of digital skills among the elderly can hinder their participation in gamification systems (Mendez et al., 2019). Psychological engagement involves the motivation driving citizens to engage psychologically in gamified citizen participation. An example is the narrative element of the Climate4Kids app, where the character Mani helps create an emotional connection, making the topic more relatable and motivating children to take action (Gabriel & Schmölzer, 2022). Recruitment networks refer to the ability of citizens engaged in gamified activities to attract others to join. For instance, citizen involvement in Community Planit led to greater engagement and support

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

for initiatives (Hassan & Hamari, 2020). These factors reveal potential motivators for citizens and can be used to maintain their engagement.

3.3 Drivers and barriers to citizen participation

We explore the aspect of engagement to see why gamification in civic activities appeals to citizens. Seven driving factors are identified, as outlined in Tab. 2. Five relate to individual motivation: 1) Gamification enhances motivation by making activities enjoyable and rewarding. 2) Autonomy and control give citizens power over the system, boosting engagement. 3) Personalized experiences meet citizens' needs and interests, keeping them engaged. 4) Clear goals and progress provide a sense of transparency and achievement. Finally, 5) Challenges encourage mastery and a sense of completion. The other two are related to social dynamics: 6) A sense of community is created through multiplayer features or leaderboards, encouraging participation. Lastly, 7) competitions ignite motivation for showing skills and long term engagement.

To understand why some gamification failed, we investigate barriers to gamification from its design and external conditions. Ten barriers are identified, four related to design: 1) Focusing too much on extrinsic rewards can reduce engagement. 2) Intense competition and rewards may dampen intrinsic motivation. 3) Poor user interface leads to difficulty in participating effectively. Lastly, 4) Poor gamification mechanisms can reduce engagement. The other six barriers are related to external factors: 5) Skepticism leads to distrust and difficulty in attracting users. 6) Economic barriers may prevent low-income participation. 7) Socio-cultural factors can hinder engagement in specific demographics. 8) Privacy concerns can deter participation if not handled correctly. 9) Limited feedback or support makes citizens refrain from gamification. Finally, 10) technology overload can overwhelm and disengage citizens.

More studies report on the drivers of gamification than on its barriers. This suggests researchers focus more on the positive outcomes than the drawbacks. These differences show the current state of gamification research and highlight the need for future studies to examine both aspects.

Tab. 2 - Drivers and barriers to citizens' participation with detailed information in Appendix A and B (in supplemental material)

Drivers	Number of studies	Barriers	Number of studies
Enhancing personal motivation	52	Overemphasis on external rewards	5
Autonomy and control	10	Dampened intrinsic motivation	1
Personalized experiences	7	Poor user interface	1
Transparent goals and progress	19	Poor gamification mechanism	2
Sense of community	23	Skepticism	4
Challenges	17	Economic barriers	1
Competitions	27	Socio-cultural factors	1
		Privacy concerns	3
		Limited feedback or support	1
		Technology barriers	4

3.4 Game elements in the literature

The literature provides examples of different types of games, namely serious games, commercial games, and gamification. Serious games are designed for educational purposes or to change behavior, not just for entertainment, focusing on user experience and achieving real-world outcomes (Abt, 1975; Michael & Chen, 2011). Commercial games, by contrast, aim purely to entertain, concentrating on engaging gameplay, graphics, and storytelling to generate profit (Wolf, 2002). Gamification applies game elements to non-gaming contexts to increase engagement (Deterding et al., 2011). Although these categories differ in purpose, they all share the common use of game elements to achieve their objectives.

To better identify these game elements, we classify them into static and dynamic, as outlined in Tab. 3. Static elements are predefined components such as features or metrics. Dynamic elements are the processes that interact with static elements. For example, points and ranks are static, while the difficulty of earning those points and ranks is dynamic.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 3 – The game elements with detailed information in Appendix C and D (in supplemental material)

Static Elements	Number of studies	Dynamic Elements	Number of studies
Points/Scores	37	Progress	22
Badges/Achievements	21	Aesthetics	4
Leaderboards	27	Ease of use	2
Levels/Ranks	21	Challenges/Difficulties	13
Rewards/Bonuses/Prizes	30	Rarity	3
Punishments/Penalties	12	Competition/Cooperation	24
Avatars	5	Narrative/Themes/Plots/Story	17
Virtual Goods/Collections	3	Feedback	27
Virtual currencies	3	Discovery	2
Tutorials	2	Social Interaction	19

Further delving into the static and dynamic elements, we explore each element and then connect each to the motivation, drivers, and barriers as reported or implied in the literature. We summarize our findings of static game elements in Tab. 4 and the findings of dynamic game elements in Tab. 5.

Tab. 4 – Taxonomy of static game elements

Game Elements	Individual Motivation	Citizen Motivation	Drivers	Barriers
Points/Scores	External	Resources	Enhancing motivation	Overemphasis on extrinsic rewards
Badges/Achievements	• External • Introjected	• Resources • Recruitment Networks	• Enhancing motivation • Personalized experiences	• Overemphasis on extrinsic rewards • Poor UI • Poor mechanism
Leaderboards	• External • Introjected	• Resources • Recruitment Networks	• Enhancing motivation • Challenges • Competitions	• Overemphasis on extrinsic rewards • Privacy concerns
Levels/Ranks	• External • Introjected	Resources	Enhancing motivation	Overemphasis on extrinsic rewards
Rewards/Bonuses/Prizes	External	• Resources • Psychological Engagement • Recruitment Networks	Enhancing motivation	• Overemphasis on extrinsic rewards • Poor mechanism
Punishments/Penalties	External	• Psychological Engagement • Recruitment Networks	• Enhancing motivation • Challenges	Overemphasis on extrinsic rewards
Avatars	Introjected	Psychological Engagement	Personalized experiences	Poor UI
Virtual Goods/Collections	External	• Resources • Recruitment Networks	• Enhancing motivation • Personalized experience	• Overemphasis on extrinsic rewards • Poor mechanism
Virtual currencies	External	• Resources • Psychological Engagement	Enhancing motivation	Overemphasis on extrinsic rewards
Tutorials	External	Resources	Autonomy or control	• Poor UI • Skepticism

Points or scores are widely used to measure users based on actions, serving as motivational tools for rewards and engagement (Hassan, 2017). For example, users might use mobile esports to compete, win, or even earn monetary

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

rewards, indicating that investing skills and time are required for participation (Hassan & Hamari, 2020; Vanolo, 2019). While points can boost engagement, relying too much on them without other rewards risks losing participation over time (Foxman & Forelle, 2014; Hassan & Hamari, 2020; Peischl et al., 2014; N. R. Prestopnik & Tang, 2015; Resek et al., 2024).

Badges or achievements indicate that users have met a game's objectives (Hassan, 2017). They seem to influence external motivation and drive introjected motivation, serving as proof of success and encouraging other users' participation (Bhéreur-Lagounaris, 2016; Bowser et al., 2014; Clarke et al., 2017; Gabriel & Schmölzer, 2022; Gastil & Broghammer, 2021; Gicquel et al., 2019; Hantke et al., 2018; Iacovides et al., 2013; Mendez et al., 2019; Peischl et al., 2014; Rehm et al., 2018; Sergeyeva et al., 2020). However, obtaining them requires citizens to invest time, money, or skills (Becker et al., 2019; Clarke et al., 2017; Dargan & Evequoz, 2015; De Francisco et al., 2024; Gastil, 2023; Gastil & Broghammer, 2021; Hantke et al., 2018; Mendez et al., 2019). Badges can boost engagement and offer personalized experiences, however, overemphasizing their extrinsic rewards and their poor user interface or gamification mechanism may disengage users (Dargan & Evequoz, 2015; Mendez et al., 2019).

Leaderboards rank users based on their points or achievements (Hassan, 2017). Similar to badges, leaderboards seem to provide external motivation and can be proof of success to others, but acquiring them requires an investment of resources (Bousios et al., 2017; Hassan & Hamari, 2020; Torres-Toukoumidis et al., 2017). Although leaderboards increase motivation and offer challenges or competitions, excessive rewards and privacy concerns may deter engagement (Foxman & Forelle, 2014; Gastil, 2023; Hassan, 2017; Hassan & Hamari, 2020; Moreira et al., 2020; Peischl et al., 2014; Torres-Toukoumidis et al., 2017; Vanolo, 2019).

Levels or ranks show a user's progression or challenges in a game, such as in "Papers, Please," which uses days as levels (Pflanzl et al., 2017). Levels seem to affect external and introjected motivation, but they need an investment of time, cost, or skills (Avolicino et al., 2022; Bousios et al., 2017; Fernandes & Junior, 2016; Hantke et al., 2018; Padilla-Zea et al., 2022; Torres-Toukoumidis et al., 2017). Although levels enhance motivation, excessive rewards might disengage users (Eveleigh et al., 2013; Gicquel et al., 2019; Palacin-Silva et al., 2018; Thiel, 2015; Thiel et al., 2016).

Rewards, bonuses, or prizes are given to users for completing game challenges and can be virtual or real-world rewards, such as currency or other in-game benefits, as seen in Forgotten Island (N. R. Prestopnik & Tang, 2015). Rewards seem to be linked to external motivation and can influence psychological engagement, as well as encourage others to join, but they need resources to invest (Bhéreur-Lagounaris, 2016; Lee et al., 2017; Schell & Kaufman, 2016; Wilis & Parningotan Manik, 2022). However, poorly designed and too much focus on extrinsic rewards can hinder engagement (Bu et al., 2023; Clarke et al., 2017; Foxman & Forelle, 2014; Hassan & Hamari, 2020; Thiel & Lehner, 2015).

Unlike rewards, **punishments or penalties** impose negative consequences on users who do not meet objectives. For example, penalties in evolutionary game theory promote green innovation and enforce driving regulations (Sun et al., 2023; Wang et al., 2021). They seem to motivate psychologically and encourage others to join, but they require an investment of resources (Sun et al., 2023). Punishments present challenges, but excessive rewards from punishments may deter engagement (Li et al., 2023).

Avatars, visual representations of users, provide a sense of presence or personality within a game, such as avatars in EcoGo (Avolicino et al., 2022). Avatars can serve as proof of success and seem to provide psychological motivation (Avolicino et al., 2022; Resek et al., 2024; Thiel et al., 2016). They also provide a personalized experience, but poor interface may deter engagement (Thiel et al., 2016).

Virtual goods or collections, such as collectables in the iHEARu-PLAY game and in-game pets (Clarke et al., 2017; Hantke et al., 2018)(Clarke et al., 2017; Hantke et al., 2018), seem to be linked to external motivations and encourage the participation of others. However, they require an investment of resources (N. R. Prestopnik & Crowston, 2011). Virtual goods enhance the personalized experience, but excessive use and poor mechanisms may deter engagement (Clarke et al., 2017).

Virtual currency, such as GeoCoins or eco-points (Avolicino et al., 2022; Clarke et al., 2017), acts as in-game money to facilitate actions in the game. Virtual currency seems to tap external motivation and provide psychological motivation, but it requires an investment of resources (Clarke et al., 2017; Hantke et al., 2018; N. Prestopnik & Souid, 2013), and excessive use of it may disengage users (De Francisco et al., 2024).

Tutorials help users understand what they must do in a game, making it more approachable. They familiarize users with game mechanics, requiring an investment of time and skills, such as in The Climate Game or the Climate4Kids game (Torres-Toukoumidis et al., 2017; Vicens et al., 2018). Tutorials seem to provide a sense of autonomy and control, but a poor interface and skepticism can deter engagement (Schell & Kaufman, 2016; Torres-Toukoumidis et al., 2017).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 5 – Taxonomy of dynamic game elements

Game Elements	Individual Motivation	Citizen Motivation	Drivers	Barriers
Progress	Identified	• Resources • Psychological Engagement	• Autonomy or control • Clear goals or progress	• Poor UI • Poor mechanism
Aesthetics	Intrinsic	Psychological Engagement	• Enhancing motivation • Personalized experiences	• Socio-cultural factors • Technology overload • Poor UI
Ease of use	Intrinsic	Psychological Engagement	• Enhancing motivation • Personalized experiences	• Technology overload • Poor UI
Challenges/Difficulties	Intrinsic	• Resources • Psychological Engagement	Challenges	• Poor mechanism • Dampened intrinsic motivation
Rarity	Intrinsic	• Resources • Psychological Engagement • Recruitment Networks	• Enhancing motivation • Challenges	Dampened intrinsic motivation
Competition/Cooperation	• External • Introjected	• Resources • Psychological Engagement • Recruitment Networks	Competitions	• Poor mechanism • Skepticism
Narrative/Themes/Plots/ Story	Identified	• Psychological Engagement • Recruitment Networks	• Clear goals and progress • Personalized experiences	• Socio-cultural factors • Skepticism
Feedback	Identified	Psychological Engagement	• Enhancing motivation • Autonomy and control	• Limited feedback or support • Skepticism • Poor mechanism
Discovery	Intrinsic	• Resources • Psychological Engagement	• Autonomy and control • Personalized experiences	• Poor mechanism • Skepticism
Social Interaction	• Intrinsic • Identified	• Resources • Psychological Engagement • Recruitment Networks	• Enhancing motivation • Sense of community • Personalized experiences	• Privacy concerns • Socio-cultural factors • Poor mechanism

Progress tracks objectives achieved by users. For example, progress bars are used to break tasks into smaller goals, as seen in eCH-BPM Switzerland's approach (Dargan & Evequoz, 2015; Vanolo, 2019). Progress, motivated by personal value to finish the task, seems to be psychologically engaging but requires an investment of resources (Becker et al., 2019; N. Prestopnik & Souid, 2013). Citizens have autonomy and control over progress, but a poor UI or mechanism can deter engagement (Hassan & Nader, 2016; Moreira et al., 2020; Rehm et al., 2018).

Aesthetics, including visuals and sounds, influence a game's atmosphere and user engagement (De Francisco et al., 2024; Romero-Hernandez et al., 2018). They seem to provide intrinsic motivation and personal enjoyment, fostering psychological engagement (Clarke et al., 2017; Latifi et al., 2022). However, socio-cultural differences, technological limitations, and poor interface seem to deter participation (Hassan & Nader, 2016; Pflanzl et al., 2017; Quecke & Mariani, 2021).

Ease of use in gaming means features that simplify gameplay, such as user-friendly interfaces for the elderly, children, or people with (Bousios et al., 2017; Mendez et al., 2019; Schell & Kaufman, 2016). It links to intrinsic

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

motivation and psychological engagement (Minge et al., 2014; Schell & Kaufman, 2016). This game element personalizes the experience, but technological overload and a poor UI can deter engagement (Mendez et al., 2019; N. R. Prestopnik & Crowston, 2011; Redondo, Giménez, Navarro, & Fonseca, 2020; Schell & Kaufman, 2016; Vicens et al., 2018).

Challenges or difficulties in games make users overcome obstacles to reach goals. They provide intrinsic and psychological motivation but require an investment of time, money, or skills (Bhéreur-Lagounaris, 2016; Pflanzl et al., 2017; N. R. Prestopnik & Tang, 2015; Torres-Toukoumidis et al., 2017; Wilis & Parningotan Manik, 2022). Although the challenge element drives gamification, a poor challenge mechanism can deter engagement (Chian, 2023; Eveleigh et al., 2013; Hantke et al., 2018; Kongeseri & Coley, 2019; Minge et al., 2014; N. R. Prestopnik & Tang, 2015; Thiel & Lehner, 2015).

Rarity in games refers to the scarcity of items, which creates a sense of achievement when obtained. This element seems to provide intrinsic and psychological motivation and encourages others to join, but it requires an investment of resources (Clarke et al., 2017). Although driven by challenges similar to rewards, an excess of rarity may dampen intrinsic motivation (Dargan & Evequoz, 2015).

Competition or cooperation among users is linked to external motivation, as it can demonstrate success and encourage others to join. However, it requires resources to play (Dargan & Evequoz, 2015; Foxman & Forelle, 2014; Hassan & Hamari, 2020; Iacovides et al., 2013; Palacin-Silva et al., 2018; Resek et al., 2024; Thiel & Lehner, 2015; Wilis & Parningotan Manik, 2022). Poor competition or cooperation mechanisms and skepticism about them may reduce engagement (Bossavit & Parsons, 2016; Bousios et al., 2017; Eveleigh et al., 2013; Foxman & Forelle, 2014; Hassan & Hamari, 2020; Palacin-Silva et al., 2018; Thiel et al., 2016; Wilis & Parningotan Manik, 2022).

Narratives, themes, plots, or story provide context and emotion, guiding user actions, and connecting with personal values and psychological engagement (Clarke et al., 2017; Eveleigh et al., 2013; Gabriel & Schmölzer, 2022; Gastil & Broghammer, 2021; Kongeseri & Coley, 2019; Padilla-Zea et al., 2022; N. R. Prestopnik & Crowston, 2011; N. R. Prestopnik & Tang, 2015; Ronzhyn et al., 2020; Tennent et al., 2016; Vicens et al., 2018). They seem to give personalized experiences and clear goals for citizens. However, sociocultural factors and skepticism in narratives can deter engagement (Foxman & Forelle, 2014; Kongeseri & Coley, 2019; Padilla-Zea et al., 2022; Quecke & Mariani, 2021).

Feedback helps to assess user actions and can motivate them by aligning with personal values (Avolicino et al., 2022; Bhéreur-Lagounaris, 2016; De Francisco et al., 2024; Gastil & Broghammer, 2021; Peischl et al., 2014). Feedback seems to provide autonomy and control to citizens. However, limited support, skepticism, and poor mechanisms can reduce engagement (Palacin-Silva et al., 2018; Thiel & Lehner, 2015).

Discovery motivates users to explore new aspects of a game. It seems to be driven by intrinsic motivation and psychological engagement, but it needs resources to interact (Pflanzl et al., 2017). Discovery provides personalized experience and autonomy or control to interact. However, skepticism and poor mechanisms seem to lower participation (Foxman & Forelle, 2014).

Social interactions engage users with each other beyond cooperation or competition. It seems to be driven by intrinsic motivation and aligns more with personal values to communicate, foster psychological engagement, and encourage participation, however, it requires an investment of resources (Bhéreur-Lagounaris, 2016; Iacovides et al., 2013; Palacin-Silva et al., 2018). Social interaction gives a sense of community and personalized experience. However, privacy concerns, socio-cultural issues, and poor interaction mechanisms seem to deter engagement (Palacin-Silva et al., 2018).

During our analysis, we noticed the ambiguities of the game elements, such as one element can target different kinds of motivations. To clarify these ambiguities, we examine their similarities, subsets, and broader specifics. For instance, 'Competition/Cooperation' relates to external and introjected motivation but can also be intrinsic. For example, competing or cooperating for rewards without comparing to others tends toward external motivation, while competing or cooperating to seek recognition tends toward introjected motivation. However, competing or cooperating purely for enjoyment falls under 'Challenges/Difficulties' or 'Social Interaction' and is intrinsic. We specify the motivational context for each element to address its complexity.

4. Discussion

Various studies have explored the link between game elements and different factors by proposing classifications (Hassan & Hamari, 2020; Resek et al., 2024; Thiel & Lehner, 2015). This paper continues in the same direction by focusing on linking game elements with personal and civic motivations as well as the drivers and barriers to citizen engagement. However, the connection between these game elements can be unclear. Therefore, this study narrows its analysis to individual game elements rather than the entirety of gamification. For instance, while an economic

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

barrier might affect overall gamification, it may not impact individual game elements. The objective is to simplify understanding the relationship between motivations and influencing factors while acknowledging the need for empirical evidence.

In our findings, we notice that static elements mainly target external or introjected motivations and require time, money, or skills. This suggests that while these elements can incentivize engagement, individuals may need to invest to participate. Further delving into the engagement, a preliminary study suggested that static game elements, such as badges and leaderboards, can effectively stimulate external motivation and foster initial engagement (Steffens et al., 2017). Therefore, by leveraging static elements, it becomes possible to jumpstart initial involvement, laying the groundwork for subsequent engagement. However, overemphasizing extrinsic rewards on these static elements can hinder engagement. This argument is backed up by Thiel & Lehner's (2015) research that indicates citizens tend to find game elements monotonous over time.

On the other hand, our findings indicate that the dynamic elements are hypothetically linked to intrinsic and identified personal motivation, except for competition and cooperation, which align more closely with external and introjected motivation. The Civic Engagement Model highlights psychological engagement as a crucial factor across all dynamic elements for maintaining emotional involvement. On a similar note, Huang et al. (2024) underscores the importance of intrinsic motivation in cultivating long-term engagement. This argument emphasizes that incorporating dynamic elements into gamified systems can foster deeper motivational connections, which are crucial for supporting long-term participation, especially in situations that require sustained engagement. We also note that socio-cultural factors emerged in dynamic rather than static elements, underscoring the importance of considering the socio-cultural context when implementing these dynamic elements.

Recognizing that static and dynamic game elements target different types of motivation is important to understanding their role in fostering engagement. Static elements relate to external and introjected motivation, making them effective for jumpstarting engagement by providing an external incentive to participate. In contrast, dynamic elements are more aligned with intrinsic and identified motivation, sustaining engagement over time by fostering a deeper emotional and psychological connection. Previous studies emphasize that external motivation is useful for starting engagement, while intrinsic motivation can maintain long-term involvement (Huang et al., 2024; Steffens et al., 2017). We suggest combining these static and dynamic game elements to encourage initial participation and sustain engagement over time.

5. Conclusions

In the realm of digital government, engaging citizens is key to generating benefits for both governments and citizens. Gamification, which uses game elements in digital government initiatives, has been explored to increase this engagement. Our literature review reveals how game elements influence citizens' motivation to participate and identifies the factors that facilitate or hinder engagement.

For our first research question on citizens' motivation, we employed the Self-Concordance Model to categorize individual motivations and utilized the Civic Engagement Model to explain civic motivations. In addressing the second question on drivers and barriers, we identified seven drivers that enhance motivation and ten barriers that impede it. For the third question on game elements, we examined the literature and linked game elements to personal and civic motivations, drivers, and barriers, as outlined in Section 3.

Our findings suggest that static game elements such as Points, Badges, and Avatars are hypothetically associated with external and introjected motivation. In contrast, dynamic elements such as Progress and Aesthetics are hypothetically related to intrinsic and identified motivation, whereas Competition/Cooperation is more aligned with external and introjected motivation. We discuss that static game elements can jump-start engagement, and dynamic game elements can sustain engagement over time. We suggest a combination of static and dynamic elements as a balanced approach to designing gamified systems, ensuring both initial participation and long-term engagement.

5.1 Limitations

We acknowledge several limitations in this research. First, the studies we reviewed were selected according to the PRISMA, which might introduce biases in study selection. The biases include the exclusion of non-English articles, reliance on Scopus and Web of Science as primary databases, and the potential oversight of some relevant studies. Second, our research specifically examines gamification in citizen engagement and may not be generalizable to other fields. Third, our discussion linking game elements to citizens' motivations and influencing factors is based on both explicit and implicit relationships in the literature, which could introduce reporting bias. Lastly, while we recognize the challenges in practical applications, such as ethical concerns, our taxonomy lacks empirical validation. Thus, the conclusions remain theoretical.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5.2 Future research

Game elements can drive meaningful engagement over time by aligning with citizens' motivations. Our proposed taxonomy facilitates the distinction between different types of game elements and offers a new avenue for studying their impacts on citizens' activities. Future research should investigate the effectiveness of these game elements in increasing citizen engagement. Additionally, researchers should incorporate studies from a wider array of sources and in multiple languages. Furthermore, empirical validation of this taxonomy is necessary, with future studies supporting it through case studies.

Acknowledgement

We thank the reviewers for their valuable guidance during the revision process and our colleagues for their valuable suggestions during the conduct of this study.

Funding or Grant

This work presented herein was funded by the Indonesia Endowment Fund for Education (LPDP) grant number: 202308221741246.

Data/Software Access Statement

Supplemental materials of the selected studies are available through https://doi.org/10.4121/0e098400-604e-4908-8155-b51ebef71c97.

Contributor Statement

Budi Satrio: Writing – original draft, Formal analysis. Fernando Kleiman: Writing – review & editing, Supervision, Conceptualization. Marijn Janssen: Writing – review & editing, Supervision.

Use of AI

During the preparation of this work, the author(s) used Rewrite/Copilot in order to improve readability. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict of Interest (COI)

Budi Satrio reports financial support was provided by the Indonesia Endowment Fund for Education (LPDP) grant no: 202308221741246. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abt, C. C. (1975). *Serious games* (5. print). Viking Press.

AlMarshedi, A., Wills, G. B., Wanick, V., & Ranchhod, A. (2014). Towards a sustainable gamification impact. *International Conference on Information Society (i-Society 2014)*, 195–200.

Arndt, E., Burgman, M., Schneider, K., & Robinson, A. (2020). Working with government–innovative approaches to evidence-based policy-making. *Conservation Research, Policy and Practice*, 216–229.

Avolicino, S., Di Gregorio, M., Romano, M., Sebillo, M., Tortora, G., & Vitiello, G. (2022). EcoGO: Combining eco-feedback and gamification to improve the sustainability of driving style. *Proceedings of the 2022 International Conference on Advanced Visual Interfaces*, 1–5. https://doi.org/10.1145/3531073.3531127

Balestrini, M., Rogers, Y., Hassan, C., Creus, J., King, M., & Marshall, P. (2017). A city in common: A framework to orchestrate large-scale citizen engagement around urban issues. *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 2282–2294.

Becker, M., Ksenia Koroleva, Diogo Vitorino, K. D., & Novak, J. (2019). Developing a Collective Awareness Platform for Urban Sustainability Challenges: Case Study of the POWER Project. *European Journal of Sustainable Development*, *8*(4), 214. https://doi.org/10.14207/ejsd.2019.v8n4p214

Bhéreur-Lagounaris, A. (2016). Is Citizen Science Gaming the Next 'Level Up' for Social Impact Games? Crossing Public Involvement, Technological Accessibility and Game Design. In B. Kuhn (Ed.), *Levelling Up: The Cultural Impact of Contemporary Videogames* (pp. 111–120). BRILL. https://doi.org/10.1163/9781848884380_013

Bianchini, D., Fogli, D., & Ragazzi, D. (2016). Promoting citizen participation through gamification. *Proceedings of the 9th Nordic Conference on Human-Computer Interaction*, 1–4.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Bossavit, B., & Parsons, S. (2016). Designing an educational game for and with teenagers with high functioning autism. *Proceedings of the 14th Participatory Design Conference: Full Papers - Volume 1*, 11–20. https://doi.org/10.1145/2940299.2940313
Bousios, A., Gavalas, D., & Lambrinos, L. (2017). CityCare: Crowdsourcing daily life issue reports in smart cities. *2017 IEEE Symposium on Computers and Communications (ISCC)*, 266–271. https://doi.org/10.1109/ISCC.2017.8024540
Bowser, A., Hansen, D., Preece, J., He, Y., Boston, C., & Hammock, J. (2014). Gamifying citizen science: A study of two user groups. *Proceedings of the Companion Publication of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*, 137–140. https://doi.org/10.1145/2556420.2556502
Bu, Z., Liu, J., & Zhang, X. (2023). Collaborative government-public efforts in driving green technology innovation for environmental governance in PPP projects: A study based on prospect theory. *Kybernetes*. https://doi.org/10.1108/K-08-2023-1415
Chian, Y. X. (2023). Sustainable, inclusive city-making through smart, playable environments: Developing and testing the CO2rdinates pervasive mobile game. *26th International Academic Mindtrek Conference*, 321–328. https://doi.org/10.1145/3616961.3617803
Clarke, S., Arnab, S., Lewis, M., Morini, L., Depriori, S., Bogliolo, A., & Klopfenstein, L. (2017). A gamified approach for facilitating a user-engagement strategy for public-led collective awareness platform for road sensing. *Proceedings of the 11th European Conference on Games Based Learning, ECGBL 2017*, 79–87.
Contreras-Espinosa, R. S., & Blanco-M, A. (2022). A Literature Review of E-government Services with Gamification Elements. *International Journal of Public Administration*, *45*(13), 964–980. https://doi.org/10.1080/01900692.2021.1930042
Dargan, T., & Evequoz, F. (2015). Designing Engaging e-Government Services by Combining User-Centered Design and Gamification: A Use-Case. *Proceedings of the European Conference on E-Government, ECEG*, *2015-January*, 70–78.
De Francisco, M. S., Díaz, P., Onorati, T., Monteron, Á., & Aedo, I. (2024). Designing mobile technologies to encourage civic engagement: The role of situated motivational affordances. *IEEE Transactions on Emerging Topics in Computing*, 1–12. https://doi.org/10.1109/TETC.2023.3296772
Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 9–15. https://doi.org/10.1145/2181037.2181040
Eveleigh, A., Jennett, C., Lynn, S., & Cox, A. L. (2013). "I want to be a captain! I want to be a captain!": Gamification in the *old weather* citizen science project. *Proceedings of the First International Conference on Gameful Design, Research, and Applications*, 79–82. https://doi.org/10.1145/2583008.2583019
Fernandes, F. T., & Junior, P. T. A. (2016). Gamification Aspects in the Context of Electronic Government and Education: A Case Study. In F. F.-H. Nah & C.-H. Tan (Eds.), *HCI in Business, Government, and Organizations: Information Systems* (Vol. 9752, pp. 140–150). Springer International Publishing. https://doi.org/10.1007/978-3-319-39399-5_14
Firmstone, J., & Coleman, S. (2015). Public engagement in local government: The voice and influence of citizens in online communicative spaces. *Information, Communication & Society*, *18*(6), 680–695.
Foxman, M., & Forelle, M. (2014). Electing to Play: MTV's Fantasy Election and Changes in Political Engagement Through Gameplay. *Games and Culture*, *9*(6), 454–467. https://doi.org/10.1177/1555412014549804
Fung, A. (2015). Putting the public back into governance: The challenges of citizen participation and its future. *Public Administration Review*, *75*(4), 513–522.
Gabriel, S., & Schmölzer, B. (2022). Climate4Kids: A Gamified App Teaching about Climate Change. *Proceedings of the European Conference on Games-Based Learning*, *16*, 236–243.
García Iruela, M., Fonseca, M. J., Hijón Neira, R., & Chambel, T. (2019). Analysis of gamification elements. A case study in a computer science course. *Artificial Intelligence in Education: 20th International Conference, AIED 2019, Chicago, IL, USA, June 25-29, 2019, Proceedings, Part II 20*, 89–93.
Gastil, J. (2023). To Play Is the Thing: How Game Design Principles Can Make Online Deliberation Compelling. *American Behavioral Scientist*, *67*(8), 1042–1060. https://doi.org/10.1177/00027642221093592
Gastil, J., & Broghammer, M. (2021). Linking Theories of Motivation, Game Mechanics, and Public Deliberation to Design an Online System for Participatory Budgeting. *Political Studies*, *69*(1), 7–25. https://doi.org/10.1177/0032321719890815
Geiselhart, K. (2004). Citizen engagement: The next horizon for digital government.[Paper in: The Vocal Citizen, Patmore, Glenn and Jungwirth, Gary (eds.).]. *Labor Essays*, *2004*, 86–99.
Gicquel, P.-Y., Hamon, L., Plaut, F., & George, S. (2019). Albiziapp: A Gamified Tool Dedicated to Tree Mapping. In A. Liapis, G. N. Yannakakis, M. Gentile, & M. Ninaus (Eds.), *Games and Learning Alliance* (Vol. 11899, pp. 287–297). Springer International Publishing. https://doi.org/10.1007/978-3-030-34350-7_28
Google. (2024). *Gamification on google trends*. Google Trend. https://trends.google.com/trends/explore?date=all&q=gamification
Graham, S., Metcalf, A. L., Gill, N., Niemiec, R., Moreno, C., Bach, T., Ikutegbe, V., Hallstrom, L., Ma, Z., & Lubeck, A. (2019). Opportunities for better use of collective action theory in research and governance for invasive species management. *Conservation Biology*, *33*(2), 275–287.
Haddaway, N. R., Page, M. J., Pritchard, C. C., & McGuinness, L. A. (2022). *PRISMA2020*: An R package and Shiny

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. *Campbell Systematic Reviews*, *18*(2), e1230. https://doi.org/10.1002/cl2.1230

Haklay, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., Vohland, K., Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., & others. (2021). What is citizen science? The challenges of definition. *The Science of Citizen Science*, *13*.

Hantke, S., Appel, T., & Schuller, B. (2018). The Inclusion of Gamification Solutions to Enhance User Enjoyment on Crowdsourcing Platforms. *2018 First Asian Conference on Affective Computing and Intelligent Interaction (ACII Asia)*, 1–6. https://doi.org/10.1109/ACIIAsia.2018.8470330

Haro-de-Rosario, A., Sáez-Martín, A., & del Carmen Caba-Pérez, M. (2018). Using social media to enhance citizen engagement with local government: Twitter or Facebook? *New Media & Society*, *20*(1), 29–49.

Hassan, L. (2017). Governments Should Play Games: Towards a Framework for the Gamification of Civic Engagement Platforms. *Simulation & Gaming*, *48*(2), 249–267. https://doi.org/10.1177/1046878116683581

Hassan, L., & Hamari, J. (2019). Gamification of e-participation: A literature review. *Proceedings of the Annual Hawaii International Conference on System Sciences*, *2019-January*, 3077–3086.

Hassan, L., & Hamari, J. (2020). Gameful civic engagement: A review of the literature on gamification of e-participation. *Government Information Quarterly*, *37*(3), 101461. https://doi.org/10.1016/j.giq.2020.101461

Hassan, L., Morschheuser, B., Alexan, N., & Hamari, J. (2018). First-hand experience of why gamification projects fail and what to do about it. *2018 the 2nd International GamiFIN Conference*, 141–150.

Hassan, L., & Nader, A. (2016). Gamification design in action: The practical cases of gamification platforms for employee work motivation and citizens' civic engagement. *PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON ICT MANAGEMENT FOR GLOBAL COMPETITIVENESS AND ECONOMIC GROWTH IN EMERGING ECONOMIES (ICTM 2016)*, 67–70.

Huang, L., Deng, C., Hoffman, J., Hadi Mogavi, R., Kim, J. J., & Hui, P. (2024). Long-Term Gamification: A Survey. In X. Fang (Ed.), *HCI in Games* (pp. 32–43). Springer Nature Switzerland.

Hunicke, R., LeBlanc, M., Zubek, R., & others. (2004). MDA: A formal approach to game design and game research. *Proceedings of the AAAI Workshop on Challenges in Game AI*, *4*(1), 1722.

Iacovides, I., Jennett, C., Cornish-Trestrail, C., & Cox, A. L. (2013). Do games attract or sustain engagement in citizen science?: A study of volunteer motivations. *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, 1101–1106. https://doi.org/10.1145/2468356.2468553

Irvin, R. A., & Stansbury, J. (2004). Citizen participation in decision making: Is it worth the effort? *Public Administration Review*, *64*(1), 55–65.

Jüni, P., Holenstein, F., Sterne, J., Bartlett, C., & Egger, M. (2002). Direction and impact of language bias in meta-analyses of controlled trials: Empirical study. *International Journal of Epidemiology*, *31*(1), 115–123.

Kaur, M., Buisman, H., Bekker, A., & McCulloch, C. (2022). *Innovative capacity of governments: A systemic framework*.

Kazhamiakin, R., Marconi, A., Perillo, M., Pistore, M., Valetto, G., Piras, L., Avesani, F., & Perri, N. (2015). Using gamification to incentivize sustainable urban mobility. *2015 IEEE First International Smart Cities Conference (ISC2)*, 1–6.

Kongeseri, S., & Coley, C. (2019). Design of a Collaborative Tabletop Game for Civic Engagement: Serious Games in Rural India. In N. Zagalo, A. I. Veloso, L. Costa, & Ó. Mealha (Eds.), *Videogame Sciences and Arts* (Vol. 1164, pp. 86–98). Springer International Publishing. https://doi.org/10.1007/978-3-030-37983-4_7

Kumagai, S., & Ilorio, F. (2020). *Building trust in government through citizen engagement*. World Bank.

Latifi, G. R., Monfared, M. P., & Khojasteh, H. A. (2022). Gamification and citizen motivation and vitality in smart cities: A qualitative meta-analysis study. *GeoJournal*, *87*(2), 1217–1230. https://doi.org/10.1007/s10708-020-10295-0

Lee, C.-S., Foo, J.-J., Sangar, V. J., Chan, P.-Y., Hor, W.-K., & Chan, E.-K. (2017). A Knowledge Management-Extended Gamified Customer Relationship Management System. *2017 International Conference on Soft Computing, Intelligent System and Information Technology (ICSIIT)*, 341–346. https://doi.org/10.1109/ICSIIT.2017.46

Li, X., Wu, L., Xie, T., & Wang, T. (2023). The evolution of public participation under dynamic government intervention in nuclear NIMBY events: A network evolutionary game method. *Environmental Science and Pollution Research*, *30*(24), 65026–65040. https://doi.org/10.1007/s11356-023-26662-6

Lopez, L. S., Basu, A., Blagrave, K., Bove, G., Stewart, K., Bazely, D., & Sharma, S. (2024). Establishing a long-term citizen science project? Lessons learned from the Community Lake Ice Collaboration spanning over 30 yr and 1000 lakes. *Limnology and Oceanography Letters*, *9*(2), 99–111.

Martín-Martín, A., Orduna-Malea, E., Thelwall, M., & López-Cózar, E. D. (2018). Google Scholar, Web of Science, and Scopus: A systematic comparison of citations in 252 subject categories. *Journal of Informetrics*, *12*(4), 1160–1177.

Mendez, J. I., Ponce, P., Meier, A., Peffer, T., Mata, O., & Molina, A. (2019). Framework for promoting social interaction and physical activity in elderly people using gamification and fuzzy logic strategy. *2019 IEEE Global Conference on Signal and Information Processing (GlobalSIP)*, 1–5.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://doi.org/10.1109/GlobalSIP45357.2019.8969110
Michael, D., & Chen, S. (2011). *Serious games: Games that educate, train, and inform* (Nachdr.). Course Technology.
Minge, M., Bürglen, J., & Cymek, D. H. (2014). Exploring the Potential of Gameful Interaction Design of ICT for the Elderly. In C. Stephanidis (Ed.), *HCI International 2014—Posters' Extended Abstracts* (Vol. 435, pp. 304–309). Springer International Publishing. https://doi.org/10.1007/978-3-319-07854-0_54
Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group*, t. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine*, *151*(4), 264–269.
Moreira, F., Ferreira, M. J., Escudero, D. F., Pereira, C. S., & Durao, N. (2020). Teaching and learning Modelling and Specification based on gamification. *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)*, 1–6. https://doi.org/10.23919/CISTI49556.2020.9140829
Morrison, A., Polisena, J., Husereau, D., Moulton, K., Clark, M., Fiander, M., Mierzwinski-Urban, M., Clifford, T., Hutton, B., & Rabb, D. (2012). The effect of English-language restriction on systematic review-based meta-analyses: A systematic review of empirical studies. *International Journal of Technology Assessment in Health Care*, *28*(2), 138–144.
Mossberger, K., Tolbert, C. J., & McNeal, R. S. (2007). *Digital citizenship: The Internet, society, and participation*. MIt Press.
Padilla-Zea, N., Burgos, D., Holloway, G., & Cullen, J. (2022). Social interaction and gamification with youth at risk of social exclusion: The technological approach of the Keystone project. *Entertainment Computing*, *43*, 100502. https://doi.org/10.1016/j.entcom.2022.100502
Palacin-Silva, M. V., Knutas, A., Ferrario, M. A., Porras, J., Ikonen, J., & Chea, C. (2018). The Role of Gamification in Participatory Environmental Sensing: A Study In the Wild. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–13. https://doi.org/10.1145/3173574.3173795
Peischl, B., Schantl, J., & Holzinger, A. (2014). Energizing People's Work—Transforming Organizations Through Gamification: *Proceedings of the 11th International Conference on E-Business*, 201–208. https://doi.org/10.5220/0005050502010208
Pflanzl, N., Classe, T., Araujo, R., & Vossen, G. (2017). Designing Serious Games for Citizen Engagement in Public Service Processes. In M. Dumas & M. Fantinato (Eds.), *Business Process Management Workshops* (Vol. 281, pp. 180–191). Springer International Publishing. https://doi.org/10.1007/978-3-319-58457-7_14
Prestopnik, N. R., & Crowston, K. (2011). Gaming for (Citizen) Science: Exploring Motivation and Data Quality in the Context of Crowdsourced Science through the Design and Evaluation of a Social-Computational System. *2011 IEEE Seventh International Conference on E-Science Workshops*, 28–33. https://doi.org/10.1109/eScienceW.2011.14
Prestopnik, N. R., & Tang, J. (2015). Points, stories, worlds, and diegesis: Comparing player experiences in two citizen science games. *Computers in Human Behavior*, *52*, 492–506. https://doi.org/10.1016/j.chb.2015.05.051
Prestopnik, N., & Souid, D. (2013). Forgotten island: A story-driven citizen science adventure. *CHI '13 Extended Abstracts on Human Factors in Computing Systems*, 2643–2646. https://doi.org/10.1145/2468356.2479484
Purwanto, A., Zuiderwijk, A., & Janssen, M. (2020). Citizen engagement with open government data: Lessons learned from Indonesia's presidential election. *Transforming Government: People, Process and Policy*, *14*(1), 1–30.
Quecke, A., & Mariani, I. (2021). How to design taskification in video games. A framework for purposeful game-based crowdsourcing. *CEUR Workshop Proceedings*, *2934*.
Raftopoulos, M. (2020). Has gamification failed, or failed to evolve? Lessons from the frontline in information systems applications. *GamiFIN*, 21–30.
Rehm, S., Foth, M., & Mitchell, P. (2018). DoGood: Examining gamification, civic engagement, and collective intelligence. *AI & SOCIETY*, *33*(1), 27–37. https://doi.org/10.1007/s00146-017-0711-x
Resek, C. L., Siniscalchi, P. P., Caetano, B. P., Oliveira, K. W. R., Paula, M. M. V., & Souza, J. M. (2024). Gamification of Citizen Participation: A Systematic Mapping. *IEEE Transactions on Games*, *16*(1), 1–15. https://doi.org/10.1109/TG.2022.3216750
Romero-Hernandez, A., Gonzalez Riojo, M., Diaz-Faes-Perez, C., & Manero-Iglesias, B. (2018). The Courtesy of Spain: Theater for the New Generations. *IEEE Revista Iberoamericana de Tecnologias Del Aprendizaje*, *13*(3), 102–110. https://doi.org/10.1109/RITA.2018.2862738
Ronzhyn, A., Wimmer, M. A., Viale Pereira, G., & Alexopoulos, C. (2020). Gamification in Public Service Provisioning: Investigation of Research Needs. *The 21st Annual International Conference on Digital Government Research*, 294–300. https://doi.org/10.1145/3396956.3398256
Schell, R., & Kaufman, D. (2016). Cognitive Benefits of Digital Games for Older Adults—Strategies for Increasing Participation: *Proceedings of the 8th International Conference on Computer Supported Education*, 137–141. https://doi.org/10.5220/0005878501370141
Schrape, N. (2014). *Gamification and governmentality*. meson press.
Sergeyeva, O., Bogomiagkova, E., Orekh, E., & Kolesnik, N. (2020). Gamification as a Trend in the Development of Civic and Political Participation. In A. Chugunov, I. Khodachek, Y. Misnikov, & D. Trutnev (Eds.), *Electronic Governance and Open Society: Challenges in Eurasia* (Vol. 1135, pp. 125–137). Springer

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

International Publishing. https://doi.org/10.1007/978-3-030-39296-3_10
Sheldon, K. M., & Elliot, A. J. (1999). Goal striving, need satisfaction, and longitudinal well-being: The self-concordance model. *Journal of Personality and Social Psychology*, *76*(3), 482.
Sigmund, K., & Nowak, M. A. (1999). Evolutionary game theory. *Current Biology*, *9*(14), R503–R505.
Steffens, F., Marczak, S., Figueira Filho, F., Treude, C., & Souza, C. R. (2017). A preliminary evaluation of a gamification framework to jump start collaboration behavior change. In *2017 IEEE/ACM 10th International Workshop on Cooperative and Human Aspects of Software Engineering (CHASE* (pp. 90–91). IEEE.
Sun, C., Liu, J., & Lu, G. (2023). Collaborative strategies of multiple stakeholders in green innovation of megaprojects based on a three-group evolutionary game. *Developments in the Built Environment*, *16*, 100279. https://doi.org/10.1016/j.dibe.2023.100279
Tennent, P., Pantidi, N., & Benford, S. (2016, July). *Playful Campaigning*. Proceedings of the 30th International BCS Human Computer Interaction Conference. https://doi.org/10.14236/ewic/HCI2016.39
Thiel, S.-K. (2015). Investigating the influence of game elements on civic engagement. *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers - UbiComp '15*, 819–823. https://doi.org/10.1145/2800835.2804403
Thiel, S.-K., & Lehner, U. (2015). Exploring the effects of game elements in m-participation. *Proceedings of the 2015 British HCI Conference*, 65–73. https://doi.org/10.1145/2783446.2783587
Thiel, S.-K., Reisinger, M., Röderer, K., & Fröhlich, P. (2016). Playing (with) Democracy: A Review of Gamified Participation Approaches. *JeDEM - eJournal of eDemocracy and Open Government*, *8*(3), 32–60. https://doi.org/10.29379/jedem.v8i3.440
Torres-Toukoumidis, Á., Romero-Rodríguez, L. M., Aguaded, I., Pérez-Rodríguez, A., & Sandoval, Y. (2017). Procedural model in the evaluation of public policy through gamification. *Revista de Administração Pública*, *51*(5), 810–827.
Van Zoonen, L. (2020). Data governance and citizen participation in the digital welfare state. *Data & Policy*, *2*, e10. https://doi.org/10.1017/dap.2020.10
Vanolo, A. (2019). Playable Urban Citizenship: Social Justice and the Gamification of Civic Life. In P. Cardullo, C. Di Feliciantonio, & R. Kitchin (Eds.), *The Right to the Smart City* (pp. 57–69). Emerald Publishing Limited. https://doi.org/10.1108/978-1-78769-139-120191004
Verba, S., Schlozman, K. L., & Brady, H. E. (1995). *Voice and equality: Civic voluntarism in American politics*. Harvard University Press.
Vicens, J., Perelló, J., & Duch, J. (2018). Citizen Social Lab: A digital platform for human behavior experimentation within a citizen science framework. *PLOS ONE*, *13*(12), e0207219. https://doi.org/10.1371/journal.pone.0207219
Wang, X., Cho, S.-H., & Scheller-Wolf, A. (2021). Green Technology Development and Adoption: Competition, Regulation, and Uncertainty—A Global Game Approach. *Management Science*, *67*(1), 201–219. https://doi.org/10.1287/mnsc.2019.3538
Wilis, N., & Parningotan Manik, L. (2022). The Effect of Visual Appeal, Social Interaction, Enjoyment, and Competition on Mobile Esports Acceptance by Urban Citizens. *Interdisciplinary Journal of Information, Knowledge, and Management*, *17*, 601–624. https://doi.org/10.28945/5045
Wohlin, C. (2014). Guidelines for snowballing in systematic literature studies and a replication in software engineering. *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering*, 1–10.
Wolf, M. J. P. (Ed.). (2002). The Medium of the Video Game. In *The Medium of the Video Game* (pp. 193–200). University of Texas Press. https://doi.org/10.7560/791480-013

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

How Could Public Libraries Empower Communities to Participate in Government AI Initiatives? A Practical View of Benefits and Challenges

Zong-Xian Huang [a], *Mila* Gascó-Hernandez [b], *J. Ramon* Gil-Garcia [c].

[a] Rockefeller College of Public Affairs and Policy & Center for Technology in Government, University at Albany – SUNY, Albany, NY, USA, zhuang7@albany.edu, 0000-0002-3751-6583.

[b] Rockefeller College of Public Affairs and Policy & Center for Technology in Government, University at Albany – SUNY, Albany, NY, USA, mgasco@albany.edu, 0000-0002-6308-8519.

[c] Rockefeller College of Public Affairs and Policy & Center for Technology in Government, University at Albany – SUNY, Albany, NY, USA, and Universidad de las Americas Puebla, Mexico, jgil-garcia@albany.edu, 0000-0002-1033-4974.
Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. Public libraries hold significant potential for advancing inclusive civic engagement in government Artificial Intelligence (AI) initiatives. Drawing on interviews with 34 staff members from three public libraries across the United States—Palo Alto Public Library (PAPL) in California, Queens Public Library (QPL) in New York, and Schaumburg Township District Library (STDL) in Illinois—this study examines the AI-related programs offered by these libraries, along with the benefits, costs, and challenges associated with designing and implementing these programs. Built on the purposes of increasing awareness of patrons about AI and fostering competencies of patrons in using AI tools, public libraries offer various AI-related programs that create notable benefits for their patrons and the libraries themselves. Moreover, when designing and implementing AI-related programs, challenges such as insufficient staff expertise and limited staff engagement, as well as the lack of a unified and comprehensive strategy to promote AI-related programs to the public, must be addressed. This study also discusses that public libraries currently focus on informing citizens rather than higher levels of civic engagement, such as collaboration and empowerment. However, we argue that public libraries already provide a strong foundation for promoting civic engagement in government AI initiatives by informing citizens about the fundamentals of AI and enabling them to explore specific AI tools and applications. Future studies can build on this foundation to develop actionable strategies that public libraries can use to achieve more advanced levels of civic engagement in government AI initiatives.

Keywords. Artificial Intelligence, Public Libraries, Case Study, Civic Engagement, Community Involvement, Challenges, Benefits
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1034

1. Introduction

Artificial intelligence (AI) has been increasingly adopted in various social contexts, offering a range of opportunities and risks not only to individual users but also to the broader community. For instance, several studies have recognized that AI systems can reflect and even amplify existing societal biases against marginalized populations due to the data used for the learning processes of AI systems (Bird et al., 2024; Fountain, 2022; Papakyriakopoulos & Mboya, 2023; Valle-Cruz et al., 2024). To address some of the harms and risks of AI, scholars and practitioners advocate for public engagement to incorporate diverse stakeholders' knowledge and insights across sectors and fields (European Commission, 2019). Specifically, by including the voices of a broader range of stakeholders, participatory approaches to AI initiatives can ensure transparency and accountability in implementing AI systems while fostering an environment that prioritizes inclusion and safety in the design of AI tools (Birhane et al., 2022). Nevertheless, clear strategies to engage communities in government AI initiatives and the specific identification of spaces where such engagement can take place remain lacking (Wilson, 2022).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Previous studies address the role of public libraries in the Internet age. In this respect, public libraries have continuously evolved in the digital era to respond to the changing demands of communities, expanding their roles beyond traditional service providers or information repositories. Currently, public libraries can provide broadband and technology to bridge the digital divide, offer safe and neutral spaces for community discussions, and serve as community-center innovation hubs (Buyannemekh, Gascó-Hernandez, et al., 2024; Buyannemekh, Gil-Garcia, et al., 2024; Scott, 2011b). In the AI age, public libraries are also expected to remain active in empowering users and communities, striving to engage with community stakeholders and gather user feedback to ensure inclusive and equitable AI implementation (Hodonu-Wusu, 2024). In light of this, we argue that public libraries could also be essential in spearheading inclusive civic participation in government AI initiatives, by serving as trusted learning spaces where individuals and groups can equally access resources and knowledge, and engage in meaningful dialogues about AI and its societal implications.

However, despite public libraries being viewed as critical hubs for leveraging the benefits and mitigating the risks of AI for the communities they serve, empirical evidence and systematic knowledge on the implementation and impact of such programs remain limited. To address this gap, this study examines AI-related programs offered in public libraries, based on interviews conducted in three public libraries where AI programs have been implemented and promoted to the public. Specifically, this study focuses on two key research questions: (1) what are the purposes of providing AI-related programs in public libraries, and (2) what are the benefits, costs, and challenges of designing and implementing AI-related programs in public libraries?

2. Literature review

Given the potential impacts of AI on society, how to amplify its benefits while mitigate its risks has become an urgent question for both scholars and practitioners (Dwivedi et al., 2021; Medaglia et al., 2023; Sousa et al., 2019; Wirtz & Müller, 2019; Valle-Cruz et al, 2024; Zuiderwijk et al., 2021). Previous studies have argued that the involvement of a diverse range of stakeholders in the development of AI systems could ensure they are both beneficial and equitable (Moon, 2023). This section discusses the approach of inclusive civic engagement in AI initiatives, exploring both benefits and challenges. Furthermore, it reviews the role of public libraries in developing smart citizens, providing spaces for community innovation, and enabling citizen participation, illustrating how public libraries can serve as crucial actors in advancing an inclusive civic engagement approach.

2.1 Inclusive civic engagement in AI initiatives

The benefits of promoting an inclusive civic engagement approach have been widely acknowledged by researchers. For instance, Birhane et al. highlight several advantages of the participatory approach to AI, including the inclusion of marginalized communities, the enhancement of collective knowledge, the empowerment of communities, and the transformation of the relationships between AI designers and users (Birhane et al., 2022). Furthermore, by formalizing mechanisms and processes that evaluate the social and ethical implications of AI systems for stakeholders, AI systems can better serve public interests rather than being driven solely by corporate priorities (Gilman, 2022; Moon, 2023). As a result, a civic engagement approach to AI holds a normative justification to drive long-term benefits for the public, by democratizing AI systems as public goods that prioritize the inclusive well-being of diverse stakeholders in a sustainable manner (Maas & Inglés, 2024; Sieber et al., 2024; Taylor et al., 2024).

Aligned with the necessity of incorporating a broader range of stakeholders in an inclusive manner, several countries and international organizations have begun developing ethical governance standards to encourage civic engagement in AI initiatives across various sectors and disciplines (European Commission, 2019; Wilson, 2022). For instance, in the process of algorithmic impact assessment—a primary method for promoting algorithmic accountability—the institution employing the algorithm is expected to include multiple stakeholders in order to anticipate potential harms (Gilman, 2022). Additionally, some scholars advocate for algorithm audits, emphasizing the importance of assessing algorithms' negative impacts on stakeholders' rights in different contexts (Brown et al., 2021), as well as evaluating the accuracy, interpretability, and unintended consequences of AI systems (Engler, 2021). These efforts constitute the legitimate foundation for promoting inclusive civic engagement in AI initiatives.

However, in practice, promoting inclusive civic engagement in AI is not without challenges. One of the most noticeable challenges is symbolic participation or "window dressing," which refers to superficial involvement that lacks genuine influence or power (Gilman, 2022). As criticized by scholars, some civic engagement activities frame citizens as "customers" or "users" of AI systems, rather than active participants with meaningful input into the design, implementation, and oversight of these AI applications that impact their interests and rights (Birhane et al., 2022; Sieber et al., 2024; Taylor et al., 2024). Delgado et al. (2023) examine this wave of the "participatory turn" in AI design, finding that most projects primarily operate in a consultative mode that aims to elicit preferences and values from stakeholders instead of granting them full ownership of the projects.

Another challenge undermining genuine empowerment in AI initiatives is the prevalence of abstract strategies that recognize the importance of civic engagement without establishing concrete activities. According to Wilson's

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

analysis of 16 national strategies for AI, there is a lack of specific civic engagement initiatives and limited emphasis on engagement values (e.g., democracy, deliberation, and participation) in the AI strategies of most developed countries (Wilson, 2022). This gap highlights the need for actionable plans that go beyond rhetoric endorsement on the participatory approach to AI. Without legal and institutional frameworks that communicate actual stakeholder influence in the formation of AI systems, civic engagement can become a mere formality and fail to address the power imbalance between AI developers and other stakeholders (Massaro et al., 2022).

In light of these challenges—ranging from symbolic participation that fails to grant genuine influence, to the lack of concrete institutional and legal frameworks for engagement—it becomes essential to identify specific entities and mechanisms capable of supporting truly inclusive civic involvement in government AI initiatives. As longstanding community institutions, this study argues that public libraries are uniquely positioned to address some of these shortcomings. Specifically, public libraries offer accessible spaces and resources to foster community participation in an inclusive manner, allowing the involvement of participants from marginalized groups. Moreover, due to their historical legacy, public libraries generally have a high level of trust from the public and multiple stakeholders, positioning them as credible mediators capable of bridging diverse interests and fostering meaningful dialogue on AI-related issues. In the next subsection, we will review the studies that underscore how public libraries act as community hubs in empowering the communities they serve.

2.2 Public libraries as community hubs

Public libraries serve their communities not only as trusted institutions but also as community hubs that address the evolving needs of patrons (Buyannemekh et al., 2023; Buyannemekh, Gascó-Hernandez, et al., 2024; Buyannemekh, Gil-Garcia, et al., 2024; Hernández-Pérez et al., 2022; Sherman & Sanders, 1989; Yerden et al., 2021). Scholars have explored the role of public libraries in fostering community engagement, arguing that public libraries can encourage social inclusion and equity by functioning as "third places" that are inclusive and welcoming to all (Aabø & Audunson, 2012; Gasco-Hernandez et al., 2022; Scott, 2011b). Additionally, public libraries offer programs that serve as access points to information, benefiting community involvement and becoming vital resources for enhancing the civic health of their communities through conversation and action (Cocciolo, 2013; Scott, 2011a). These various pieces of evidence reflect that public libraries have the capacity to serve as transformative spaces, fostering both individual and collective empowerment within their communities.

Public libraries are also at the forefront of equipping their communities to navigate the rapidly digitalizing world, playing multiple roles. First, public libraries can foster the development of smart citizens by educating them about emerging technologies. For instance, in the context of smart city initiatives, researchers have highlighted that public libraries can act as key players in the governance of such projects (Mersand et al., 2019; Yerden et al., 2021). In addition, public libraries are uniquely positioned to enhance digital literacy among underserved groups and contribute to the advancement of inclusive and sustainable smart communities (Buyannemekh, Gil-Garcia, et al., 2024). Also, to respond to the increasing popularity of AI, studies have shown that public libraries can support STEM education and provide career training for in-demand skills to address trends in automation and AI (Barbakoff, 2021).

Second, public libraries provide spaces for community innovation through initiatives such as makerspaces and living labs. They serve not only as centers for co-creation between various stakeholders (Gasco-Hernandez et al., 2022; Hernández-Pérez et al., 2022) but also as community innovation hubs where technical infrastructure is accessible to the public (Buyannemekh, Gil-Garcia, et al., 2024; Mersand et al., 2019). Lastly, public libraries occupy a unique niche in enabling citizen participation in emerging technologies, fostering engagement and empowering communities to contribute to technological advancements. For example, public libraries have recently begun offering accessible AI education to the public, contributing to the enhancement of algorithmic literacy among their patrons (Ridley & Pawlick-Potts, 2021) and democratizing AI for communities (Finley, 2019). In a similar vein, by offering programs that raise awareness and build competencies in AI, public libraries have the potential to foster an inclusive approach to civic engagement around AI (Huang, Gasco-Hernandez, et al., 2024).

It is important to note that the role of public libraries have evolved over time from offering pioneering programs to advance Internet literacy and develop accessible infrastructure (Poustie, 1999), to offering e-learning opportunities and cultivating technological fluency within the communities they serve (Abumandour, 2021; Agyekum, 2022). Building upon this cornerstone, in the AI era, public libraries have undergone a profound transformation from static repositories of books to dynamic actors, functioning as educational centers and innovation hubs where citizens can access accurate information about AI, learn its essential principles, and innovate with the assistance of AI-driven applications (Adesina & Zubairu, 2023; Garnier et al., 2024; Huang, Prasad, et al., 2024). Moreover, recognizing that AI literacy is increasingly being positioned as an important skill for individuals, public libraries are adapting to these evolving demands by offering targeted courses that foster AI literacy and algorithmic literacy (Garnier et al., 2024; Ridley & Pawlick-Potts, 2021).

Therefore, in line with arguments highlighting the necessity of investing in mechanisms for communities to

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

collectively identify problems and act on AI (Moon, 2023; Taylor et al., 2024; Wilson, 2022; Young et al., 2024), we argue that public libraries are important yet often overlooked contributors to advancing this agenda. As suggested by scholars, the approach of community-based engagement in AI does not necessarily conflict with the globalized functioning of commercial AI systems (Young et al., 2024). Instead, by recognizing the importance of redistributing power toward affected communities, AI systems can serve the broader public in a more inclusive and equitable manner. That is, public libraries can be a catalyst in the process of fulfilling this goal of meaningful civic engagement in government AI initiatives.

3. Research design

To address the research questions, this study adopts a comparative case study approach. This approach enables the analysis and comparison of contextual differences and similarities across cases, thereby uncovering common patterns and unique practices related to AI initiatives in different public libraries. This section outlines the data collection process and provides background information on the selected public libraries. For the comparative, three public libraries—Palo Alto Public Library (PAPL) in California, Queens Public Library (QPL) in New York, and Schaumburg Township District Library (STDL) in Illinois—were selected as cases based on four criteria: (1) previous and current offerings of AI-related programs, (2) geographical diversity, (3) demographic diversity, and (4) research access. By examining multiple cases situated in areas with diverse citizen attributes, this study aims to provide novel nuances into the emerging practices in public libraries while identifying patterns and themes across cases. It is important to note that these three public libraries do not only offer AI-related events as one-off occurrences; rather, all three cases have continually provided AI-related programs with different goals. As a result, we argue that these public libraries invest sustained efforts in AI-related programs and consider them valuable sources for gaining insights into our research questions.

3.1 The data collection process

Owe collected data from two different sources: official documentation and in-depth interviews. First, we began by mapping the profiles of AI programs in the three selected libraries by scanning and reviewing the official websites of each library to gather information on AI-related events and documents. Additionally, a broader online search using search engines was conducted to find content from public reports and news articles, providing more background information on these cases and helping us identify potential interviewees for the next stage of the study.

Second, to gain a deeper understanding of the three cases presented in this paper, the research team conducted a total of 34 in-depth interviews with current and former staff members from each library between September and November 2024. Specifically, 8 in-person interviews were conducted for PACL, 15 online interviews were conducted for QPL, and 11 in-person interviews were conducted for STDL. Interviewees were involved in the design, implementation, or management of AI-related programs and included librarians, IT staff, library program coordinators, executive leaders within library branches (e.g., branch directors), and library services managers responsible for digital and innovative programs.

Each interview lasted between one and two hours, covering discussions on the purpose of AI-related programs, the benefits, costs, and challenges of offering these programs, and the potential strategies and considerations regarding civic engagement in AI initiatives. As part of the process, informed consent was obtained from all interviewees, with researchers explaining the study's purpose, participants' rights, and the measures taken to ensure confidentiality. The recordings of the interviews were transcribed and coded by one of the authors in this paper to ensure consistency.

For the first research question, which focuses on the purpose of offering AI-related programs in public libraries, this study employed a deductive coding approach based on categories developed in prior studies and reports (Huang, Gasco-Hernandez, et al., 2024; Huang, Prasad, et al., 2024). This strategy enables us to achieve more consistent findings, as it is built upon prior studies that mapped a broad range of cases from various public libraries across the United States. Specifically, following prior studies (Huang, Gasco-Hernandez, et al., 2024; Huang, Prasad, et al., 2024), this research identified two primary purposes for public libraries to implement their AI-related programs: raising awareness and building competencies among their patrons. The former includes activities such as conversations on AI and lectures introducing AI; the latter comprises hands-on workshops and makerspaces where patrons can learn about the practical applications of AI. Rooted in these two purposes, this study delved into examining these AI programs from the perspectives of library staff. Regarding the second research question, which examines the benefits, costs, and challenges of offering these AI-related programs, we adopted an inductive coding approach to identify emerging themes and insights directly from the interview data.

3.2 The background of interviewed libraries

Palo Alto Public Library (PACL)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Palo Alto City, where PACL primarily serves, forms a hub of innovation with about 68,572 residents, predominantly White (48.5%) and Asian (35.4%), alongside smaller Hispanic, Black, and multi-racial populations. The city is characterized by a highly educated and relatively affluent community, with nearly 75% of the population holding a bachelor's degree or higher and a median household income of $194,782. Since 2017, Palo Alto City Library (PACL) has launched multiple AI-focused initiatives, beginning with the Robo Dojo Program, which explored robotics and coding, including speech recognition, natural language processing, and facial recognition. In 2023, PACL introduced AI at PACL, a series of workshops, lectures, and community conversations covering AI's impact in higher education, creative storytelling applications, and digital literacy for seniors.

Queens Public Library (QPL)

The Queens Borough, where QPL primarily operates, is characterized by a dense and highly diverse population. The borough has a population of approximately 2.4 million people, with a racial and ethnic composition that includes roughly 28% Hispanic or Latino residents, 27% Asian, 25% White, and 17% Black or African American individuals. The median household income is around $82,000, yet about 13% of the population lives below the poverty line, highlighting significant economic disparities within the community. Educationally, approximately 35% of residents aged 25 and older have attained a bachelor's degree or higher. Since 2020, QPL has launched three AI-related programs to provide educational and accessible information to the diverse populations of Queens borough. The first program, "We Are AI," introduces basic AI concepts and examines social and ethical dimensions. Additionally, workshops on generative AI tools—such as ChatGPT and Google Gemini—support patrons' job searches, resume writing, and productivity enhancement. For younger audiences, QPL also provides robotics programs integrate with the library's STEM curricula, fostering early interest in AI-related technologies.

Schaumburg Township District Library (STDL)

Schaumburg Township in Cook County, which STDL predominantly caters to, has evolved from a farming community into a highly diversified urban center over the past four decades. It is home to 134,809 residents, with a demographic composition of 56.38% White, 23.57% Asian, 14.88% Hispanic or Latino, and 4.53% African American. The median household income is $91,534, and only 8.7% live below the poverty line, while nearly half (46.9%) hold a bachelor's degree or higher, reflecting a solidly middle-class community with a sound economy and strong access to quality education. STDL offers several AI programs designed as educational courses to equip patrons with essential 21st-century skills. These include an introductory AI lecture, "Conversation with AI," which demonstrates generative AI tools interactively, and a recurring workshop, "ChatGPT & AI," which explores how ChatGPT works, its practical applications, and broader AI-related issues.

4. Lessons about purposes, benefits, costs, and challenges

As preliminary results, this section summarizes the main insights based on the interview data. Due to space constraints in the manuscript, we primarily integrate the results of common themes and unique perspectives emerging from the interviews without including direct quotations. Each of the two research questions is addressed in one of the following subsections, respectively.

4.1 Purposes of offering AI-related programs in public libraries

The purposes of offering AI programs vary, with two primary themes emerging from the interviews: (1) increasing awareness about AI, (2) building competencies on using AI tools. Echoing the literature mentioned above, it shows that public libraries have gradually evolved from static repositories of books into more active educational actors in response to trending AI technologies in society.

Increasing awareness of patrons about AI

As an institution whose primary role is a facilitator of information dissemination, public libraries have long served as trusted community hubs for information and learning, and their role in increasing patrons' awareness of AI is a natural extension of that mission. Staff members at various libraries emphasize the importance of keeping patrons informed about emerging AI technologies, enhancing community members' awareness and understanding of AI. For instance, staff members at PACL and STDL emphasize that these libraries design and offer AI-related programs with the goal of equipping patrons with balanced, accurate, and forward-thinking information and awareness about AI technologies. Both PACL and STDL have hosted lectures discussing how AI impacts individuals and exploring safe ways to leverage its benefits.

Similarly, with AI-related programs featuring introductory sections discussing the ethical risks and harms of automated systems conducted by local governments, staff members at QPL designed their AI programs to enable community members to critically evaluate the use of automated decision-making systems by government agencies. In doing so, public libraries can become not only the catalysts for raising public awareness on the implications of AI but also the forefront institutions for disseminating unbiased insights into how AI works.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Furthermore, public libraries facilitate conversations on AI to showcase emerging technologies to their patrons, creating a space for meaningful discussions on AI. Through interactive conversations about AI and other emerging technologies, such as blockchain, staff members at both QPL and PACL emphasize that these discussion-oriented programs not only enhance patrons' basic understanding of these complex topics but also open possibilities for rethinking the broader implications of these technologies. These efforts reflect that public libraries are becoming a crucial forum for potential further civic engagement in government AI initiatives.

For younger audiences growing up in an AI-driven world, public libraries also offer AI-related programs designed to spark their interest and raise their awareness of AI. For instance, robotics classes at QPL and PACL provide students with hands-on experimentation with AI and related technologies, fostering curiosity and enthusiasm about AI. As a result, public libraries establish a positive cycle of continuous learning and dialogue on AI, cultivating patrons' interest and awareness in this subject.

Building competencies of patrons on using AI tools

Public libraries are leveraging AI-related programs to help patrons build competencies in emerging AI tools. At STDL, for instance, staff members emphasize the importance of showing how individuals are already using AI every day—often without realizing it—and then introducing newer tools such as ChatGPT to expand their horizons. By focusing on both the potential benefits and the limitations of AI, this course invites participants to understand, discuss, and apply these resources in their personal and professional lives.

In addition, QPL offers AI workshops designed to enhance career development and build STEM competencies for all ages, from adults exploring generative AI platforms like Google Gemini to kids and teenagers engaging with robotics and coding. According to one QPL program coordinator, the goal is to guide patrons toward envisioning how these technologies might shape their future careers.

Compared to other two cases, PACL underscores the broader mission of ensuring equitable access to AI education and resources. A staff member notes that even in an area considered relatively affluent and educated, not every patron has the same opportunities to access educational resources about AI. Therefore, PACL aims to help bridge the digital divide and position itself as a catalyst for community learning and professional development through equipping users with practical AI skills.

4.2 Benefits, costs, and challenges of offering AI-related programs

Offering and implementing these AI-related programs at public libraries engenders various benefits, along with associated costs and challenges. This underscores the role of public libraries in continually contributing to their communities in the context of AI while navigating the complexities of resource allocation and program execution.

Benefits

Public libraries' AI-related programs offer multiple benefits, beginning with enhancing patrons' knowledge and literacy about emerging technologies. As staff members from various institutions note, these programs help the public recognize how AI seamlessly integrates into everyday life. By providing comprehensive, accessible, and accurate information about AI, public libraries empower patrons and help them make sense of the presence of AI technologies in their daily lives. In doing so, public libraries not only reduce misconceptions about AI but also cultivate a sense of digital preparedness within the community.

Another key benefit lies in boosting patrons' confidence in exploring AI for personal or professional pursuits. Instructors at PACL and STDL noted that participating in these AI programs encourages patrons to envision future applications of AI while providing transformative long-term benefits, such as advancing their careers or exploring new interests. In other words, these introductory experiences could serve as catalysts for patrons' future engagement with cutting-edge innovations.

In addition to the benefits for patrons, public libraries themselves can also reap substantial advantages from offering these AI-related programs. For instance, staff members at STDL and QPL underscore that AI programs can attract new audiences keen on AI education and strengthen public libraries' roles as trusted information centers. Moreover, as emphasized by a librarian at PACL, these AI programs enhance the public libraries' reputation and recognition, fostering stronger connections with their communities.

Costs

Offering AI-related programs in public libraries generally entails costs, primarily related to staff time, speaking fees, and the infrastructure required for these programs. At STDL, staff members must allocate specific time slots to ensure the continuity of generative AI programs. Furthermore, as public libraries often rely on external experts to host courses or programs, speaking fees for these experts may represent a significant expense. Lastly, some

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

interviewees highlighted costs associated with infrastructure updates. For instance, modest hardware upgrades—such as updating a graphics card—may be necessary to support advanced AI tools available in public library makerspaces.

Nevertheless, compared to the benefits associated with offering AI programs, public libraries do not appear to need to spend an exorbitant amount on providing these events and services. For instance, senior service librarians at PACL highlight that volunteers or guest speakers can significantly reduce expenses, enabling events to run at little to no cost. Moreover, while libraries such as QPL and PACL have acquired subscriptions for generative AI tools and made partial updates to their technological infrastructure, these costs are generally perceived as reasonable investments and do not impose significant financial strain on the operations of public libraries.

Challenges

The challenges of offering AI programs are not absent. Since AI programs are just one of many tasks that library staff must manage, developing and maintaining staff expertise in AI-related topics is an urgent challenge for public libraries. For instance, as emphasized by program managers at both QPL and STDL, public libraries face a fundamental challenge in cultivating and retaining staff members with domain knowledge not only to teach AI-related courses but also to design AI-related programs. Without well-trained replacements to sustain these efforts, an AI program may risk collapsing.

Another shared challenge in the three public libraries is how to genuinely encourage more staff to become involved in AI programs and training. If librarians and staff harbor personal misunderstandings or fears about rapidly evolving AI technologies, such as concerns over generative AI tools, the implementation of AI-related programs might be stymied, hindering their ability to effectively educate and engage patrons on these topics. Consequently, nurturing staff motivation and confidence—alongside ensuring adequate training opportunities—is vital.

Last but not least, our observations reveal that none of the three public libraries have developed a comprehensive strategy for designing and promoting AI-related programs to the public. For example, while QPL serves an extremely diverse and expansive area with more than 60 branches and centers, it still lacks a unified strategy to coordinate these efforts. A comprehensive strategy plan for AI-related programs could create greater synergy within a public library system through resource and information sharing. Moreover, by avoiding the siloed style of program development, public libraries can offer a wider range of diverse and complementary programs to better serve their communities.

5. Discussion and conclusion

Based on interviews with 34 staff members from three public libraries in the United States, this study examines the AI-related programs offered by these libraries and how they could help enhance inclusive civic engagement in government AI initiatives. The findings reveal that public libraries focus on two key objectives when designing and implementing AI-related programs: increasing awareness about AI and building competencies on using AI tools. Additionally, with reasonable costs, these programs yield substantial benefits for both patrons and the libraries themselves. However, challenges persist in relation to staff, particularly insufficient staff expertise, limited staff engagement, and the lack of a comprehensive strategy to promote AI-related programs. This echoes previous studies on AI in public libraries (Barbakoff, 2021; Hodonu-Wusu, 2024; Huang, Gasco-Hernandez, et al., 2024; Ridley & Pawlick-Potts, 2021), demonstrating that public libraries can supplement AI education within their communities while highlighting the need for greater investment in specific areas, such as staff development and librarian expertise on AI.

Regarding the role of public libraries in fostering civic engagement in government AI initiatives, our results show that public libraries are currently focused on the initial stages of civic engagement. Based on different degrees of citizen participation proposed by prior studies (Delgado et al., 2023; Gilman, 2022; International Association for Public Participation, 2025; Sieber et al., 2024), public libraries currently offer their AI-related programs to provide balanced and objective information as well as to collect feedback and have conversations about AI. At the present time, we did not observe higher levels of civic engagement in AI, such as collaboration and empowerment, occurring in the public libraries we interviewed. Nevertheless, these observations should not be interpreted as an indication that public libraries do not play a crucial role in civic engagement in AI.

In our opinion, while public libraries have not explicitly enabled inclusive civic engagement in government AI initiatives, they have acknowledged the importance of this agenda and seem willingness to experiment with and launch such programs in the near future. As suggested by the well-known ladder of citizen participation (Arnstein, 2019), civic engagement can be understood as a continuum encompassing different levels of citizen involvement. In this study, public libraries have demonstrated their roles to raise patrons' awareness about AI and gradually build patrons' competencies in using AI. By doing so, it can be reasonably argued that public libraries can lay a solid foundation for higher levels of civic engagement by informing citizens and familiarizing them with the basics of AI.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Civic engagement in AI is a challenging and long-term effort, as emphasized by a variety of studies conducted in different fields (Birhane et al., 2022; Delgado et al., 2023; Taylor et al., 2024; Young et al., 2024), but we argue that public libraries have the potential to advance this challenging agenda by adopting more comprehensive strategies.

For instance, public libraries can explicitly adopt the goals of inclusive civic engagement and digital literacy into their strategic plans, providing clearer guidelines for staff on program design and community outreach. Moreover, since it is crucial to allocate sufficient resources—such as budget and personnel—to effectively implement and scale these AI-related programs, public libraries should consider seeking additional funding and allocating strategic resources to support these initiatives. Last, but not least, enhancing outreach to other community-based organizations, such as school districts, churches, local nonprofits, or government agencies, could contribute significantly to improving the inclusiveness of the agenda for AI, ensuring that diverse community members are engaged in the conversation.

This study contributes to understanding AI-related programs in public libraries and the roles public libraries may play in fostering civic engagement in government AI initiatives. More research on this topic is essential, as public libraries can be key actors in inclusively engaging more citizens and communities in a society where AI increasingly influences various aspects of individuals' lives and governance. Scholars and practitioners can further investigate how to build an actionable framework that public libraries can leverage to achieve a higher level of civic engagement, as well as the drawbacks and opportunities public libraries can address in a participatory approach to AI in their communities. A systematic understanding of the role of public libraries in civic engagement for AI initiatives can not only enable public libraries to achieve their goals and visions but also ensure that AI generates inclusive benefits for the general public.

Funding

This study was partially supported by the Institute of Museum and Library Services (IMLS) under grant No. LG-254889-OLS-23. The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of IMLS.

Contributor Statement

Author 1: Conceptualization, Investigation, Methodology, Writing-Original Draft

Author 2: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – Review & Editing

Author 3: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – Review & Editing

Use of AI

During the preparation of this work, the author(s) used ChatGPT, Grammarly in order to: Grammar and spelling check. After using these tool(s)/service(s), the author(s) reviewed and edited the content as needed and take(s) full responsibility for the publication's content.

Conflict Of Interest (COI)

The authors declare that they have no conflict of interest.

References

Aabø, S., & Audunson, R. (2012). Use of library space and the library as place. *Library & Information Science Research, 34*(2), 138–149. https://doi.org/10.1016/j.lisr.2011.06.002

Abumandour, E.-S. T. (2021). Public libraries' role in supporting e-learning and spreading lifelong education: A case study. *Journal of Research in Innovative Teaching & Learning, 14*(2), 178–217. https://doi.org/10.1108/JRIT-06-2019-0063

Adesina, A. S., & Zubairu, A. N. (2023). Contemporary library and artificial intelligence technology. Alexandria, 33(1–3), 18–30. https://doi.org/10.1177/09557490241231483

Agyekum, B. (2022). Public Libraries: Enacting "public spaces" for community development and lifelong learning. *Journal of Learning Spaces, 11*(1), Article 1. https://libjournal.uncg.edu/jls/article/view/2150

Arnstein, S. R. (2019). A ladder of citizen participation. *Journal of the American Planning Association, 85*(1), 24–34. https://doi.org/10.1080/01944363.2018.1559388

Barbakoff, A. (2021). Building a future-ready workforce: The role of public libraries in creating equitable, resilient,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and entrepreneurial communities. *Public Library Quarterly, 40*(2), 167–181. https://doi.org/10.1080/01616846.2019.1688094

Bird, K. A., Castleman, B. L., & Song, Y. (2024). Are algorithms biased in education? Exploring racial bias in predicting community college student success. *Journal of Policy Analysis and Management, 44*(2), 379-402. https://doi.org/10.1002/pam.22569

Birhane, A., Isaac, W., Prabhakaran, V., Diaz, M., Elish, M. C., Gabriel, I., & Mohamed, S. (2022). Power to the people? Opportunities and challenges for participatory AI. In *Proceedings of the 2nd ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization* (pp. 1-8). https://doi.org/10.1145/3551624.3555290

Brown, S., Davidovic, J., & Hasan, A. (2021). The algorithm audit: Scoring the algorithms that score us. *Big Data & Society, 8*(1), 2053951720983865. https://doi.org/10.1177/2053951720983865

Buyannemekh, B., Gascó-Hernandez, M., & Gil-Garcia, J. R. (2024). Fostering smart citizens: The role of public libraries in smart city development. *Sustainability, 16*(5), Article 5. https://doi.org/10.3390/su16051750

Buyannemekh, B., Gil-Garcia, J. R., & Gascó-Hernández, M. (2023). Exploring emergent collaborations for digital transformation in local governments: The engagement of public libraries in the development of smart cities. *Public Policy and Administration*, 09520767231197600. https://doi.org/10.1177/09520767231197600

Buyannemekh, B., Gil-Garcia, J. R., & Gascó-Hernandez, M. (2024). The expanding role of public libraries in tribal settings: From traditional services to (advanced) digital skills, citizen engagement, and innovation. *Public Library Quarterly*, 1–27. https://doi.org/10.1080/01616846.2024.2430060

Cocciolo, A. (2013). Public libraries and PBS partnering to enhance civic engagement: A study of a nationwide initiative. *Public Library Quarterly, 32*(1), 1–20. https://doi.org/10.1080/01616846.2013.760310

Delgado, F., Yang, S., Madaio, M., & Yang, Q. (2023). The participatory turn in AI design: Theoretical foundations and the current state of practice. In *Proceedings of the 3rd ACM Conference on Equity and Access in Algorithms, Mechanisms, and Optimization* (pp. 1-23). https://doi.org/10.1145/3617694.3623261

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, P. V., Janssen, M., Jones, P., Kar, A. K., Kizgin, H., Kronemann, B., Lal, B., Lucini, B., … Williams, M. D. (2021). Artificial intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management, 57*, 101994. https://doi.org/10.1016/j.ijinfomgt.2019.08.002

Engler, A. (2021). *Auditing employment algorithms for discrimination*. Brookings Institute. https://www.brookings.edu/articles/auditing-employment-algorithms-for-discrimination/

European Commission. (2019). *Ethics guidelines for trustworthy AI*. European Commission. https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai

Finley, T. K. (2019). The democratization of artificial intelligence: One library's approach. *Information Technology and Libraries, 38*(1), Article 1. https://doi.org/10.6017/ital.v38i1.10974

Fountain, J. E. (2022). The moon, the ghetto and artificial intelligence: Reducing systemic racism in computational algorithms. *Government Information Quarterly, 39*(2), 101645. https://doi.org/10.1016/j.giq.2021.101645

Garnier, M., Cussac, M., Delaune, C., Espy, C., & Papon-Vidal, L. (2024). The pivotal role of libraries in sustainable AI development. *Canadian Journal of Information and Library Science, 47*(2), 137–149. https://doi.org/10.5206/cjils-rcsib.v47i2.17699

Gasco-Hernandez, M., Yerden, X., Burke, G. B., & Gil-Garcia, J. R. (2022). The potential role of public libraries in a quadruple helix model of "smart city" development: lessons from Chattanooga, Tennessee. *The Library Quarterly, 92*(4), 419–436. https://doi.org/10.1086/721399

Gilman, M. E. (2022). Beyond window dressing: public participation for marginalized communities in the datafied society. *Fordham Law Review, 91*, 503–555.

Hernández-Pérez, O., Vilariño, F., & Domènech, M. (2022). Public libraries engaging communities through technology and innovation: Insights from the library living lab. *Public Library Quarterly, 41*(1), 17–42. https://doi.org/10.1080/01616846.2020.1845047

Hodonu-Wusu, J. O. (2024). The rise of artificial intelligence in libraries: The ethical and equitable methodologies, and prospects for empowering library users. *AI and Ethics*, 1-11. https://doi.org/10.1007/s43681-024-00432-7

Huang, Z.-X., Gasco-Hernandez, M., Prasad, A., & Gil-Garcia, J. R. (2024). Public libraries and their role in raising awareness about AI and fostering inclusive civic engagement: Current practices and future development. In *Proceedings of the 25th Annual International Conference on Digital Government Research* (pp. 703–710). https://doi.org/10.1145/3657054.3657137

Huang, Z.-X., Prasad, A., Gascó-Hernandez, M., Gil-Garcia, J. R., Adelakun, F., & Rainwater, B. (2024). *Empowering communities: Public libraries, inclusive civic engagement and artificial intelligence*. Center for Technology in Government, University at Albany, SUNY. https://www.ctg.albany.edu/publications/imls2024/

International Association for Public Participation. (2025). *Core values, ethics, spectrum – the 3 pillars of public participation.* International Association for Public Participation. https://www.iap2.org/page/pillars

Maas, J., & Inglés, A. M. (2024). Beyond participatory AI. In *Proceedings of the AAAI/ACM Conference on AI, Ethics, and Society* (Vol. 7, pp. 932-942). https://doi.org/10.1609/aies.v7i1.31693

Massaro, V. A., Dhar, S., Mir, D., & Ryan, N. C. (2022). Carceral algorithms and the history of control: An analysis of the Pennsylvania additive classification tool. *Big Data & Society, 9*(1), 20539517221094002. https://doi.org/10.1177/20539517221094002

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Medaglia, R., Gil-Garcia, J. R., & Pardo, T. A. (2023). Artificial intelligence in government: Taking stock and moving forward. *Social Science Computer Review, 41*(1), 123–140. https://doi.org/10.1177/08944393211034087

Mersand, S., Gasco-Hernandez, M., Udoh, E., & Gil-Garcia, J. R. (2019). Public libraries as anchor institutions in smart communities: Current practices and future development. In *Proceedings of the 52nd Hawaii International Conference on System Sciences* (pp. 3305-3314). http://hdl.handle.net/10125/59766

Moon, M. J. (2023). Searching for inclusive artificial intelligence for social good: Participatory governance and policy recommendations for making AI more inclusive and benign for society. *Public Administration Review, 83*(6), 1496–1505. https://doi.org/10.1111/puar.13648

Papakyriakopoulos, O., & Mboya, A. (2023). Beyond algorithmic bias: A socio-computational interrogation of the google search by image algorithm. *Social Science Computer Review, 41*(4), 1100–1125. https://doi.org/10.1177/08944393211073169

Poustie, K. (1999). Educating for information literacy through the internet: Another role of the public library. *Australasian Public Libraries and Information Services, 12*(2), 60–68. https://doi.org/10.3316/informit.984664459077217

Ridley, M., & Pawlick-Potts, D. (2021). Algorithmic literacy and the role for libraries. *Information Technology and Libraries, 40*(2), Article 2. https://doi.org/10.6017/ital.v40i2.12963

Scott, R. (2011a). Strategies that public libraries use to build communities. *Public Library Quarterly, 30*(4), 307–346. https://doi.org/10.1080/01616846.2011.625604

Scott, R. (2011b). The role of public libraries in community building. *Public Library Quarterly, 30*(3), 191–227. https://doi.org/10.1080/01616846.2011.599283

Sherman, M., & Sanders, J. (1989). Community involvement and support of the public library in the 21st century. *Journal of Library Administration, 11*(1–2), 137–150. https://doi.org/10.1300/J111v11n01_10

Sieber, R., Brandusescu, A., Sangiambut, S., & Adu-Daako, A. (2024). What is civic participation in artificial intelligence? *Environment and Planning B: Urban Analytics and City Science*, 23998083241296200. https://doi.org/10.1177/23998083241296200

Sousa, W. G. de, Melo, E. R. P. de, Bermejo, P. H. D. S., Farias, R. A. S., & Gomes, A. O. (2019). How and where is artificial intelligence in the public sector going? A literature review and research agenda. *Government Information Quarterly, 36*(4), 101392. https://doi.org/10.1016/j.giq.2019.07.004

Taylor, R. R., Murphy, J. W., Hoston, W. T., & Senkaiahliyan, S. (2024). Democratizing AI in public administration: Improving equity through maximum feasible participation. *AI & Society*, 1-10. https://doi.org/10.1007/s00146-024-02120-w

Valle-Cruz, D., García-Contreras, R., & Gil-Garcia, J. R. (2024). Exploring the negative impacts of artificial intelligence in government: The dark side of intelligent algorithms and cognitive machines. *International Review of Administrative Sciences, 90*(2), 353–368. https://doi.org/10.1177/00208523231187051

Wilson, C. (2022). Public engagement and AI: A values analysis of national strategies. *Government Information Quarterly, 39*(1), 101652. https://doi.org/10.1016/j.giq.2021.101652

Wirtz, B. W., & Müller, W. M. (2019). An integrated artificial intelligence framework for public management. *Public Management Review, 21*(7), 1076–1100. https://doi.org/10.1080/14719037.2018.1549268

Yerden, X., Gil-Garcia, R., Gasco-Hernandez, M., & Burke, B. (2021). The role of public libraries in developing smart cities and communities: Comparing the perspectives of local governments and public libraries. In *Proceedings of the 22nd Annual International Conference on Digital Government Research* (pp. 252-263). https://doi.org/10.1145/3463677.3463701

Young, M., Ehsan, U., Singh, R., Tafesse, E., Gilman, M., Harrington, C., & Metcalf, J. (2024). Participation versus scale: Tensions in the practical demands on participatory AI. *First Monday*. https://doi.org/10.5210/fm.v29i4.13642

Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly, 38*(3), 101577. https://doi.org/10.1016/j.giq.2021.101577

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

What do we know about E-participation at the Local Level?

Cláucia Piccoli Faganello [a*], *Edimara Mezzomo Luciano* [b], *Gabriela Viale Pereira* [c].

[a] Dr. Jorge Lacerda Professional Education Center, Santa Catarina State Department of Education, Brazil, claucia.faganello@edu.pucrs.br, ORCID number 0000-0003-2248-8249.

[b] Management Graduate Program, Pontifical Catholic University of Rio Grande do Sul, Brazil, eluciano@pucrs.br, ORCID number 0000-0002-2847-8845

[c] Department for E-Governance and Administration, University for Continuing Education Krems, Austria, gabriela.viale-pereira@donau-uni.ac.at, ORCID number 0000-0002-7602-3052.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. This paper aims to examine the phenomenon of e-participation at the local level. This study addresses the following research question: What is currently known about the transition from participation to e-participation at the local level? This paper employs a systematic literature review to understand the current state of art about e-participation at the local level by identifying and categorizing the relevant structures, assessing the prevailing barriers, recognizing the challenges, and analyzing the potential benefits of e-participation at the local level. The purpose of this research is to provide insight into the existing knowledge base on the transition from traditional forms of participation to e-participation at the local level. The findings indicate that while e-participation presents an opportunity to improve democratic engagement and inclusivity, it also faces substantial challenges, including digital devices, institutional resistance, and the necessity for solid technological infrastructure. These findings have implications for both practice and academic discourse. From a practical perspective, the findings suggest that local governments need to invest in technology and digital literacy programs to ensure effective e-participation. From an academic viewpoint, the study contributes to the existing literature by providing a comprehensive understanding of the dynamics of e-participation and its implications for local governance.

Keywords. Participation, e-participation, local level
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1035

1. Introduction

The idea for this paper starts with the classical article written by Sherry Arnstein (Arnstein, 2002), a valuable contribution to the literature about participation in the public sphere that investigates the changes from participation to e-participation at the local level. In the last century, democracy has altered most countries' reality (Bobbio, 1992). With this, public participation became a vital tool to understand what citizens want from a representative government (Pateman, 1992). Still, without a legally binding or mandatory observance of government decisions, some contributions aren't considered in the decision-making process and do not translate into concrete actions (Dagnino, 2004). Local instances sometimes don't have the possibilities and capabilities to focus on public policies at different levels of government (da Fonseca, 2019). All of these are influenced by the technological changes of the last century (Castells, 2005), and the participation process has also changed. Initially, the participation process was sometimes in-person and sometimes online. This changed with the COVID-19 pandemic because the participation process that was in person needs to change to digital (Criado et al., 2020).

Focusing on participation practices (Bourdieu, 2011), this paper aims to understand the current state of art about e-participation at the local level. To this end, a literature review was conducted to identify the categories, structures, barriers, challenges, and benefits of e-participation at the local level. The paper wants to answer the following question: What do we know about the transition from participation to e-participation at the local level?

This study is based on the assumption that cities have choices (Savitch & Kantor, 2004) and that localism has a particular potential to build movements in local politics in practice (Clarke & Cochrane, 2013). For years, the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

mostly interesting practices of participation started and became strong at the local level or in the municipalities, an example of participatory budgeting (Dagnino, 2002; Fedozzi & Martins, 2015; Lüchmann, 2014). Participation is a part of the democratic system and a way to involve citizens in the public sphere. Understanding where we are situated in participation literature is fundamental to attempting to impact society. The following theory and literature review aim to advance our comprehension of the elements that potentialized public participation.

This contributes to the existing literature and, as a consequence, to the development of new research by providing elements that contribute to an understanding of the actual stages of the transition from participation to e-participation. The remainder of this paper is structured as follows: section 2 presents a brief theoretical foundation, section 3 describes the methodological procedures, section 4 presents the participation categories identified in the studies, section 5 discusses the main findings from the research analyzed and, finally, section 6 presents the final remarks.

2. Theoretical Background

2.1 Democracy

To discuss participation, it is first necessary to define democracy. Given the infinite number of democratic systems in existence, it is evident that not all of them provide adequate space for effective citizen participation. In this paper, we will make a distinction between two forms of democracy: on the one hand, we will examine dominant forms of democracy, and on the other, we will consider alternative, counter-hegemonic systems. (Miguel; Vitullo, 2021a).

For Ellen Wood, the hegemonic conception - also known as liberal or bourgeois – defends a merely representative democratic system, where the people's form of participation is only through periodic voting to choose representatives who will fulfil their mandate for a certain period, without, in most cases, existing direct dialogue with the voting people (Wood, 2011). On the other hand, counter-hegemonic democracy is based on the conception of the democratic system adopted in ancient Greece, where there was no political state structure distinct from the people, considering citizen participation as a central fact (Wood, 2011).

According to Wood (2011), the concept of democracy has historically been inserted into the field of social tensions as political strategies of the dominant classes aiming to perpetuate a model of representative, hegemonic democracy adopted by most so-called democratic countries. From this point of view, democracy is much more a method of choosing representatives than a system of representing the people's will.

It is important to understand that the dominant currents of democracies have different origins and, therefore, founding conceptions that lead to divergent democratic practices (Bourdieu, 2007). According to Wood (2011), one of the central criteria of democracy is the balance of power between rich and poor, and what would be intrinsic is the condition of being a citizen, not each one’s economic condition. In a capitalist democracy, the distinction between civic status and class position functions bidirectionally: socioeconomic status does not dictate the right to citizenship, embodying the democratic aspect of capitalist democracy. Still, the capitalist's ability to appropriate workers' surplus labour remains unaffected by privileged legal or civil status. Consequently, civil equality does not directly influence or substantially alter class inequality, thereby constraining democracy within capitalism. Class relations between capital and labour persist despite legal equality and universal suffrage (Boron, 2001; Wood, 2011).

Therefore, although there is civil equality where everyone is seen as a rightful citizen, regardless of socioeconomic position, this is superimposed in the capitalist context. Democracy becomes limited since civil equality is not capable of modifying the logic of exploitation and class inequality. The concept of democracy becomes accepted by the elite classes to the extent that it is useful to them and allows them to maintain power in their hands. This can be analyzed according to the “generalized defamation of democracy by the dominant classes” (Wood, 2011, p.194), allowing it to be subjected to a transformation that makes it “possible for its enemies to yesterday to hug her” (Wood, 2011). This “transformation” pointed out by Wood can be understood in part as the minimization of mass participation in political life.

In this original sense, democracy was understood to refer to government by the demos, or the "people," with the additional double meaning of civil status and social category. In "representative democracy," the principle of government by the people remained the primary criterion for defining democracy, even though government was filtered through representation controlled by the oligarchy, and the people were stripped of their social content. In the following century, the concept of democracy would become increasingly divorced from its ancient and literal meaning (Wood, 2011, p. 194).

Participation theories are based on the concept of democracy within our system. They aim to broaden the possibilities of generating active citizenship and, consequently, change the system's structures (Pateman, 1992a). Within the prevailing paradigm, wherein representation is the dominant model, participation is either absent or

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

perceived as transparency and social control (Lavalle; Vera, 2011). In the counter-hegemonic current, participation is the primary focus, with social control and transparency serving as conditions that facilitate participation (Miguel; Vitullo, 2021b).

2.2 Theories and the concept of participation

Participation, in its etymological Latin derivation, is derived from the term "participatio", meaning to take part in the action. The term's etymological origin elucidates the necessity of access to act and collaborate in decision-making. Many authors have examined this issue, offering perspectives on the significance of participation, underscoring its human necessity, the pedagogical and constructive role of participation, and proposing strategies for the development of greater participation (Arnstein, 2002; Barber, 2003; Bobbio, 1992; Bordenave, 1983; Pateman, 1992a).

Bordenave (1983, p. 10) writes that participation is a fundamental human need and, thus, a human right. The author maintains that participation is justified in and of itself, independent of its outcomes: "Participation facilitates the growth of the population's critical awareness, strengthens their power of demand, and prepares them to acquire more power in society" (Bordenave, 1983, p. 12), a process that leads to the people's appropriation of development. Furthermore, the author posits that participation can be learned, like Pateman (1992). Participation does not have a ready-made formula; rather, it can be provoked and organized in a manner that does not result in manipulation. Participation is facilitated by organization and creating spaces and networks that facilitate communication, always respecting individual differences in how people participate (Arnstein, 2002; Barber, 2003). The author posits that participation can be understood as having two distinct bases. The first is an effective base, which is a sense of enjoyment derived from engaging with others in collective endeavours. The second is an instrumental base, which can be understood as a perception of efficiency and effectiveness gained from working with others rather than alone (Bordenave, 1983).

In a similar vein, the author posits that citizens can engage in "micro-participation" and "macro-participation" (Bordenave, 1983, p. 21). The former is defined as natural participation, which encompasses involvement in family, school, community, and association activities. The latter is characterized by a conscious intention to utilize participation as a means of influencing social, economic, and political struggles within one's immediate context. Consequently, social participation (or participation at a macro level) is defined as the process by which different social groups participate in the production, management, and enjoyment of the goods of a historically determined society. Nevertheless, both forms of participation are mutually reinforcing, as the former, in addition to achieving immediate objectives, can also serve as an opportunity for the learning process and the primary pathway to the full exercise of citizenship (Bordenave, 1983, p. 57).

Furthermore, as a theoretical contribution, Bordenave characterizes participation in levels based on two key questions: "How much control do the members have over decisions? How relevant are the decisions that they can participate in?" (1983, p. 30). The levels of participation range from the lowest, information, to the highest, self-management. At the lower end of the spectrum, the decision-making power of the leaders is greatest, as they are the sole decision-makers, and citizens are merely informed. At the next level, optional consultation, the administration may, if it chooses, consult the population on a given subject. This precedes compulsory consultation, in which the government must consult the public on certain issues. The next level, drafting/recommending, is where the public can propose and recommend actions that the administration can accept or reject. Co-management assumes a slightly greater proportion, as administration is shared through shared or collegiate decision-making. Delegation, on the other hand, is when participation is delegated to citizens in certain areas in which they have the autonomy to decide. Finally, the final level is self-management, in which the distinction between administration and citizenship is diminished, and the groups themselves determine their objectives, choose the means of execution, and establish controls without the interference of external authorities (Bordenave, 1983, p. 30–33).

In her seminal work, Participation and Democratic Theory (1992), Carole Pateman delineates three distinct forms of participation: Pseudo-participation occurs when there is only consultation on a matter by the authorities, and participation is limited to endorsing a decision that has already been made. Partial participation is a situation in which many take part in the process, but only one party decides. On the other hand, full participation is a situation in which each group of individuals has equal influence on the final decision (Pateman, 1992a). Two points in Pateman's theory of participation are noteworthy. The first emphasizes the educational function of participation, while the second underscores the pivotal role of participation in industrial settings for workers. In these two points, the author is referring to a theory of participatory democracy (Pateman, 1992a).

Sherry Arnstein observes a paucity of in-depth analyses of the content of the controversial slogans currently used, such as "citizen participation" or "maximum possible participation," even in academic circles. The author's solution to the problem primarily imposes the integration of empowerment within the participatory framework of the aforementioned groups, which she identifies as the group of the have-nots: blacks, Mexican immigrants, Puerto Ricans, Indians, Eskimos, and poor whites. These groups' conception of participation as a means of redistributing

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

power is a central aspect of her argument (Arnstein, 2002).

The term participation is often used as a synonym for citizen power. In essence, participation is the redistribution of political and economic power, allowing those currently excluded to become actively included in future decision-making processes. It is the strategy through which those without a voice are integrated into the decision-making process. In essence, participation is how those without a voice can promote significant social reforms that allow them to share in the benefits of the surrounding society (Arnstein, 2002).

Among Brazilian authors, the contributions of Dallari, who made significant efforts to advance this discussion during the Brazilian military dictatorship, are worth noting. In his 1984 publication, "What is Political Participation?" the jurist posits that decision-making is a necessity for society and that a political system is only democratic when decisions are taken freely and the will of the majority is respected. According to the jurist, if "everyone recognizes this need and positively assumes their responsibility," conflicts will be overcome more fairly and in a manner that aligns with common needs (Dallari, 1984, p. 25). The theoretical framework is thus based on the acquisition of this right by the population, beginning with the Universal Declaration of Human Rights, which states in Article 21 that "all human beings have the right to take part in the government of their country directly or through freely chosen representatives" (ONU, 1948). The construction proceeds from the law to the citizen's influence on the social environments in which he lives, as the author asserts that every individual exerts social influence.

Dallari's work is most closely aligned with that of the authors in his assertion that "for the people to choose authentic representatives, there must, first of all, be full freedom of information, allowing people to freely form their opinions based on as much data as possible" (1984, p. 41). In this sense, he posits that participation leads to awareness and organization, and he distinguishes between formal and real participation. Formal participation, which he defines as "the practice of formality that only affects secondary aspects of the political process", does not influence fundamental political decisions. In contrast, real participation "is that which influences fundamental political decisions in some way" (Dallari, 1984, p. 92).

Notably, none of the authors view participation as a substitute for representation, particularly in large-scale democracies. All the authors assert that participation is a foundational process for democracy and serves to complement representation (Arnstein, 2002; Bordenave, 1983; Dallari, 1984; Pateman, 1992a). For this to be viable, it is essential to embrace a contemporary conception of democracy, wherein participation is situated at the core of the decision-making process.

The advent of technology has also impacted participatory practices, with many shifting from a face-to-face format to an online one. Consequently, the literature is beginning to discuss e-participation, which is often used interchangeably with digital participation. This concept will be further examined in the subsequent section of this paper.

2.3 E-participation

E-participation emerged in the mid-1990s because of government informatization. Also called electronic participation or, more recently, digital participation, refers to the use of Information and Communication Technologies (ICT) to engage citizens in government decision-making and public policymaking (Quintero-Angulo; Sánchez-Torres; Cardona-Román, 2020). The concept of "eParticipation involves the extension and transformation of participation in societal democratic and consultative processes, mediated by information and communication technologies (ICTs)" (Sanford; Rose, 2007, p. 1). It encompasses not only democratic participation but also citizen involvement in e-government service delivery (Simonofski et al., 2021). It is a complex phenomenon involving various activities, including online expression and interaction (Tai; Porumbescu; Shon, 2020). It is not a separate form of participation but rather a complement to traditional modes of participation (Kubicek, 2010).

E-participation is considered a citizenship technology, increasing citizen involvement and collaboration in political processes (Banjac, 2017). It is an emerging research area focusing on using ICT to facilitate government-citizen relationships (Sanford; Rose, 2007). Despite its potential, implementing e-participation initiatives often falls short of expectations as a result of limited knowledge and policies (Mukherjee, 2019). Macintosh (2004) mentions the need for e-enabling to support the process of e-participation, as it is not enough to have the tool; you need to know how to deal with the amount of information beyond internet access. In addition to enabling, the author brings up the need for engaging as a second stage of the Levels of Participation model (Macintosh, 2004). Finally, in this model, we come to empowerment, which is characterized by citizens becoming producers of public policy and being involved in its formulation and agenda (Macintosh, 2004).

Working on the role of e-participation in expanding capacities, Macadar, Pereira, and Pinto (2019) place e-participation as a mechanism for expanding capacities since it increases the democratic and participatory involvement of individuals in society. Here, e-participation is shown as a different way of making participation in

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

democratic spaces effective, but with the same discussion of intrinsic and necessary values for participation, even more so because, as the authors point out, e-participation is not yet available to everyone, in this case, indirectly contributing to the increase in social inequalities, thus requiring the formulation of public policies to reduce the digital lacking (Macadar; Pereira; Pinto, 2019).

More recently, in an examination of how to integrate citizen deliberation in climate assemblies through governance, Boswell, Dean and Smith (2022) concluded that in public deliberation spaces, such as assemblies, the more space is opened up to stakeholders, which can help the governance process, the more difficult it is to attract wide publicity and grassroots activists to the discussion. This leads the authors to warn against being conscious of choices, as they generate trade-offs and unintended consequences for the deliberation process. The effectiveness of e-participation is contingent on its integration into existing participation processes (Kubicek, 2010).

Despite the proliferation of e-participation initiatives, their impact on broader and deeper citizen participation remains uncertain (Blanc, 2020), and some authors are trying to understand the cause of the decrease in e-participation (Pozzebon; Cunha; Coelho, 2016). The field of e-participation is dynamic, with a growing variety of tools and technologies available (Ergazakis; Metaxiotis; Tsitsanis, 2011; Tambouris; Kalampokis; Tarabanis, 2008). However, the potential of e-participation at the local level and in urban planning is not fully realized, and its low acceptance may be attributed to a lack of understanding of its context and barriers (Kubicek, 2010). Despite its potential, e-participation faces challenges, including needing a more comprehensive evaluation and identifying problem areas (Quintero-Angulo; Sánchez-Torres; Cardona-Román, 2020). This literature review aims to collaborate in this field.

3. Methodological procedures

To better understand how the scientific world has recently dealt with the issue of participation and e-participation, we decided to consult the main scientific bases using the systematic literature review methodology (Chapman, 2021; Denyer & Tranfield, 2009), investigating aspects to understand the approaches and elements of participation in studies on urban governance at the local level. The systematic review followed the following steps: elaboration of the research problem, definition of the corpus of analysis, construction and validation of the research strategy, data collection, reading the titles and abstracts, data cleaning based on exclusion criteria, complete reading of the articles and data analysis (Denyer & Tranfield, 2009).

The corpus of this research is constituted by articles on participation and e-participation, indexed in the databases Web of Science (WoS), Spell (Scientific Periodicals Electronic Library), Scopus, and Scielo (Scientific Electronic Library Online), without applying any filters regarding the year of publication. The databases were chosen considering that WoS and Scopus are world-renowned databases in different scientific fields; Spell is a reference in Brazil, especially in the fields of public and business administration, accounting, and tourism, and Scielo is a reference in studies carried out in Latin America.

The data were collected in April and May 2024, and the search strategy was determined based on the author's interest in research. The search strategy consisted of the search criteria shown in Table 1.

Table 1 – Criteria of Search

Database	Criteria of Search	Number of documents
Web of Science	English Title: ("public participation" OR "participation" OR "citizen participation") AND ("e-participation" OR "digital participation" OR "electronic participation") AND ("local governance" OR "municipal governance" OR "local government" OR "city governance" OR "urban governance" OR "local administration")	Title: 16
	Abstract: ("public participation" OR "participation" OR "citizen participation") AND ("e-participation" OR "digital participation" OR "electronic participation") AND ("local governance" OR "municipal governance" OR "local government" OR "city governance" OR "urban governance" OR "local administration")	Abstract: 16
Scopus	English Title, abstract, Keywords: ("public participation" OR "participation" OR "citizen participation") AND ("e-participation" OR "digital participation" OR "electronic participation") AND ("local governance" OR "municipal governance" OR "local government" OR "city governance" OR "urban governance" OR "local administration")	209

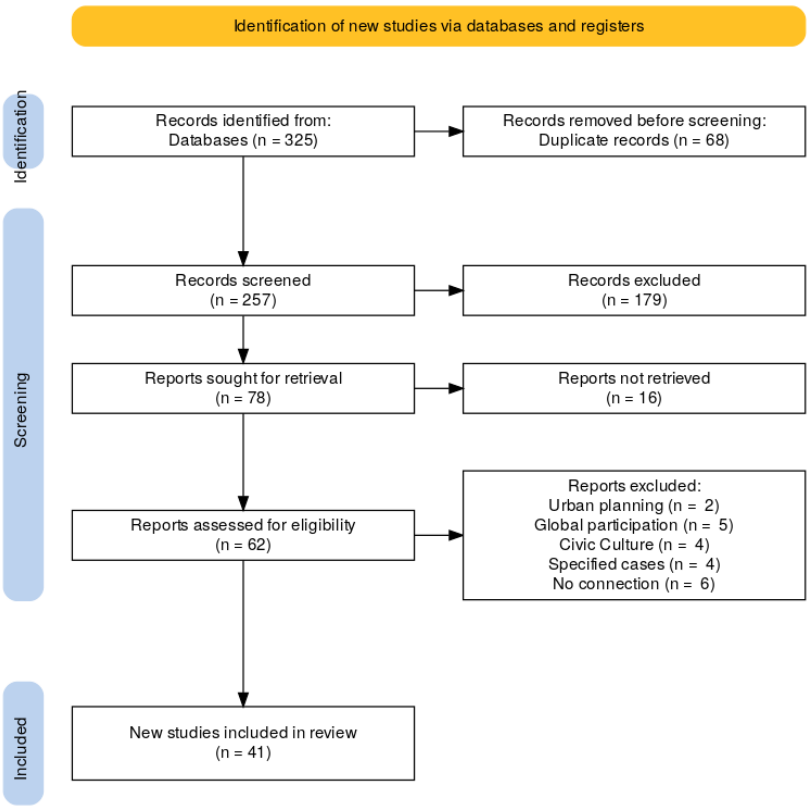
Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Scielo	Portugueses (all indexes): Option 1 - (participação pública OR participação OR participação cidadã AND governança local OR governança municipal OR governo local OR governança urbana OR administração local) Option 2 - (e-participação OR participação digital OR participação eletrônica AND governança local OR governança municipal OR governo local OR governança urbana OR administração local)	Port Op 1 – 1 Op 2 – 3
	Spanish (all indexes): Option 1: (participación pública OR participación OR participación ciudadana) AND (gobernanza local OR gobernanza municipal OR gobierno local OR gobernanza urbana OR administración local) Option 2: (e-participación OR participación digital OR participación electrónica) AND (gobernanza local OR gobernanza municipal OR gobierno local OR gobernanza urbana OR administración local)	Spa Op 1 – 15 Op 2 - 0
Spell	Portuguese (Title and abstract): Option 1 – "participação" E "cidade" OU "gestão municipal" Option 2 - "e-participação" E "cidade" OU "gestão municipal"	Port Op 1 – 38 Op 2 - 27
All documents		325

Source: Elaborated by the author (2024).

Data were collected from the databases and cleaned using the Rayyan software developed by the Qatar Computing Research Institute (QCRI) for systematic literature reviews (Ouzzani et al., 2016). All the cleaning follows the PRISMA protocol (Page et al., 2021). The software was used to read the documents' titles and abstracts and define the exclusion criteria. Documents without the words participation and e-participation in the abstract, articles dealing with participation in private spaces, which is not the focus of this study, and articles not focusing on participation and e-participation at the local level were excluded. Figure 1 shows the details of the PRISMA flowchart for the data collection and cleaning phases, describing the results of the article identification, screening, and included phases.

Figure 1 – Stages of collecting and cleaning data



Source: Elaborated by the author using Rayyan software (2024)

The literature search results in a total of 325 documents from the databases. After 68 duplicates were removed, 257 documents remained for title and abstract screening. Out of these, 179 documents were excluded as they were

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

irrelevant to the research subject, resulting in 78 documents being included in the sample for this literature review. In the search, there was no year limitation. The included documents consisted of 59 papers from scientific journals, 9 book chapters, and 10 conference papers. Access to the full text was not possible for 16 documents (3 journal papers, 5 conference papers, and 8 book chapters). Therefore, 62 full-text documents were available for the literature analysis. In the second phase, from the detailed analysis of these 62 texts, 21 were excluded for not fitting the research focus. The reasons for exclusion are shown in Table 2:

Table 2 – Reason for exclusion in the reading phase

Reason for exclusion	Reference
General Public Participation without Digital Focus	(Aravena & Silva, 2020; Esau, 2018; Lima-Silva et al., 2020; Panagiotopoulos et al., 2012).
Specific case analysis	(Dunne, 2010; Marin et al., 2001; Simione & Ckagnazaroff, 2017; Tramontano, 2021); Simione; Ckagnazaroff, 2017; Dunne, 2010; Marin; Vargas; Guerrini, 2001.
Civic culture focus	(Fernandes et al., 2010; Hovik & Giannoumis, 2022; Martins et al., 2020; Mulder & Hartog, 2011) Fernandes; Ruediger; Riccio, 2010.
Discussions of urban planning or design	(Ataman et al., 2024; Lieven, 2017).
Other discussions not related to this research	(de Moura, 1997; Goulart et al., 2016; Hernandez Bonivento, 2022; Mallan, 2018; Panagiotopoulos et al., 2011; Ruiloba Núñez, 2014)

Source: Elaborated by the author (2024).

After reading the documents, 41 documents remain for the next stage of literature review. After a detailed reading of the articles, the different types of participation were identified, and the papers were categorized for analysis. The concepts that informed the discussions are presented below.

4. Concepts of Participation applied to the Local Level

According to the objective proposal and the application of the methodology, 41 studies are relevant to this paper.

4.1 Documents description

The first article indexed in Scopus was published in 2006 in the journal RWIT Transactions on Information and Communication Technologies, with the title E-democracy and citizen's empowerment: A case study of the city of Madrid (Santos & Alonso, 2006). The authors identify the use of ICTs to improve the relationship between citizens and government, increasing participation and the quality of public services. Over the last 18 years, research on the subject has been increasing, demonstrating the growth of interest in the topic.

As for the methodological aspects of the research, qualitative approaches are predominant, as shown in Table 3, with the predominant use of case studies, demonstrating the possibility of carrying out studies using other methodologies.

Table 3 – Studies approach and methodologies

Study Approach	**Study Approach/ Method**	**Authors**
Qualitative	Case Study	(Chun & Cho, 2012; Ntaliani et al., 2017; Revyakin, 2018; Rexhepi et al., 2018; Royo et al., 2020; Santos & Alonso, 2006; Scherer & Wimmer, 2012; Silva, 2020; Sivarajah et al., 2016; Steinbach & Süß, 2018; Ntaliani; Costopoulou; Karetsos, 2017; Sivarajah Et Al., 2016; Chun; Cho, 2012; Scherer; Wimmer, 2012; Santos; Alonso, 2006).
	Comparative Case Study	(Åström & Granberg, 2008)
	Literature Review	(Cropf; Benton, 2019; Smith, 2007)
	Exploratory Analysis	(Tejedo-Romero et al., 2022)
	Ontology Analysis	(Porwol et al., 2016)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

	Model Analysis	(Porwol et al., 2014a)
	Thematic Analysis	(Naranjo-Zolotov, Oliveira, Cruz-Jesus, et al., 2019)
	Process Analysis	(Scherer & Wimmer, 2012)
	Content Analysis	(Kim & Lee, 2012)
	Longitudinal Study	(Costopoulou et al., 2021)
Quantitative	Quantitative Research	(Zolotov; Oliveira; Casteleyn, 2018; Zheng; Schachter; Holzer, 2014; Reddick; Norris, 2013)
	Survey Research	(Steinbach et al., 2020)
	Statistical Analysis	(Porwol et al., 2014a)
	Cross-Sectional Study	(Graziano, 2017)
	Structural equation modelling	(Naranjo-Zolotov, Oliveira, Casteleyn, et al., 2019)
	Experiment	(Royo et al., 2020)
Mixed	Surveys and experimental research	(Li & Kostka, 2022)
	Observation, discourse analysis, semi-structured interviews, unstructured conversations	(Graziano, 2017)
	Mixed Methods Research	(Hovik; Giannoumis, 2022; Pilehvar, 2021; Legard *et al.*, 2019; Ntaliani; Costopoulou; Karetsos, 2017; Colombo, 2010; Santos; Alonso, 2006)

Source: Elaborated by the author (2024).

Based on an analytical reading of the articles, the different categories of studies and the main concepts covered in the research will be presented below.

4.2 Analytical categories

After reading all the documents, an effort was made to categorize the papers, and five categories emerged from the analysis. Table 4 presents the results:

Table 4 – Papers categories

Categories of Analysis	**Number of studies**	**Authors**
Challenges and Barriers to E-Participation	8	Man; Manaf, 2024; Hovik & Giannoumis, 2022; Lee & Kim, 2012, 2018; Naranjo-Zolotov, Oliveira, Cruz-Jesus, et al., 2019; Norris & Reddick, 2013; Ntaliani et al., 2017; Zolotov et al., 2018.
Empowerment and Citizen Engagement	6	Åström, 2020; Chun & Cho, 2012; Naranjo-Zolotov, Oliveira, Casteleyn, et al., 2019; Santos & Alonso, 2006; Silva, 2020; Steinbach et al., 2020.
Impacts and Benefits of E-Participation	9	Åström & Granberg, 2008, 2008; Colombo, 2010; Graziano, 2017; Legard et al., 2019; Legard & Hovik, 2022; Reddick & Norris, 2013; Revyakin, 2018; Rexhepi et al., 2018;
Technologies and Tools for E-Participation	7	Dias Cordeiro & Cacho Alessandro, 2018; Feeney & Welch, 2012; Kim & Lee, 2012; Li & Kostka, 2022; Mærøe et al., 2021; Sivarajah et al., 2016; Tejedo-Romero et al., 2022;
Theoretical Models and Practices of E-Participation	11	Costopoulou et al., 2017, 2021; Cropf & Benton, 2019; Pilehvar, 2021; Porwol et al., 2014a, 2014b, 2016; Royo et al., 2020; Scherer & Wimmer, 2012; Smith, 2007; Steinbach & Süß, 2018.

Source: Elaborated by the author using NVIVO (2024).

Eleven studies were classified as Theoretical Models and Practices of E-Participation; this category includes studies that develop and analyze theoretical frameworks and practical approaches for implementing e-participation. These papers provide models and guidelines for best practices, which inform policymakers and practitioners about strategies for promoting citizen engagement through digital means.

Nine studies address the Impacts and Benefits of E-participation. These impacts can include increased

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

transparency, improved accountability, greater citizen empowerment, and improved public trust in government. The papers explore both the direct and indirect benefits of e-participation. They show how digital tools can transform the relationship between citizens and their governments.

Eight studies focus on Challenges and Barriers, alerting us to the various obstacles that hinder the effective implementation and adoption of e-participation initiatives. These obstacles can be technical, social, and organizational. Studies in this category aim to identify these barriers and propose solutions to overcome them, ensuring broader and more effective citizen engagement.

Seven studies are about Technologies and Tools for E-participation. In this category, the researchers focus on developing, analyzing, and implementing technological tools and platforms designed to facilitate e-participation. These tools range from deliberation models and ontologies to various e-government applications and open data platforms. The first concern of these studies is to understand how technology can be used to improve citizen engagement, streamline decision-making processes, and increase governance efficiency.

Six studies can be categorized as Empowerment and Citizen Engagement. These papers explore how e-participation tools and platforms can empower citizens and improve their engagement in public affairs. These studies often focus on the social and psychological aspects of participation, including how digital tools can make citizens feel more involved and influential in governmental decision-making processes. With these five categories, it is possible to understand the state of research on e-participation.

5. Discussion about participation and e-participation

5.1 Structure of E-participation: insights from recent studies

E-participation is defined as using digital technologies and online platforms to engage citizens in the governance process. This involvement can take numerous forms, extending from simple information dissemination to more complex deliberation and decision-making processes. A review of the literature reveals that the structure of e-participation is composed of several elements.

The first key component is the technological infrastructure, an element decisive to the success of e-participation. This includes developing and deploying various digital platforms such as websites, mobile applications, and social media channels that facilitate citizen engagement. These platforms must be user-friendly, accessible, and secure to ensure broad participation (Porwol; Ojo; Breslin, 2014b; Sivarajah et al., 2016).

The second component to be considered is citizen engagement mechanisms because e-participation platforms could be distant and quickly lose interest. These mechanisms must provide citizens with multiple options to express their opinions, contribute to discussions, and make decisions on public matters. It can include online forums, surveys, participatory budgeting and deliberative spaces, and polling (Royo; Pina; Garcia-Rayado, 2020; Zolotov; Oliveira; Casteleyn, 2018).

The third element is institutional support because e-participation demands a will from political agents and strong support from local government. This includes resources, the establishment of supportive policies, and the training of public officials to manage and promote e-participation initiatives effectively (Reddick; Norris, 2013; Tejedo-Romero et al., 2022).

The fourth element is inclusivity and accessibility, one of the major problems today. Platforms for e-participation need to be inclusive and accessible to all segments of the population. This involves designing platforms that accommodate people with disabilities, providing content in multiple languages, and addressing the digital divide by offering public access points and digital literacy programs (Checkoway; Allison; Montoya, 2005; Ntaliani; Costopoulou; Karetsos, 2017; Rexhepi; Filiposka; Trajkovik, 2018).

The fifth component is transparency and accountability. E-participation platforms must be transparent in their operations, allowing citizens to see how their inputs are used and what impact they have on decision-making processes. This transparency helps build trust and encourages continued citizen engagement (Chun; Cho, 2012; Kim; Lee, 2012).

The last component is continuous feedback and evaluation to improve e-participation initiatives. Gathering feedback from users and conducting regular assessments help identify areas for improvement and ensure that the platforms meet citizens' evolving needs (Graziano, 2017; Legard et al., 2019).

The structure of e-participation is complex, involving technological, institutional, and social components. Effective e-participation platforms require solid technological infrastructure, diverse engagement mechanisms, strong institutional support, inclusivity, transparency, and continuous feedback. The successful integration of these

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

elements can improve citizen e-participation, improve governance processes, and cultivate a more engaged and informed public.

5.2 Barriers and difficulties of implementing participation and e-participation at the local level

Implementing participation and e-participation at the local level is a complex effort that faces numerous barriers and difficulties. These challenges can be broadly categorized into technological, social, organizational, and political barriers. Ntaliani, Costopoulou, and Karetsos (2017) discuss infrastructure and access as technological barriers because one of the most serious is the lack of adequate infrastructure. Local governments struggle with old technology, limited internet access, and insufficient digital tools. In the same way, Rexhepi, Filiposka, and Trajkovik, (2018) emphasize youth participation, bringing the problem of digital divide in society, which refers to the gap between those who have access to modern information and communication technology and those who do not, what remains a relevant issue. This divide can be based on socioeconomic status, age, geographic location, and education level, limiting the reach and inclusivity of e-participation initiatives.

The literature reveals concerns about social barriers, digital literacy, trust, and privacy. Kim and Lee (2012) demonstrated concern about trust in government and privacy and data security. One recommendation is that ensuring that personal data is protected and that platforms are transparent about how data is used is central to building trust. Regarding digital literacy, many citizens lack the necessary skills to use and engage with the participation platforms. The studies emphasize the necessity of adequate training and support, as these individuals are unable to participate fully in digital governance processes (Chun; Cho, 2012; Kim; Lee, 2012; Lee; Kim, 2012).

Regarding organizational barriers, two situations are concerned: resource constraints and the lack of expertise. In the public sector, financial and human resources often face constraints, but implementing e-participation platforms requires investment, and many local governments struggle to allocate resources to these initiatives. The same situation concerns human resources with expertise in digital technologies and public engagement. Many local government officials absence the necessary training and knowledge to manage these platforms effectively (Reddick; Norris, 2013; Tejedo-Romero et al., 2022).

The last barrier is political because, with frequency, the elected political officers often resist sharing the power with the people or the participatory institutions. The success of e-participation initiatives heavily depends on the political will of local leaders. Without a strong commitment from political leaders to prioritize and promote these initiatives, e-participation is unlikely to be effectively implemented. Traditional bureaucratic structures and processes can be inflexible, making it difficult to integrate new e-participation tools and methods (Norris; Reddick, 2013; Zheng; Schachter; Holzer, 2014).

Implementing both participation and e-participation at the municipal level presents several significant challenges. Technological limitations, such as deficiencies in infrastructure and the digital divide, impede accessibility to digital platforms. Social barriers, including digital literacy and trust issues, further diminish citizen engagement. Organizational constraints, such as insufficient resources and expertise, impede the deployment and management of electronic participation tools. Finally, political barriers, including resistance to change and a lack of political will, can impede the implementation of these initiatives.

To address these barriers, a multifactorial approach is required. Investments must be made in technology infrastructure and digital literacy programs. The establishment of trust through the implementation of transparent practices and data security measures can facilitate increased participation. In addition, local governments must ensure the allocation of sufficient resources and the provision of training to officials. It is of the utmost importance that strong political leadership and commitment be present to drive the adoption and success of e-participation initiatives.

5.3 Agents influencing the e-participation process and their power dynamics

The implementation and success of e-participation initiatives at the local level are influenced by various agents, each playing distinct roles with different degrees of power and influence. These agents include local government officials, citizens, technology providers, and civil society organizations. Understanding the dynamics between these agents is fundamental for designing effective e-participation systems.

Local government officials are central to the e-participation process. They are responsible for initiating, managing, and promoting e-participation platforms. Their commitment and support are critical for the allocation of resources and the integration of e-participation into the broader governance framework. As decision-makers, they have considerable power. Their attitudes towards e-participation can greatly influence its adoption and effectiveness. Strong political will and managerial support can drive successful e-participation initiatives, while resistance or lack of interest can block the process or make it just a formality without effectiveness (Norris & Reddick, 2013; Reddick & Norris, 2013; Tejedo-Romero et al., 2022; Zheng et al., 2014).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Citizens are the primary users of e-participation platforms. Their engagement is important for the success of these initiatives because they can contribute with opinions, feedback, and decisions through various digital tools provided by local governments. The paradox of participation is while citizens are the main beneficiaries of e-participation, their power is often limited by their access to technology, digital literacy, and the responsiveness of government officials (Åström, 2020; Kim & Lee, 2012; Mærøe et al., 2021; Rexhepi et al., 2018).

Civil Society Organizations (CSOs), including non-governmental organizations (NGOs), advocacy groups, and community organizations, often act as intermediaries between citizens and government. Sometimes, they have a place to represent part of society in participatory institutions. They can facilitate e-participation by mobilizing communities, providing digital literacy training, and advocating for citizen interests. Their power comes from their ability to organize collective action, advocate for policy changes, and provide expertise in specific areas of public interest (Boswell et al., 2022; Chun & Cho, 2012; Smith, 2007).

The power dynamics in e-participation are shaped by the interactions between these agents. Local government officials typically hold the most power in terms of decision-making and resource allocation. However, the influence of citizens and CSOs can increase through active engagement, advocacy, and the effective use of technology. Technology providers hold technical power, influencing the usability and functionality of e-participation platforms. Balancing these power dynamics is decisive for the success of e-participation. Ensuring that citizens and CSOs have meaningful opportunities to contribute and influence decisions can lead to more inclusive and democratic governance (Boswell et al., 2022; Chun & Cho, 2012; Smith, 2007).

5.4 Factors that improve e-participation at the local level

Based on the literature review, there are best practices that should be considered when developing a model for implementing an e-participation tool at the local level. These best practices are fundamental for ensuring the success and effectiveness of the e-participation initiatives (Table 5).

Table 5 – Findings

Finding	Details	References
Solid Technological Infrastructure	Ensure high-speed internet access, reliable digital platforms, and secure data management systems.	Porwol *et al*. (2014), Sivarajah *et al*. (2016)
User-Friendly Platforms	Design intuitive interfaces with clear instructions and easy navigation to lower barriers to entry.	Ntaliani *et al*. (2017), Chun & Cho (2012)
Strong Institutional Support	Secure financial backing, active promotion by public officials, and integration into governance frameworks.	Reddick & Norris (2013), Tejedo-Romero *et al*. (2022)
Citizen Education and Digital Literacy	Provide educational programs and workshops to improve digital literacy among citizens.	Kim & Lee (2012), Rexhepi *et al*. (2018)
Inclusivity Measures	Ensure platforms are accessible to all, including support for disabilities, multilingual content, and bridging the digital divide.	Silva (2020), Santos & Alonso (2006)
Transparency and Accountability	Maintain transparent operations and clear communication on how citizen input is used.	Royo *et al*. (2020), Zheng *et al*. (2014)
Continuous Feedback and Evaluation	Regularly gather user feedback and conduct evaluations to improve platforms.	Legard *et al*. (2019), Graziano (2017)
Engagement Mechanisms	Utilize various tools like online forums, surveys, and participatory budgeting to engage citizens.	Royo *et al.* (2020), Zolotov *et al*. (2018)
Partnership with Technology Providers	Collaborate with technology providers to ensure platforms meet civic needs and are technologically sound.	Porwol *et al*. (2016), Sivarajah *et al.* (2016)
Inclusive Decision-Making	Involve diverse groups of citizens to ensure broad representation in decision-making.	Kim & Lee (2012), Hovik *et al*. (2017)

Source: Elaborated by the author (2024).

The implementation of e-participation at the local level represents a significant advance in democratic engagement, providing a platform for increased citizen involvement in governance processes. This paper has examined the multiple aspects of e-participation, highlighting the critical components necessary for its successful implementation and the barriers that must be addressed.

First, a solid technological infrastructure is indispensable for the success of e-participation initiatives (Porwol et al., 2014b; Sivarajah et al., 2016). These technological investments ensure that e-participation tools are both

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

accessible and trusted, thereby fostering greater citizen engagement. User-friendly platforms are also needed. Studies by Ntaliani et al. (2017) and Chun & Cho (2012) highlight the importance of designing intuitive interfaces that are easy to navigate. The role of local government officials is decisive. Research by Reddick & Norris (2013) and Tejedo-Romero et al. (2022) emphasizes the need for strong institutional support, including financial backing and active promotion by public officials. In addition, citizen education and digital literacy are critical factors that influence the effectiveness of e-participation. The literature shows by equipping citizens with the necessary skills, these initiatives can increase engagement. In the same way, inclusivity policies are equally relevant, ensuring that e-participation platforms are accessible to all population segments.

Transparency and accountability are fundamental to building trust in e-participation initiatives. Royo et al. (2020) and Zheng et al. (2014) emphasize the need for transparent operations and clear communication about how citizen input is used. This transparency fosters trust and encourages continued citizen participation. Continuous feedback and evaluation are necessary for continuously improving e-participation platforms. Studies by Legard et al. (2019) and Graziano (2017) show that regular feedback from users and periodic evaluations help identify areas for improvement, ensuring that platforms remain responsive to citizens' needs and preferences.

Engagement mechanisms, such as online forums, surveys, and participatory budgeting tools, provide multiple avenues for citizen participation. The effectiveness of these mechanisms has been demonstrated by Royo et al. (2020) and Zolotov et al. (2018), showing that diverse tools can facilitate richer and more meaningful citizen engagement. Partnerships with technology providers are critical to ensure that e-participation platforms are technologically sound and meet the needs of citizens. The collaborative efforts highlighted by Porwol et al. (2016) and Sivarajah et al. (2016) demonstrate the value of aligning technological solutions with local governance requirements. Finally, inclusive decision-making processes, as advocated by Kim & Lee (2012) and Hovik & Hanssen (2017), ensure that diverse groups of citizens are represented in the e-participation process. This inclusivity is fundamental for creating a participatory governance model that reflects the community.

6. Final remarks

The research results suggest that the successful implementation of e-participation at the local level depends on a multifactorial approach that addresses technological, social, and institutional factors. By following the best practices and lessons learned from the literature, local governments can create effective e-participation platforms that increase democratic participation and foment a more inclusive and responsive governance system.

This approach emphasizes the importance of incorporating the experiences and knowledge of key agents to contribute to urban governance. The analysis of the papers raised questions about the perception of agents in relation to participation and whether these agents are willing to share decision-making. Understanding the role of different agents in the participatory process, the barriers, and good practices helps to better understand the e-participation scenario. Given these aspects, future studies could investigate the relationships between agents and the impact on decision-making, demonstrating the power relations between the agents involved and the structure of e-participation.

As a possible limitation of the study, it should be acknowledged that the database refinement stage did not consider studies published in languages other than English, Spanish, and Portuguese. It is suggested that, in future studies, the search should be broadened to include other international publications. With this study, we hope to see new research that describes, discusses, exemplifies, and formulate proposals for more participatory cities.

Acknowledgements

This work was carried out with the support of the Coordination for the Improvement of Higher Education Personnel – Brazil (CAPES) – Funding code 001.

References

Aravena, J. A. L., & Silva, E. A. F. (2020). Deliberación democrática y gobernanza en la participación ciudadana local. El caso de los Consejos Comunales de la Sociedad Civil (COSOC), Biobío, Chile. *Desafíos*, *32*(2), 127–164. https://doi.org/10.12804/revistas.urosario.edu.co/desafios/a.7219

Arnstein, S. R. (2002). Uma escada da participação cidadã. *Revista Da Associação Brasileira Para o Fortalecimento Da Participação*, *2*(2), 1–17.

Åström, J. (2020). Participatory urban planning: What would make planners trust the citizens? *Urban Planning*, *5*(2), 84–93. https://doi.org/10.17645/UP.V5I2.3021

Åström, J., & Granberg, M. (2008). Urban planners, wired for change? Understanding elite support for E-participation. *Journal of Information Technology and Politics*, *4*(2), 63–77. https://doi.org/10.1080/19331680802076116

Ataman, C., Tunçer, B., & Perrault, S. (2024). *DIGITAL PARTICIPATION IN URBAN DESIGN AND PLANNING:*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Addressing Data Translation Challenges in Urban Policy- and Decision-Making through Visualization Techniques. *2*, 201–210. Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85196742495&partnerID=40&md5=b41f8158a0d7b23bc74202d43dff4ccf

Bobbio, N. (1992). *O futuro da democracia: Uma defesa das regras do jogo* (5ª). Paz e Terra.

Boswell, J., Dean, R., & Smith, G. (2022). Integrating Citizen Deliberation into Climate Governance: Lessons on Robust Design from Six Climate Assemblies. *Public Administration*. https://doi.org/10.1111/PADM.12883

Chapman, K. (2021). Characteristics of systematic reviews in the social sciences. *The Journal of Academic Librarianship*, *47*(5), 102396. https://doi.org/10.1016/j.acalib.2021.102396

Chun, S. A., & Cho, J.-S. (2012). E-participation and transparent policy decision making. *Information Polity*, *17*(2), 129–145. https://doi.org/10.3233/IP-2012-0273

Clarke, N., & Cochrane, A. (2013). Geographies and politics of localism: The localism of the United Kingdom's coalition government. *Political Geography*, *34*, 10–23. https://doi.org/10.1016/j.polgeo.2013.03.003

Colombo, C. (2010). e-Participation Experiences and Local Government in Catalonia: An Explanatory Analysis. *Conference: Electronic Participation, Second IFIP WG 8.5 International Conference, ePart 2010, Lausanne, Switzerland, August 29 - September 2, 2010. Proceedings*, *6229*, 82–94. https://doi.org/10.1007/978-3-642-15158-3_7

Costopoulou, C., Ntaliani, M., & Ntalianis, F. (2021). Evolution of e-participation in Greek local government. *Information Polity*, *26*(3), 311–325. https://doi.org/10.3233/IP-190174

Costopoulou, C., Ntalianis, F., Ntaliani, M., Karetsos, S., & Gkoutzioupa, E. (2017). E-Participation provision and demand analysis for greek municipalities. *Communications in Computer and Information Science*, *792*, 3–14. https://doi.org/10.1007/978-3-319-71117-1_1

Criado, J. I., Guevara-Gómez, A., & Villodre, J. (2020). Using Collaborative Technologies and Social Media to Engage Citizens and Governments during the COVID-19 Crisis. The Case of Spain. *Digital Government: Research and Practice*, *1*(4), 30:1-30:7. https://doi.org/10.1145/3416089

Cropf, R. A., & Benton, M. (2019). Towards a working model of e-participation in smart cities: What the research suggests. *Public Administration and Information Technology*, *34*, 99–121. https://doi.org/10.1007/978-3-319-89474-4_6

da Fonseca, I. F. (2019). *Participação como método de governo: Experiências transcalares no Rio Grande do Sul, Brasil e na Toscana, Itália*. IPEA. http://www.ipea.gov.br/portal/publicacoes

Dagnino, E. (2002). *A Experiência do Orçamento Participativo de Porto Alegre*. Universidade Estadual de Campinas.

Dagnino, E. (2004). Construção democrática, neoliberalismo e participação: Os dilemas da confluência perversa. *Politica & Sociedade*, *n. 5*, 139–164.

De Moura, G. L. (1997). Planejamento estratégico e planejamento participativo na gestão municipal: O caso do município de Porto Alegre—Gestão 1989-93. *Revista de Administração Pública*, *31*(4), 23–41.

Denyer, D., & Tranfield, D. (2009). Producing a systematic review. In *The Sage handbook of organizational research methods* (pp. 671–689). Sage Publications Ltd.

Dias Cordeiro, F., & Cacho Alessandro, N. (2018). A Platform for Measuring e-Participation in Smart Cities: A Case Study with Brazilian Capitals. *IEEE Latin America Transactions*, *16*(2), 542–548. https://doi.org/10.1109/TLA.2018.8327411

Dunne, K. (2010). Can online forums address political disengagement for local government? *Journal of Information Technology and Politics*, *7*(4), 300–317. https://doi.org/10.1080/19331681.2010.491023

Esau, K. (2018). Capturing citizens' values: On the role of narratives and emotions in digital participation. *Analyse Und Kritik*, *40*(1), 55–72. https://doi.org/10.1515/auk-2018-0003

Fedozzi, L. J., & Martins, A. L. B. (2015). Trajetória do orçamento participativo de Porto Alegre: Representação e elitização política. *Lua Nova: Revista de Cultura e Política*, 181–224.

Feeney, M. K., & Welch, E. W. (2012). Electronic Participation Technologies and Perceived Outcomes for Local Government Managers. *Public Management Review*, *14*(6), 815–833. https://doi.org/10.1080/14719037.2011.642628

Fernandes, J. D. M., Ruediger, M. A., & Riccio, V. (2010). Gestão pública e cultura cívica: A participação pública no desenho do sistema de águas na cidade de Niterói. *Organizações & Sociedade*, *17*(54), 527–542. https://doi.org/10.1590/S1984-92302010000300006

Goulart, J. O., Terci, E. T., & Otero, E. V. (2016). Planos diretores e participação política: Políticas públicas de planejamento entre o empresariamento e o estatuto da cidade. *Revista de Administração Pública*, *50*(3), 455–476. https://doi.org/10.1590/0034-7612147853

Graziano, T. (2017). Citizen e-participation in urban planning: Achievements and future challenges in a Mediterranean city. *International Journal of E-Planning Research*, *6*(3), 1–18. https://doi.org/10.4018/IJEPR.2017070101

Hernandez Bonivento, J. (2022). Antes y después del estallido: Democracia, liderazgos y mecanismos de participación ciudadana en tres ciudades de Chile. *Revista iberoamericana de estudios municipales*, *25*, 1–20. https://doi.org/10.32457/riem25.1682

Hovik, S., & Giannoumis, G. A. (2022). Linkages Between Citizen Participation, Digital Technology, and Urban Development. In *Citizen Participation in the Information Society: Comparing Participatory Channels in Urban Development* (pp. 1–23). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85161164883&doi=10.1007%2f978-3-030-99940-7_1&partnerID=40&md5=ca6030be4e19e087936c654f9f84a256

Kim, S., & Lee, J. (2012). E-Participation, transparency, and trust in local government. *Public Administration Review*, *72*(6), 819–828. https://doi.org/10.1111/j.1540-6210.2012.02593.x

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Lee, J., & Kim, S. (2012). E-Participation in the era of web 2.0: Factors affecting citizens' active e-participation in local governance. *ACM International Conference Proceeding Series*, 44–47. https://doi.org/10.1145/2463728.2463739

Lee, J., & Kim, S. (2018). Citizens' e-participation on agenda setting in local governance: Do individual social capital and e-participation management matter? *Public Management Review*, *20*(6), 873–895. https://doi.org/10.1080/14719037.2017.1340507

Legard, S., Giannoumis, G. A., Hovik, S., & Paupini, C. (2019). Variation in e-participation schemes and strategies: Comparative case study of Oslo, Madrid, and Melbourne. *ACM International Conference Proceeding Series*, 144–147. https://doi.org/10.1145/3326365.3326384

Legard, S., & Hovik, S. (2022). The Impact of Digital Participation on Democratic Urban Governance. *Citizen Participation in the Information Society: Comparing Participatory Channels in Urban Development*, 167–190. https://doi.org/10.1007/978-3-030-99940-7_8

Li, H., & Kostka, G. (2022). Accepting but not engaging with it: Digital participation in local government-run social credit systems in China. *Policy and Internet*, *14*(4), 845–874. https://doi.org/10.1002/poi3.316

Lieven, C. (2017). DIPAS - Towards an integrated GIS-based system for civic participation. *Procedia Computer Science*, *112*, 2473–2485. https://doi.org/10.1016/j.procs.2017.08.182

Lima-Silva, F., Abreu, K., & Leblanc, E. (2020). Participação consultiva no Brasil: O caso do Conselho da Cidade de São Paulo. *Revista de Administração Pública*, *54*(2), 321–339. https://doi.org/10.1590/0034-761220180427

Lüchmann, L. H. H. (2014). 25 anos de Orçamento Participativo: Algumas reflexões analíticas. *Política & Sociedade*, *13*(28), 167–197.

Mærøe, A. R., Norta, A., Tsap, V., & Pappel, I. (2021). Increasing citizen participation in e-participatory budgeting processes. *Journal of Information Technology and Politics*, *18*(2), 125–147. https://doi.org/10.1080/19331681.2020.1821421

Mallan, K. (2018). Gateways to Digital Participation: The Rhetorical Function of Local Government Websites. In *Digital Participation Through Social Living Labs: Valuing Local Knowledge, Enhancing Engagement* (pp. 333–349). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85053743194&doi=10.1016%2fB978-0-08-102059-3.00018-6&partnerID=40&md5=ee65e8903b78b1c67e461177529627f7

Man, M. N. S., & Manaf, H. A. (2024). Exploring Factors Affecting Citizens' Acceptance to Use E-Participation in Malaysian Local Governments Through an Extended UTAUT Model. *International Journal of Computing and Digital Systems*, *15*(1), 511–550. https://doi.org/10.12785/ijcds/150139

Marin, P. de L., Vargas, F. G., & Guerrini, A. W. (2001). *Participação na cidade de São Paulo no período de 2001 a 2016: Do orçamento participativo ao programa de metas*.

Martins, S., Ckagnazaroff, I. B., Brugué, J. T., & Martins, M. F. (2020). Configuração da Participação Social no Conselho Municipal de Saúde da Cidade de Belo Horizonte—Brasil ## Configuration of Social Participation in the Municipal Health Council of the City of Belo Horizonte – Brazil. *Amazônia, Organizações e Sustentabilidade*, *9*(2), 44. https://doi.org/10.17648/aos.v9i2.2316

Mulder, B., & Hartog, M. (2011). The workload for the structural implementation of edemocracy: Local government policy issues combined with the policy cycle and styles of citizenship. *Proceedings of the European Conference on E-Government, ECEG*, 398–405. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84870925538&partnerID=40&md5=ecda3eb0eb3c3ef5f2636fcbe95447d8

Naranjo-Zolotov, M., Oliveira, T., Casteleyn, S., & Irani, Z. (2019). Continuous usage of e-participation: The role of the sense of virtual community. *Government Information Quarterly*, *36*(3), 536–545. https://doi.org/10.1016/j.giq.2019.05.009

Naranjo-Zolotov, M., Oliveira, T., Cruz-Jesus, F., Martins, J., Gonçalves, R., Branco, F., & Xavier, N. (2019). Examining social capital and individual motivators to explain the adoption of online citizen participation. *Future Generation Computer Systems*, *92*, 302–311. https://doi.org/10.1016/j.future.2018.09.044

Norris, D. F., & Reddick, C. G. (2013). E-participation among american local governments. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *8075*, 37–48. https://doi.org/10.1007/978-3-642-40346-0_4

Ntaliani, M., Costopoulou, C., & Karetsos, S. (2017). Investigating the mobile side of e-participation. *International Journal of Electronic Governance*, *9*(3), 210–228. https://doi.org/10.1504/IJEG.2017.088215

Ouzzani, M., Hammady, H., Fedorowicz, Z., & Elmagarmid, A. (2016). Rayyan—A web and mobile app for systematic reviews. *Systematic Reviews*, *5*(1), 210. https://doi.org/10.1186/s13643-016-0384-4

Page, M. J., Moher, D., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … McKenzie, J. E. (2021). PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. *BMJ*, *372*, n160. https://doi.org/10.1136/bmj.n160

Panagiotopoulos, P., Elliman, T., & Fitzgerald, G. (2011). How can public sector ICT transformation be institutionally-enabled? A UK local government study. *19th European Conference on Information Systems, ECIS 2011*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84870650685&partnerID=40&md5=2975667af59fae079388e434421d0429

Panagiotopoulos, P., Moody, C., & Elliman, T. (2012). Institutional Diffusion of eParticipation in the English Local Government: Is Central Policy the Way Forward? *Information Systems Management*, *29*(4), 295–304. https://doi.org/10.1080/10580530.2012.716991

Pateman, C. (1992). *Participação e teoria democrática*. Paz e Terra.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Pilehvar, A. A. (2021). Feasibility study and modeling of the concept of participatory urban management. *International Journal of Human Capital in Urban Management*, *6*(1), 69–80. https://doi.org/10.22034/IJHCUM.2021.01.06
Porwol, L., Ojo, A., & Breslin, J. (2014a). A semantic deliberation model for e-Participation. *Innovation and the Public Sector*, *21*, 40–50. https://doi.org/10.3233/978-1-61499-429-9-40
Porwol, L., Ojo, A., & Breslin, J. (2014b). A semantic model for e-participation—Detailed conceptualization and ontology. *ACM International Conference Proceeding Series*, 263–272. https://doi.org/10.1145/2612733.2612750
Porwol, L., Ojo, A., & Breslin, J. G. (2016). An ontology for next generation e-Participation initiatives. *Government Information Quarterly*, *33*(3), 583–594. https://doi.org/10.1016/j.giq.2016.01.007
Reddick, C., & Norris, D. F. (2013). E-participation in local governments: An examination of political-managerial support and impacts. *Transforming Government: People, Process and Policy*, *7*(4), 453–476. https://doi.org/10.1108/TG-02-2013-0008
Revyakin, S. A. (2018). On the effectiveness of electronic platforms of citizen participation in public administration. *Public Administration Issues*, *2018*(2), 94–113.
Rexhepi, A., Filiposka, S., & Trajkovik, V. (2018). Youth e-participation as a pillar of sustainable societies. *Journal of Cleaner Production*, *174*, 114–122. https://doi.org/10.1016/j.jclepro.2017.10.327
Royo, S., Pina, V., & Garcia-Rayado, J. (2020). Decide Madrid: A Critical Analysis of an Award-Winning e-Participation Initiative. *Sustainability*, *12*(4), Article 4. https://doi.org/10.3390/su12041674
Ruiloba Núñez, J. M. (2014). ¿Es el gobierno local un nuevo espacio para la participación ciudadana? El punto de vista de los alcaldes. El caso español. *Estudios Políticos*, *44*, 55–77.
Santos, J. M. V., & Alonso, Á. I. (2006). E-democracy and citizen's empowerment: A case study of the city of Madrid. *WIT Transactions on Information and Communication Technologies*, *36*, 247–254. https://doi.org/10.2495/IS060241
Savitch, H. V., & Kantor, P. (2004). *Cities in the International Marketplace: The political economy of urban development in North America and Western Europe*. Princeton University Press. https://press.princeton.edu/books/paperback/9780691120140/cities-in-the-international-marketplace
Scherer, S., & Wimmer, M. A. (2012). Reference process model for participatory budgeting in Germany. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *7444*, 97–111. https://doi.org/10.1007/978-3-642-33250-0_9
Silva, C. (2020). Smart Urban Governance, Citizens' E-Participation and Local Spatial Planning Preface. *INTERNATIONAL JOURNAL OF E-PLANNING RESEARCH*, *9*(1), V–VI.
Simione, A. A., & Ckagnazaroff, I. B. (2017). Governança Participativa em Moçambique: Dinâmicas do Envolvimento dos Cidadãos na Gestão Municípal na Cidade de Xai-Xai. *Administração Pública e Gestão Social*, *1*(1), 64–74. https://doi.org/10.21118/apgs.v1i1.1185
Sivarajah, U., Weerakkody, V., Waller, P., Lee, H., Irani, Z., Choi, Y., Morgan, R., & Glikman, Y. (2016). The role of e-participation and open data in evidence-based policy decision making in local government. *Journal of Organizational Computing and Electronic Commerce*, *26*(1), 64–79. https://doi.org/10.1080/10919392.2015.1125171
Smith, R. S. (2007). Public participation in the digital age: A theoretical approach. *GIS and Evidence-Based Policy Making*, 367–394.
Steinbach, M., & Süß, S. (2018). Administrators' identities and strategies in the e-participation innovation process: A qualitative analysis of institutional logics and institutional work in German municipalities. *Information Polity*, *23*(3), 281–305. https://doi.org/10.3233/IP-170037
Steinbach, M., Wilker, N., & Schöttle, S. (2020). E-participation on the local level–A census survey approach for researching its implementation. *Journal of Information Technology and Politics*, *17*(1), 12–32. https://doi.org/10.1080/19331681.2019.1676361
Tejedo-Romero, F., Araujo, J. F. F. E., Tejada, Á., & Ramírez, Y. (2022). E-government mechanisms to enhance the participation of citizens and society: Exploratory analysis through the dimension of municipalities. *Technology in Society*, *70*. https://doi.org/10.1016/j.techsoc.2022.101978
Tramontano, M. (2021). City, culture, and urbanism: Learning from Asuncion. *Cidades*, *42*, 98–113. https://doi.org/10.15847/cct.21976
Zheng, Y., Schachter, H. L., & Holzer, M. (2014). The impact of government form on e-participation: A study of New Jersey municipalities. *Government Information Quarterly*, *31*(4), 653–659. https://doi.org/10.1016/j.giq.2014.06.004
Zolotov, M. N., Oliveira, T., & Casteleyn, S. (2018). Continued intention to use online participatory budgeting: The effect of empowerment and habit. *ACM International Conference Proceeding Series*, 209–216. https://doi.org/10.1145/3209415.3209461

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 13: Legal Informatics – Foundations and Applications

Track Description

Legal informatics is concerned with the digital transformation of law and of the public sector. The field has two main focuses. On the one hand, it investigates how new technologies can be applied to directly transform law and public administration. Classic examples include legal databases, ejustice, IT forensics, and the digitalization of public services. On the other hand, it investigates how to create appropriate legal frameworks to regulate new technologies, including data protection law, data governance, and AI regulation. The track aimed to join contributions not only to practical applications but also to the theoretical foundations of legal informatics, including the field of privacy (policies, regulations, strategies, recommendations), models of legal and ethical knowledge (especially with respect to core concepts such as 'norms', 'arguments', 'rules', 'cases', 'principles', 'values', 'procedures'), smart contracts, legal interactions of autonomous agents, digital institutions and both the practice and the foundations of the various areas of information law, and legal informatics with respect to social cohesion and the reduction of inequality.

Track Chairs

P. Parycek, Frauenhofer Fokus, Germany
J. M. Adeodato, Federal University of Pernambuco, Brazil
D. Sasdelli, University for Continuing Education Krems, Austria

Contents

A Normal Form for Representing Legal Norms and its Visualization Through Normative Diagrams 813
D. Sasdelli, B. Steffes, M. Hermann, M. Chitashvili, and C. Wüst

The Role of Regulatory Frameworks in Shaping E- Governance: Insights from Selected Case Studies 828
Z. Jordanoski

A Normal Form for Representing Legal Norms and its Visualisation Through Normative Diagrams.

Diogo Sasdelli[a*], *Bianca* Steffes[b], *Moussa* Herrmann[c], *Mari* Chitashvili[d], *Clara* Wüst[e]

[a]Center for E-Governance, University for Continuing Education Krems, Krems an der Donau, Austria, diogo.sasdelli@donau-uni.ac.at, 0000-0002-6504-9812.

[b]Saarland Informatics Campus, Saarland University, Saarbrücken, Germany, bianca.steffes@uni-saarland.de, 0009-0001-9784-8942.

[c]PG Public Law, Baker McKenzie, Düsseldorf, Germany.

[d]Institut für Zukunftsenergie und Stoffstromsysteme, Saarbrücken, Germany, 0009-0004-3105-7701.

[e]Kammergericht Berlin, Berlin, Germany.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 3 June 2025

Abstract. Representing legal norms by means of an adequate formalism is essential for the development of legally compliant autonomous systems. The remarkable variety of both formalisation and implementation frameworks proposed during the last decades enables the development of relatively efficient formalisations over a wide range of applications. Notwithstanding, this abundance of frameworks also leads to some practical problems, especially with respect to the integration of – or the translation between – different frameworks. While more or less widely applicable meta-formalisms are already available, they are often too complex and counter-intuitive, thus being clearly closer to the technical implementation than to the conception phase of the formalisation process. As a complementary, more human-oriented solution to the problem, the paper at hand introduces and discusses a more intuitive normal form structure, which is based on elements of legal theory and aims at facilitating the interdisciplinary communication among the many partners involved in the process of developing law-abiding machines.

Keywords. Legal knowledge representation, formalisation of legal norms, deontic logic, legal logic, normal form, normative diagrams, autonomous driving, legal visualisation
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1036

1. Introduction

Current advancements in the field of artificial intelligence are paving the way for the integration of autonomous systems in various areas of human activity. Autonomous agents can recommend products, steer vehicles or assist in solving difficult formal problems. Within public administration, such systems can be employed to promote the automatisation of public services, to assist public authorities in making decisions under their jurisdiction, and enhance the administration of public goods in general (cf., e.g., Dolata and Schwabe, 2023; Döring et al., 2024; Larsen and Følstad, 2024; Lindgren, 2024). In the realm of law, autonomous systems can also be employed to provide more accurate information concerning the legal aspects of specific cases – thus promoting a better access to justice –, to assist judges, lawyers and other legal practitioners in their work or also to facilitate online dispute resolution (cf., e.g., Carneiro et al., 2014; Raabe et al., 2012; Virkar et al., 2022). Whilst the main objective of these systems is to be effective and efficient in solving the respectively given problems, especially when they are supposed to directly interact with humans, they should also behave

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

in a law-abiding manner. Thus, beyond being merely effective and efficient, autonomous systems should also be lawful.

The challenges involved in achieving law-abiding autonomous systems has lead to the development of various eclectic logical formalisms and implementation frameworks (for example, *LegalRuleML*; cf. Palmirani et al., 2011). However, these frameworks are oftentimes designed from an engineer's point of view and are thus less intuitive to legal scholars and practitioners. This often leads to difficulties in the interdisciplinary task of formalising legal norms. To provide a method for the specification of these problems in a way intuitive for both engineers *and* legal professionals, the paper at hand presents a type of *normal form* for representing legal norms based on elements of legal theory. Starting with high-level descriptions, this normal form allows for a swift transition between various degrees of specification, thus facilitating the communication between actors in the many implementation layers involved when designing autonomous systems. A further advantage of the normal form presented here is the fact that it can be easily combined with so-called *normative diagrams*, thus also enabling the construction of intuitive visualisations for the logical formalae employed.

In the following, Sec. 2 gives a short introduction to the general task of formalising legal norms using an example from German traffic law and demonstrates the various problems that may arise in the formalisation process. Sec. 3 briefly discusses related work on existing widely applicable meta-formalisms for legal norms and on the field of legal visualisation. Sect. 4 then presents the here proposed normal form solution and discusses how its structure facilitates the employment of a geometric visualisation method for legal norms by means of so-called *normative diagrams*. These diagrams could be particularly useful, e.g., if integrated in an intuitive *legal norm formalisation tool* directed at supporting legal scholars when formalising norms. Sec. 5 illustrates the use of the normal form (and of normative diagrams) through the discussion of a detailed example. Finally, Sec. 6 concludes and points out further directions for future research.

2. Formalising Legal Norms as a Complex Interdisciplinary Task

The process of formalising legal norms consists of several steps and involves experts from different disciplines. The complexity and interdependencies of this process can be illustrated through the example of developing an autonomous vehicle (AV). Designing an AV that is capable of driving *safely* through a city – a rather challenging task for itself – is not enough. Beyond *safety* requirements, AVs also have to fulfil *legal* requirements, i.e., they have to comply with existing traffic rules. In fact, some countries have already passed legislation requiring AVs to be able to autonomously comply with traffic rules, e.g., Germany's *Straßenverkehrsgesetz* (*StVO*)in its § 1e (2).

In a nutshell, the formalisation task consists of implementing traffic rules for AVs so that they are able to obey them like humans do. But to autonomously comply with legal norms, these norms must first be adequately *represented*. In particular, the representation method employed should enable AVs to recognise (ideally in advance) which manoeuvres they could perform would constitute a violation of a given legal norm. Moreover, in more *difficult* cases, e.g., in so-called *contrary-to-duty* situations or in cases involving conflicting norms (in which the violation of at least one norm is unavoidable), AVs should (ideally) be able to adequately evaluate and choose those manoeuvres which constitute lesser violations. Thankfully, literature offers countless formalisms – e.g., different systems of (deontic) logic (Gabbay et al., 2013) – which promise to deliver a more or less accurate representation of the various types of reasoning involved in such scenarios. However, the task of developing law-abiding AVs is not solely a logic problem, and it neither begins nor ends with the choice of an adequate formalism. Consider, e.g., the situation illustrated in Fig. 1. The autonomous vehicle AV is driving in Germany on the road r, which is partially obstructed by some unidentified object $\mathfrak{O}$. AV could drive on by performing the manoeuvre m_1 that would lead it through the indicated trajectory. As an autonomous system, AV should be able to determine whether is is allowed to do so.

At first glance, the case seems to be regulated by § 6 of the German Road Traffic Regulation (*StVO*). § 6 regulates a manoeuvre-type called *passing* (*Vorbeifahren*). It states that drivers wishing to *pass* (because of a road narrowing, an obstacle on the carriageway or a stationary vehicle) by driving onto the left lane must allow oncoming vehicles to pass through. A simple way to represent this in first-order logic would be:

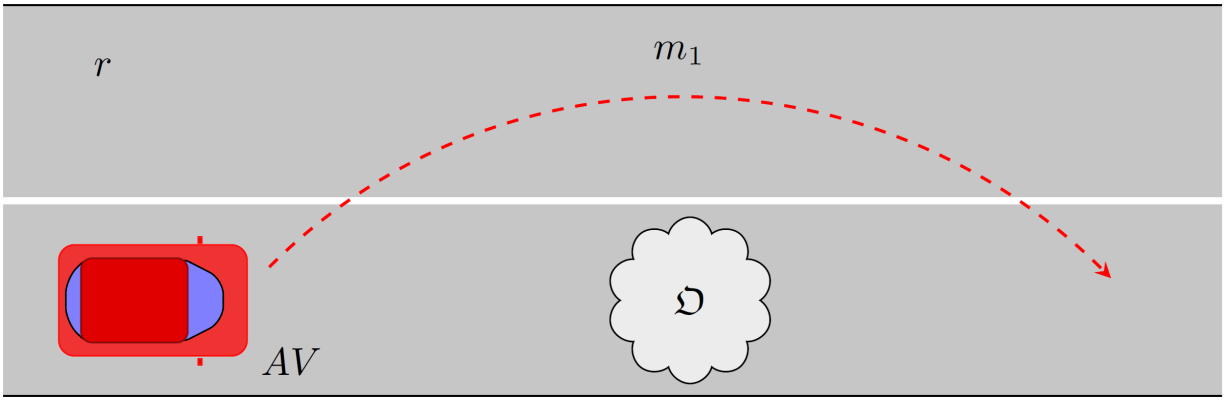


Fig. 1 – Would it be allowed for AV to drive past the unidentified object $\mathfrak{O}$ by taking the indicated trajectory?

$$\begin{aligned}&\forall x, y, z(\\&(Driver(x)\\&\wedge (Rd_Narrowing(y) \vee Obstacle(y) \vee St_Vehicle(y))\\&\wedge Onc_Vehicle(z, x)\\&\wedge Passing(x, y)\\&) \rightarrow Must_Allow_Pass_Through(x, z))\end{aligned} \quad (1)$$

Here, the predicate $Driver$ represents the property of being the operator of a vehicle (e.g., a human driver or an autonomous driving system). $Rd_Narrowing$, $Obstacle$ and $St_Vehicle$ are predicates corresponding to the conditions stated in § 6 StVO: They indicate that the driving situation is such that the lane in which one is driving is obstructed either by a road narrowing, an obstacle or a stationary vehicle. $Onc_Vehicle$ corresponds to the property of being a vehicle driving on the opposite lane. $Passing$ corresponds to the fact that a driver intends to perform the passing manoeuvre as defined in § 6 StVO. Finally, $Must_Allow_Pass_Through$ corresponds to the obligation that a driver intending to perform the passing manoeuvre has to first let oncoming traffic pass through. The variables x, y and z are assumed to be ranging over adequate sets of objects (e.g., drivers for x, road obstacles for y, vehicles for z).

Evidently, $Driver(AV)$ holds, and, at least intuitively, $Obstacle(\mathfrak{O})$ also seems to be satisfied. Hence, as long as there are no oncoming vehicles, it would seem that AV is allowed to execute the manoeuvrer m_1. In case there were oncoming vehicles, AV would only be allowed to perform m_1 if this were not to impede said vehicles from passing through, i.e., so as to satisfy $Must_Allow_Pass_Through(AV, z)$, where z is an oncoming vehicle.

However, a more careful consideration of the example depicted in Fig. 1 reveals that the road r, on which AV is driving, bears a specific road marking, namely a *solid line*. The legal norm connected to this road marking is described in the second annex to § 41 (1) of the StVO (*sign 295*). Following this norm, a vehicle driving on a road with a solid line must neither cross nor even straddle the line. A simple first-order formalisation of this norm would be:

$$\begin{aligned}&\forall x, y(\\&(Driver(x)\\&\wedge R_Sld_Line(y)\\&\wedge Drives_On(x, y)\\&) \rightarrow (Must_Not_Cross_Line(x)\\&\wedge Must_Not_Straddle_Line(x)))\end{aligned} \quad (2)$$

Since $Driver(AV)$, $R_Sld_Line(r)$ (road has a solid line) and $Driver_On(AV, r)$ hold, AV must neither cross nor straddle the solid line on r. Since, as implied by Fig. 1, performing m_1 requires crossing the solid line, the manoeuvre would actually be forbidden. This would mean that AV would have to wait behind $\mathfrak{O}$ until the carriageway is cleared or at least until it is able to pass by $\mathfrak{O}$ *without* crossing or straddling the line (Helle, 2021, Rn. 14). Formalisations (1) and (2) are, however, still far from ideal. Overall, they display two general problems, namely a *legal-theoretical* and a *technical* one.

The *legal-theoretical problem* consists in the fact that formalisations (1) and (2) do not really consider the valid *legal norms* applicable to the case, but only (some parts of) the corresponding *legal texts*. Formalisation proceeds from the assumption that law is a system of legal norms. From this perspective, it is important to distinguish between the law itself and its many sources, in particular between the law and written legislation (Nawiasky, 1948). Overall, legal norms are obtained from legal sources through the use of different interpretation techniques (Alexy, 1994, pp. 42-47, Weinberger & Weinberger, 1979, pp. 108-112). One can distinguish between five different classes of legal sources (for a more detailed discussion, cf., e.g., Kelsen, 2017, pp. 417-423, Bobbio, 1993, pp. 173-182): (I) written legislation; (II) legal precedents; (III) private autonomy (e.g., contracts, wills etc.); (IV) usages and customs; (V) legal dogmatics (e.g., the opinion of legal scholars). Hence, assessing the actual *norms* applicable to a given case requires way more than simply reading the text of written legislation. This is illustrated well by the fact that the last assessment given above, i.e., that AV would have to wait behind $\mathfrak{O}$ due to the solid line, is actually wrong. Following a well-established understanding adopted by German courts, a driver passing an obstacle in the sense of § 6 of the StVO is allowed to cross the solid line (Helle, 2021, Rn. 14; cf. also the court decisions OLG Saarbrücken, decision from 01.12.2016, 4 U 109/15, Rn. 47; OLG Düsseldorf, decision from 07.06.2022, I-1 U 222/20 Rn. 61). In other words, § 6 entails an (*unwritten*) exception to the solid line rule. The importance of interpretation becomes even clearer when considering the vagueness of the concepts used in § 6. For example, the predicate $Obstacle$, as represented in (1), could, intuitively, be satisfied *prima facie* by anything standing on the carriageway. Yet a more careful consideration of how legal dogmatics defines the concept of *passing* reveals that a non-stationary vehicle (or even a vehicle that stopped due to the traffic circumstances (Helle, 2021, Rn. 6, Heß, 2022a, Rn. 2-3) would not qualify as an obstacle in the sense of this norm. In other words, one does not *pass* by a non-stationary vehicle, one *overtakes* it. In the StVO, passing and overtaking (*Überholen*) are two different manoeuvres. Overtaking is regulated in § 5, and, more importantly for the case at hand, it does *not* constitute an exception to the solid line rule (Heß, 2022b, Rn. 92; cf. also the decision BGH NJW-RR 1987, 1048, 1049). Hence, whether or not AV is allowed to execute the manoeuvre m_1 depends on what exactly the object $\mathfrak{O}$ is.

This leads to the second, *technical problem* raised by formalisations (1) and (2): such formalisations have to be *implemented* in real machines, which leads to a series of challenges. For example, the predicates employed in formalisations of legal norms are often not logically independent from one another. For example, if r is a road with a solid line, i.e., if $R_Sld_Line(r)$ holds, then r cannot be (at least in the same segment) a road with a double centre line comprising one continuous and one broken line (*sign 296*); if z is a stationary vehicle, z cannot be a non-stationary vehicle etc. These inter-dependencies are usually represented by using so-called *ontologies* (Leone et al., 2022; Van Engers et al., 2008), which are basically first-order theories containing the rules of these inter-dependencies. In theory, such ontologies should be as detailed as possible, so as to be able to represent all the relevant factors included in legal norms. For example, following German courts and legal dogmatics, the minimal distance a driver must observe when passing by a stationary vehicle depends on several factors such as the width of the road, the type of the stationary vehicle, and whether there are visible people inside it or not. Ideally, one should employ an ontology containing all these concepts. Yet, using overly detailed formalisms might lead to implementation problems. In its core, verifying the legality of a manoeuvre with respect to a set of formalised norms is reducible to a *SAT problem* (or rather to a *satisfiability modulo theories* problem, cf. Lin & Althoff, 2022), i.e., checking whether a set of propositions is jointly satisfiable under a set of assumptions. However, SAT problems belong to the category of computationally expensive, so-called *NP-complete* problems. In general, adding more details to the formalism will lead to an exponential growth of the computational power required to verify the legality of a manoeuvre, which will quickly overwhelm even the fastest of modern computers. This is particularly problematic because, ideally, an autonomous vehicle should be able to consider various possible manoeuvres and trajectories in a relatively short amount of time, instead of analysing only one possibility *ad nauseam*. Moreover, an autonomous vehicle would not only have to be able to operate with all these concepts, but also to *detect* the existence of corresponding objects in its environment. In the example illustrated in Fig. 1, before it could even begin assessing the legality of following the trajectory m_1, AV would have to detect that it is driving on a road with a solid line and that there is an object $\mathfrak{O}$ obstructing its path. Then, it would have to determine what kind of object $\mathfrak{O}$ is. If it is a stationary vehicle, it would have to detect what kind of vehicle it is, and whether there are visible people inside it etc., which would require considerable computational power.

These examples show that formalising legal norms for the development of law-abiding machines is a complex interdisciplinary task. Legal norms are not just simply derived from written legislation. With the increasing degree of detail given in a formalisation, the computational resources for the calculation of the corresponding reasoning problems might also increase drastically. The formalisation process itself starts with legal scholars

delivering a description of what the law actually is, i.e., of the legal norms proper, it continues with logicians representing these norms in a logical formalism, and ends with computer scientists and engineers implementing this formalism in a practically feasible manner. This interdisciplinary work-flow is illustrated in Fig. 2.

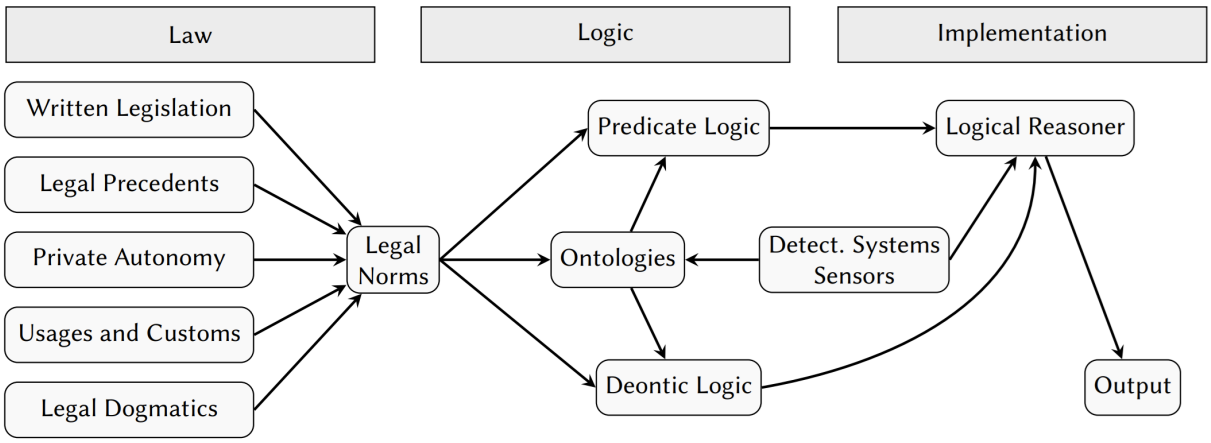


Fig. 2 – Representation of the work-flow from the analysis of the sources of law to the final implementation of legal norms in a law-abiding machine.

In this process, logicians see themselves caught between the need to adequately formalise the scientifically accurate norm descriptions given by legal scholars and the practical requirements and limitations determined by computer scientists and engineers. In particular, legal scholars tend to prefer a wider, *open-texture* formalisation, i.e., one that employs vague general concepts, thus being closer to a natural-language description of the respective norms. Computer scientists require variables and constants pertaining to a given domain to be assigned to these concepts, and engineers require these variables and constants to correspond to real-world objects which they can effectively detect. Hence in practice, more often than not, the formalisation first agreed upon between the involved parties has to undergo several modifications before it can actually be implemented. Furthermore, the use of many different formalisms and systems, e.g., formal languages, ontologies, logical reasoners, theorem provers, detection and driving systems along these different steps, with each possibly being based on different abstraction levels, often requires translating from one formalism into the other. This could eventually result in unnoticed errors, especially since the various employed formalisms might differ in their inherent expressiveness. Finally, having to constantly translate between formalisms also hinders the interdisciplinary communication between the many partners involved in developing law-abiding autonomous systems.

3. Related Work

Representing legal norms in a *normal form* constitutes a promising solution to the problems discussed above, as this could greatly simplify and unify the formalisation process with its various existing frameworks. As long as this normal form is at least partially based on elements of legal theory, it could also present a middle ground for legal professionals, logicians, computer scientists and engineers. In the following, Sec. 3.1 briefly discusses already existing widely applicable meta-formalisms for representing legal norms and their shortcomings with respect to interdisciplinarity. Sect. 3.2 then briefly discusses related work in the field of legal visualisation.

3.1. Meta-Formalisms for Legal Norms

Eclectic *meta-formalisms* for representing legal norms – i.e., symbolisms applicable to a wide range of underlying logical formalisms – already exist. For example, especially if norms are represented using (variations of) classic predicate logic, in particular first-order logic, one could employ the symbolism of the *Thousands of Problems for Theorem Provers (TPTP)* library (Sutcliffe, 2017). Beyond its overall flexibility, the TPTP-symbolism is both fairly easy for humans to read and compatible with PROLOG, which facilitates further implementations. Another good example is *LegalRuleML* (Palmirani et al., 2011), an XML-based annotation framework capable of directly representing legal norms and several properties usually associated with normativity, especially *defeasibility*. One could also, as proposed by Steen and Fuenmayor, 2022, attempt to combine

both TPTP and LegalRuleML. However, while these meta-formalisms are extremely useful, they were evidently crafted with the implementation part of the process in mind. For the average legal scholar – and even for logicians and technicians not used to working with them –, they remain relatively complex and unintuitive. Hence, they do not facilitate the interdisciplinary communication between legal scholars, logicians, computer scientists and engineers. The normal form discussed here aims at filling this gap. It is far more primitive than the remarkable meta-formalisms mentioned above, and it focuses more on didactic aspects, on clarity, and on promoting and facilitating communication between humans. Hence, it is obviously not conceived as an alternative to implementation-oriented meta-formalisms such as TPTP's language or LegalRuleML, but as a human-focused methodological complement to them.

3.2. Legal Visualisation

Furthermore, the normal form proposed here was designed to be employed together with the legal visualisation method of *normative diagrams* (Sasdelli & Trivisonno, 2023), which is introduced in more details below in Sec. 4.2. Combining a textual formalism (like the normal form) with a visual one (like the diagrams) offers several advantages. Legal visualisations can be defined as human-oriented, (semi-) formal, pictorial (rather than verbal) knowledge management structures or *visual representations* in a general sense (Cyras & Lachmayer, 2023). Overall, depending on the goal pursued, visualisations found in the literature display different degrees of abstraction and formalism. Less formalised or structured imagery is usually employed for didactic (especially mnemonic) purposes (e.g., McCloskey, 1998), as well as for communication with children (Kessel, 2014), laymen (Carnein et al., 2014) and the public in general (e.g., in the context of the so-called *Proactive Law Movement* and *Legal Design*; cf. Murray, 2021); for an overview, cf. also Brunschwig, 2014. More formal methods, e.g., decision trees, graphs and the normative diagrams discussed here, are used not only within legal higher education, but also for theoretical and practical purposes (Kohlhase et al., 2021; Muff & Fill, 2021; Röhl & Ulbrich, 2007; Sasdelli & Trivisonno, 2023). As an intermediate abstraction level between natural language and a logical formalism (Lachmayer & Cyras, 2021), visualisations also constitute a valuable extension to legal tech applications, by facilitating both the interdisciplinary communication during the development of such applications as well as their later use by legal experts and the public in general. A good example is the PROLOG-based practical legal reasoning system PROLEG (Satoh, 2023), which in more user-friendly implementations also generates a decision tree diagram illustrating the reasoning process leading to the decision derived by the program. A new trend in the field involves the usage of virtual reality tools (Muff & Fill, 2021; Muff et al., 2022).

4. Normal Form and Normative Diagrams

The following Sec. 4.1 gives an in-depth description of the proposed normal form and also considers its advantages in light of different existing legal formalisms. Sec. 4.2 shows how *normative diagrams* can be used to visualise the normal form and thus further facilitate the comprehension for the involved parties of the formalisation process.

4.1. Normal Form Structure and Theoretical Background

In general terms, one can distinguish between two main types of legal norms (Kelsen, 1979, pp. 76-78):

1. Norms that refer to the validity of other norms, e.g., procedural law, norms regulating the legislative process and derogative norms;
2. Norms that refer directly to the actions or to the overall behaviour of agents.

In the following, only norms of the latter type shall be considered. Such norms can be further subdivided into three categories: (1) prohibitions, (2) obligations, and (3) permissions (Kelsen, 1979, pp. 76-77, Bobbio, 1993, pp. 96-99). Each of these categories is connected to different violation conditions. Prohibitions, for example, are violated when a case corresponds to the norm's content or, in case of analogy, when a case is sufficiently similar to the norm's content. Determining the violation conditions for obligations is a more difficult task. Generally speaking, it seems reasonable to assume that obligations are violated when it becomes impossible to satisfy the norm's content. This would indicate an important temporal element to the definition of the violation conditions of obligations, which, however, would become a challenge when considering obligations

that can never be completely fulfilled (even without being thus necessarily violated). Examples would be very general legal or moral principles, in particular so-called *imperfect duties* (Johnson & Cureton, 2024), like the duty to respect human dignity, the duty to live a healthy life etc. Further challenges concerning the definition of the violation conditions of obligations could arise from the concept of supererogation, i.e., roughly speaking, doing more than one's duty actually requires (Heyd, 2023; Wessels, 2002). For simplicity, in the paper at hand, it shall be assumed, as it is done in some works of legal theory (cf., e.g., Kelsen, 1979), that obligations can be reformulated as prohibitions. Finally, Permissions cannot be violated.

Intuitively, norms regulate sets of actions or behaviours that:

- belong to specific action or behaviour categories;
- happen at a given place;
- are performed by specific agents;
- transpire at a specific point in time.

Hence, irrespective of its category, the content or *validity domain* of a norm can be seen as stretching throughout four *dimensions*: object (O), space (R), subject (S) and time (T) (cf. Bobbio, 1993, p 214, Kelsen, 1979, pp. 116-119, Nawiasky, 1948, p. 85). When considering only prohibitions, the most obvious violation condition of a norm coincides with a description of its validity domain in the four dimensions mentioned above: a case will constitute a violation to the norm if it falls (or is subsumed) under its normative content or validity domain, i.e., if it is subsumed under the category of actions which the norm directly state as being prohibited. Further violation conditions could still be derived, e.g., by considering analogy arguments. Setting analogies aside and focussing on subsumption, the conditions for the violation V_ϕ of the norm ϕ can be determined by:

$$V_\phi \Leftarrow (O_\phi \wedge R_\phi \wedge S_\phi \wedge T_\phi) \tag{3}$$

Where $\Leftarrow$ is a *necessary condition* operator and O_ϕ, R_ϕ, S_ϕ and T_ϕ are high-level descriptions respectively of the objective, spacial, subjective and temporal dimensions of the norm ϕ's validity domain.

The structure of the equation (3) can be used as a normal form for logic-based representations of legal norms. This claim is based on the assumption that every norm can be adequately represented by its violation conditions. This is fairly obvious, under the assumptions made above, for prohibitions and obligations. For *permissions*, which, as stated above, cannot be violated, it seems reasonable to establish the convention that their representation in this normal form corresponds to an empty expression. This means that permissions will be basically ignored, except when dealing with them as exceptions to other norms. This should not constitute a problem for the applications discussed here: when developing a law-abiding autonomous agent, it is more convenient to only keep track of the actions which the machine should avoid, i.e., of which actions constitute violations – all other actions (which are evidently way larger in number) can then be considered to be permitted. Moreover, permissions constituting exceptions to prohibitions or obligations can be considered as (partial) *derogations*, i.e., as limitations of a norm's violation conditions.

The normal form promotes a natural formalisation process. One first starts with the high-level descriptions O_ϕ, R_ϕ, S_ϕ and T_ϕ of the violation conditions of the norm ϕ, which basically just state that the conditions for a case to fall under the norm's validity domain and thus be violated (if the norm is a prohibition norm) are satisfied. Then, one can, by means of interdisciplinary work between legal scholars, computer scientists and engineers, introduce further, more detailed descriptions of the circumstances that satisfy each of these high-level descriptions. The possibility to reduce such different formalisms back to one and the same normal form demonstrates the flexibility of the presented method. Since each high-level description is directly associated with one of the norm's validity dimensions, using the normal form leads to a better organisation of the formalisation work. Ideally, one would then be able to more easily identify which elements of the legal norm (as described by legal scholars) cannot (yet) be efficiently processed or detected by the available methods employed (as determined by computer scientists and engineers). This could facilitate the search for approximations or other alternative solutions.

Finally, besides being based on the legal-theoretical division of a norm's validity domain in four dimensions, the normal form presented here was also conceived to be easily combined with existing formalisms like the ones just mentioned above. For example, the necessary condition operator $\Leftarrow$ was chosen because of the long tradition of using *horn-clauses* to formalise legal norms in PROLOG or related formalisms (cf., e.g., Satoh, 2023; Sergot et al., 1986). Due to its relatively simple structure, it can be easily combined with any formalism based

on predicate logic, especially with temporal logics (Maierhofer et al., 2022). The normal form can also be combined with formalisms based on modal logic, especially with deontic logic (Gabbay et al., 2013). This can be done, e.g., by conditioning the fulfilment of one or more predicates on the satisfaction of formulae under given conditions represented in the desired formalism. Overall, the normal form offers an elegant way of both organising the designed formulae and guiding the further development of the formalisation process, while also enabling a combination of various different formalisms. This can be employed to determine adequate conditions for the satisfaction of the respective predicates culminating in the normal form's four conjuncts.

4.2. Enhancing the Normal Form with Normative Diagrams

Like the normal form presented here, normative diagrams are also based on the idea that a norm's validity domain extends over four dimensions. By assigning each dimension to an axis in a coordinate system, the validity domain of a norm can be represented as a region in a four-dimensional metric space. For example, if it is assumed that the action of crossing or straddling a solid line is delimited by the values o_1 and o_4; the set of all German roads with solid lines by the values r_1 and r_3; the set of all drivers by the values s_1 and s_2; and the set of all possible points in time by $\{t_x | x \in \mathbb{N}\}$, then the validity domain U_ψ of the norm associated with sign 295 of the German StVO (let this norm be called ψ) can be defined as being the set:

$$U_\psi = \{ < o_a, r_b, s_c, t_d > \mid o_a \in [o_1, o_4] \wedge r_b \in [r_1, r_3] \wedge s_c \in [s_1, s_2] \wedge t_d \in \{t_x | x \in \mathbb{N}\} \} \tag{4}$$

Since the norm is valid at all points in time, i.e., it is *always* prohibited to cross or straddle the line, the temporal dimension can be omitted. Hence, it is possible to represent the norm ψ in a three dimensional normative diagram, as illustrated in Fig. 3. The region delimited by the red three-dimensional figure corresponds to ψ's validity domain. Here, the colour red is used to indicate that ψ is a prohibition norm. Similarly, the colours blue and yellow can be used to represent obligation and permission respectively. Concrete cases can be depicted as points in this three-dimensional metric space. Since the norm ψ is a prohibition, if a point is located inside of the three-dimensional cuboid of the norm, the corresponding case falls under its validity domain and thus *violates* the norm. Hence, the violation conditions specified by the *normal form* can be easily visualised through respective normative diagrams, while the concrete values on the axes can help in defining the normal form for a norm.

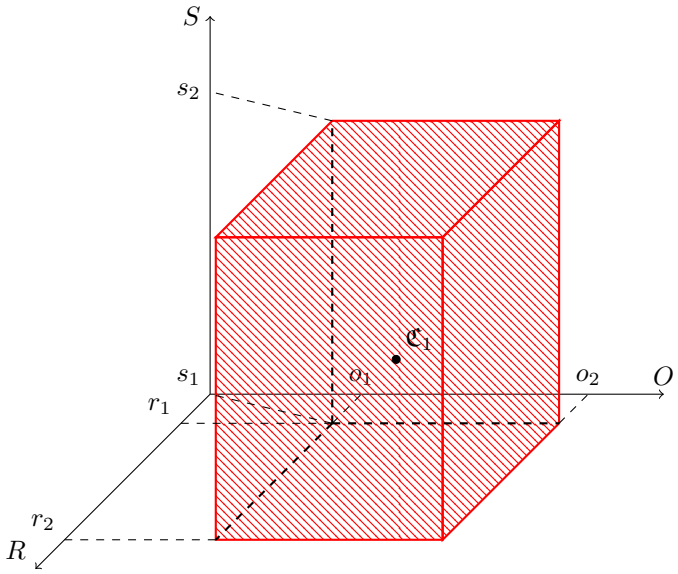


Fig. 3 – A three-dimensional normative diagram for the norm ψ with case $\mathfrak{C}_1$ violating the norm.

For simplicity, one could also restrict the analysis of the subjective dimension of the norm's validity domain to the set of all *drivers*. In this case, it would be possible to also omit the subjective dimension of the norm's validity domain; for it is in fact prohibited for *all drivers* to cross or straddle the solid line. In this case, a two-dimensional representation would suffice (left side of Fig. 4). Finally, one could also restrict the analysis to the set of roads with solid lines, because, evidently, one can only cross or straddle these lines while driving on roads that have them. Hence, the norm could also be adequately represented with a one-dimensional diagram containing only the objective dimension (right side of Fig. 4).

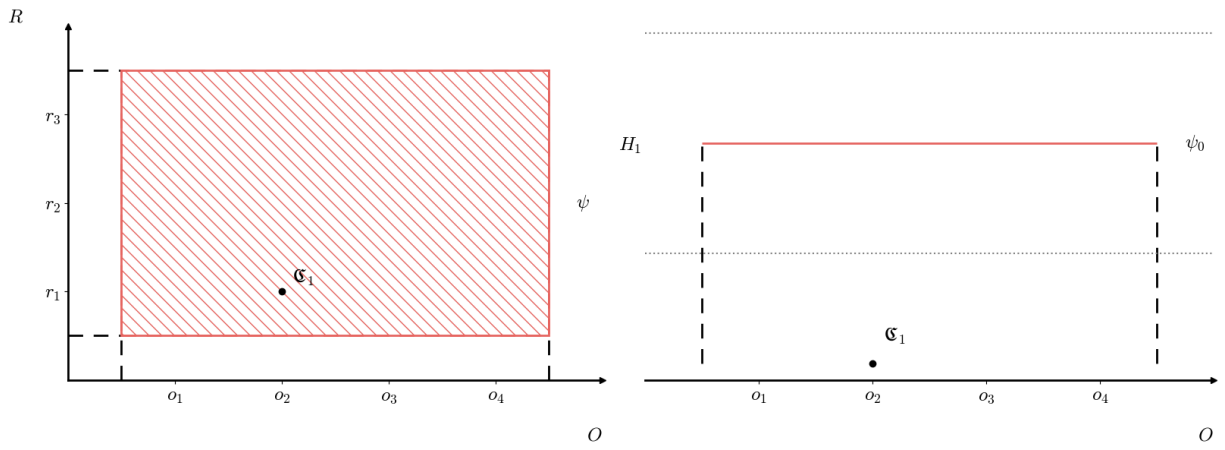


Fig. 4 – Simplified diagrams for ψ with two dimensions (left) and with one dimension (right), each with case $\mathfrak{C}_1$ violating the norm.

The *unwritten* exception to the solid line norm which allows drivers to cross the line when passing by a road narrowing, an obstacle or a stationary vehicle in the sense of § 6 of the StVO can be represented by adding a second norm ζ to the diagram, as shown in Fig. 5. Since the validity domains of the norms intersect, i.e., since $U_\psi \cap U_\zeta \neq \emptyset$, and since the norms differ in their mode, i.e., ψ is a prohibition and ζ is a permission, these norms constitute a *normative conflict* or a (legal) *antinomy* (Bobbio, 1993, pp. 209-216, Engisch, 1985, p. 160). Moreover, since $U_\zeta \subset U_\psi$, this conflict is of the type *total-partial*, and can thus be solved by the classic speciality criterion (*lex specialis derogat legi generali*). When representing the antinomy between ψ and ζ, it is useful to employ a two-dimensional diagram (left side of Fig. 5), because one could argue that the exception contained in ζ does not apply to all roads with solid lines, but only to those which are wide enough to allow for the vehicle to pass through.

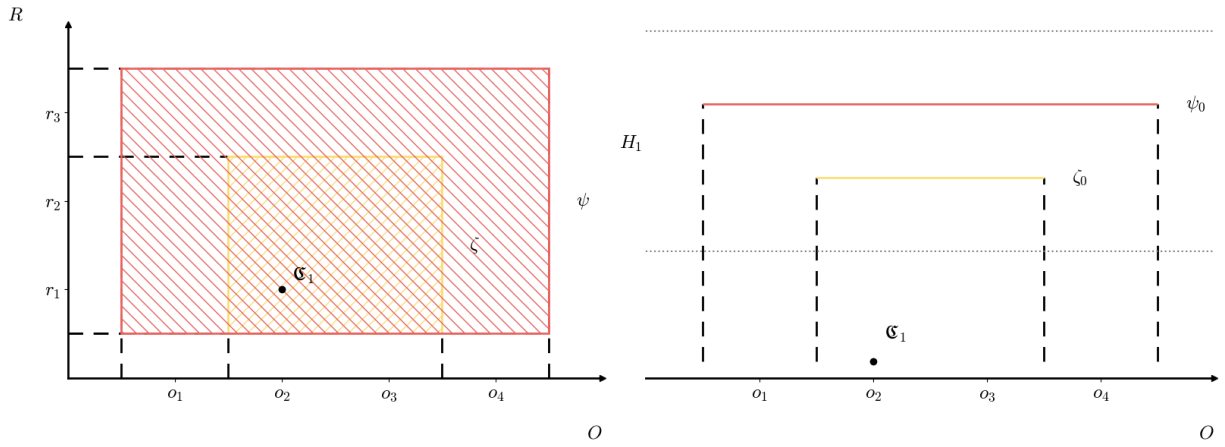


Fig. 5 – The unwritten exception to the solid line norm can be represented as a legal antinomy between the norms ψ and ζ. The values between o_2 and o_3 correspond to the action of crossing a solid line while passing by an obstacle, a road narrowing or a stationary vehicle in the sense of § 6 of the StVO. The values between r_1 and r_2 represent those roads that are wide enough to allow for the manoeuvre to be performed. Evidently, this will depend on the object obstructing the way and on the width of the passing vehicle.

Normative diagrams can also be employed to represent legal arguments, e.g., analogy, appeals to the contrary, as well as more complex aspects of legal norms, e.g., their hierarchy level in the legal order (for details, cf. Sasdelli and Trivisonno, 2023). Alternative representation forms that allow the complete visualisation of all four dimensions of the validity domain in one single figure have also been developed (Steffes & Sasdelli, 2025). Being a simple but nonetheless efficient way of visualising legal norms and other legal phenomena, these diagrams could constitute a valuable component in a user-friendly *legal norm formalisation tool*. This tool could be employed in a wide range of different applications, e.g., for research and development purposes in the

area of law-abiding autonomous agents or for didactic purposes in law faculties or in the field of legistics. Such tool could be developed on the basis of ViNo, an open-source tool[1] that automatically generates normative diagrams from given inputs (a prototype was presented by Steffes and Sasdelli, 2024).

5. Example

This section now presents a precise example on how to apply the presented normal form with a particular focus on its combination with normative diagrams. For this example, the manoeuvre m_1 depicted in Fig. 1 shall be considered again.

The legality of m_1 depends on a set of norms $\mathfrak{N}$ containing the norms applicable to m_1. In this case, it consists of the norms corresponding to sign 295 and to § 6 of the German Road Traffic Regulation, as well as further prescriptions such as speed limits or norms related to the general obligation to drive carefully and to be mindful of other road users (§ 1 of the German Road Traffic Regulation). For simplicity, assume $\mathfrak{N} = \{\psi,\ \chi,\ \kappa\}$, i.e., $\mathfrak{N}$ contains only the three norms ψ, χ and κ. These norms correspond respectively to the prohibition of crossing the solid line (sign 295, ψ), to the regulation of the manoeuvre-type *passing* (§ 6, χ), and to the speed limit of road r, which can be assumed to be 30 km/h (κ). In the normal form, each of these norms can be represented through the expression

$$V_x \Leftarrow (O_x \wedge R_x \wedge S_x \wedge T_x). \tag{5}$$

Assuming $[m_1]$ to be a comprehensive description of the manoeuvre m_1 in some logic formalism, checking whether the manoeuvre m_1 is legal can be reduced to the task of checking whether the expression

$$(O_x \wedge R_x \wedge S_x \wedge T_x) \Leftarrow [m_1] \tag{6}$$

is satisfied for any $x \in \mathfrak{N}$. Following the structure of the normal form, the expression $[m_1]$ can be further divided in the subformulae O_{m_1}, R_{m_1}, S_{m_1} and T_{m_1} which each contain the predicates for detecting a violation in one of the four dimensions:

$$(O_x \wedge R_x \wedge S_x \wedge T_x) \Leftarrow (O_{m_1} \wedge R_{m_1} \wedge S_{m_1} \wedge T_{m_1}) \tag{7}$$

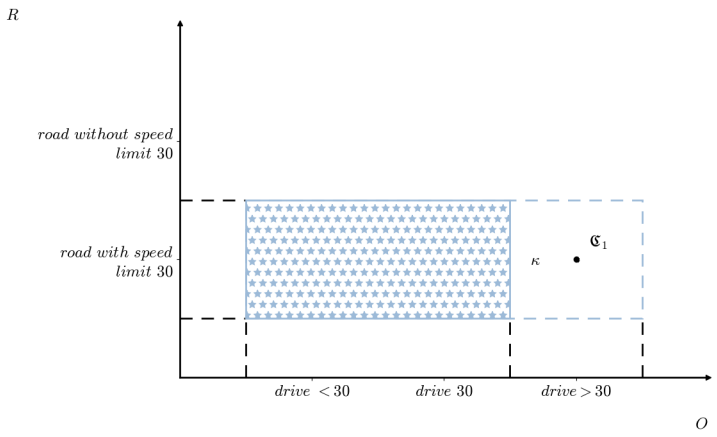
For this, it is first necessary to further define both $[m_1]$ and the norms in $\mathfrak{N}$. In particular, a more detailed definition of the norms in $\mathfrak{N}$ – to be provided by legal scholars – should clarify which kinds of information $[m_1]$ should ideally contain – i.e., as provided by the sensors of an AV – to determine the violations.

The speed limit κ can be assumed to be valid at all times for all subjects with respect to all manoeuvres they perform. Thus, the norm is violated by all manoeuvres performed while driving faster than 30 km/h on road r (this ignores, for the sake of simplicity, the obvious exception given to emergency vehicles, e.g., ambulances). Hence, one can further specify the violation condition of κ by determining that $T_\kappa \Leftarrow \top$ and $S_\kappa \Leftarrow \top$ hold, where $\top$ is any logical tautology. For the further conditions, one can determine, e.g., $R_\kappa \Leftarrow Road_{30}(m)$ and $O_\kappa \Leftarrow f_{speed}(m) > 30$, where m is a variable ranging over all possible manoeuvres, $Road_{30}$ is a predicate that is satisfied if and only if a manoeuvre is performed on a road with a speed limit of 30 km/h, and f_{speed} is a function that retrieves the maximum speed of a given manoeuvre.[2] These thoughts are illustrated with example values in Fig. 6 when considering κ to be an obligation, i.e., the obligation of driving in a speed below the set limit. Following the assumption made above that an obligation may also be generally reformulated as a prohibition, Fig. 7 depicts the norm as a prohibition, i.e., the prohibition of driving in a speed above the set limit.

The solid line norm ψ can be likewise assumed to be valid at all times and with respect to all subjects. As discussed above, its spatial violation condition only refers to roads containing solid lines; hence, one can further determine $R_\psi \Leftarrow R_Sld_Line(m)$. At first glance, its objective dimension refers to all possible manoeuvres (e.g., overtaking, turning left, making a U-turn) that imply crossing or straddling the solid line. However, as discussed above, the norm corresponding to § 6 (*Passing*) of the German Road Traffic Regulation contains

[1] The code can be found at https://github.com/bs-000/norm-visuals. The repo also contains a Windows executable file to provide an easy access for technical laymen.

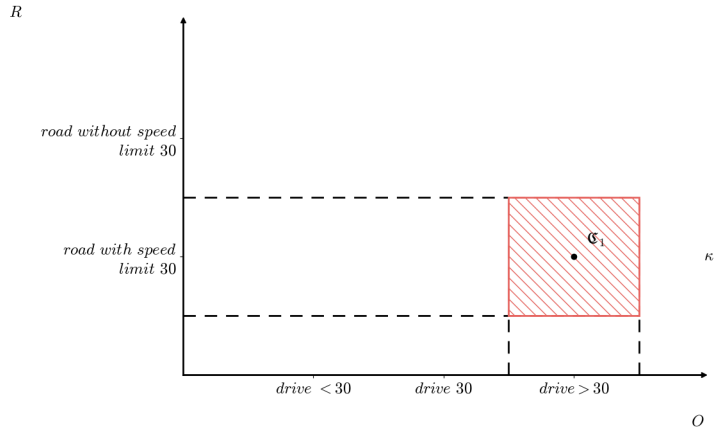
[2] Alternatively, one could replace the predicate $Road_{30}$ by a respective function f_{road} that retrieves the road (or rather, a road-index $[r] \in \mathbb{N}$ functioning as a name for the road) in which a given manoeuvre is performed. In this case, one would write the respective condition as $R_\kappa \Leftarrow f_{road}(m) = [r]$.



$$V_\kappa \Leftarrow (O_\kappa \wedge R_\kappa \wedge S_\kappa \wedge T_\kappa)$$

$$O_\kappa \Leftarrow f_{speed}(m) > 30$$
$$R_\kappa \Leftarrow Road_{30}(m)$$
$$(R_\kappa \Leftarrow f_{road}(m) = [r])$$
$$S_\kappa \Leftarrow \top$$
$$T_\kappa \Leftarrow \top$$

Fig. 6 – Diagram and normal form description of the speed limit of 30 km/h with κ as an obligation.



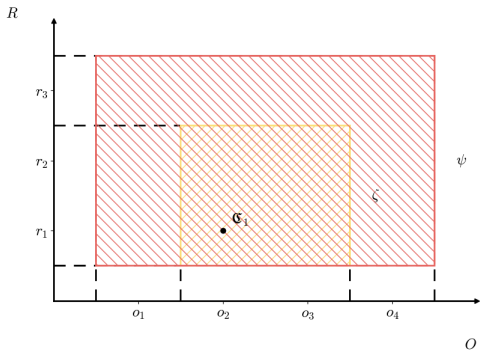
$$V_\kappa \Leftarrow (O_\kappa \wedge R_\kappa \wedge S_\kappa \wedge T_\kappa)$$

$$O_\kappa \Leftarrow f_{speed}(m) > 30$$
$$R_\kappa \Leftarrow Road_{30}(m)$$
$$(R_\kappa \Leftarrow f_{road}(m) = [r])$$
$$S_\kappa \Leftarrow \top$$
$$T_\kappa \Leftarrow \top$$

Fig. 7 – Diagram and normal form description of the speed limit of 30 km/h with κ as a prohibition.

an implicit exception to this rule: when performing the manoeuvre *Passing*, drivers are allowed to cross the solid line. Hence, one could determine $O_\psi \Leftarrow m \in \mathfrak{M}_{xsl} \backslash \{Passing\}$, where $\mathfrak{M}_{xsl} \backslash \{Passing\}$ is the set of all manoeuvres that imply crossing or straddling the solid line except the manoeuvre *Passing*. To visualise this rule-exception, one can interpret § 6 StVO to also contain (or at least imply) a permissive norm ζ, stating that it is allowed to cross or straddle the solid line when passing by. The resulting normative conflict between ψ and ζ would be solvable by the collision rule *lex specialis*, which, in effect, leads to the same result as stating that *passing* manoeuvres constitute exceptions to the general solid line rule. These thoughts are illustrated in Fig. 8.

Finally, a direct interpretation of § 6 StVO also entails an obligation norm χ, which regulates the *Passing* manoeuvre. This norm can be specified as follows. As it was the case with κ and ψ, χ's temporal and subjective violation conditions can be assumed to be always fulfilled. Its spatial condition concerns roads wide enough so that *Passing* is possible. Hence, one could determine: $R_\chi \Leftarrow Rd_Width_Ok(m)$. § 6 StVO stipulates that drivers passing by an obstacle have to allow for oncoming vehicles to pass through. Hence, by means of a still fairly high-level description, the objective violation condition could be specified as $O_\chi \Leftarrow Impedes_Onc_Traffic(m)$. Evidently, the predicates Rd_Width_Ok and $Impedes_Onc_Traffic$ are still too abstract to allow for meaningful practical implementations. Therefore, it would be necessary to further specify the conditions under which these predicates are satisfied. For example, one could further define $Road_Width_Ok$ as a function of the overall width of the road, the width of the vehicle performing the respective manoeuvre and the width of the obstacle in question. However, even after the addition of these specifications, this representation of the norm regulating the *Passing* manoeuvre would still be missing an important point: while this is not explicitly stated in the text of § 6 StVO, a deeper analysis of legal precedents and legal dogmatics reveals that *Passing* is only allowed when the manoeuvre is performed while observing a *minimal safety distance*, which depends on the circumstances of the concrete case. Hence, it would be more appropriate to represent χ's objective violation condition as $O_\chi \Leftarrow (Impedes_Onc_Traffic(m) \vee$

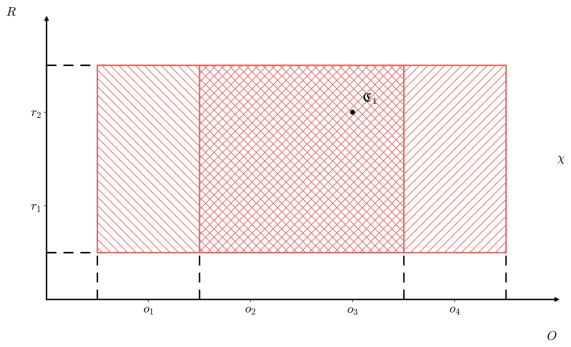


$$V_\psi \Leftarrow (O_\psi \wedge R_\psi \wedge S_\psi \wedge T_\psi)$$

$$O_\psi \Leftarrow m \in \mathfrak{M}_{xsl} \backslash \{Passing\}$$
$$R_\psi \Leftarrow R_Sld_Line(m)$$
$$S_\psi \Leftarrow \top$$
$$T_\psi \Leftarrow \top$$

Fig. 8 – Diagram and normal form description of the solid line rule ψ. The implicit exception derived from the *passing* rule is represented by ζ. Notice that, although they are both derived mainly from the same legal source (§ 6 of the German Traffic Road Regulation) ζ is different from χ.

$Violates_Safety_Distance(m)$). This is illustrated in Fig. 9.



$$V_\chi \Leftarrow (R_\chi \wedge T_\chi \wedge S_\chi \wedge O_\chi)$$

$$O_\chi \Leftarrow Impedes_Onc_Traffic(m) \vee Violates_Safety_Distance(m)$$
$$R_\chi \Leftarrow Rd_Width_Ok(m)$$
$$S_\chi \Leftarrow \top$$
$$T_\chi \Leftarrow \top$$

Fig. 9 – Diagram and normal form description of the norm χ regulating the *Passing* manoeuvre (§ 6 of the German Road Traffic Regulation). The area between $o_{1'}$ and $o_{1''}$ corresponds to manoeuvres that satisfy both predicates $Impedes_Onc_Traffic$ and $Violates_Safety_Distance$.

Likewise, it would be necessary to further specify the predicate $Violates_Safety_Distance$. According to legal scholarship, the *minimal safety distance* required when performing the manoeuvre *Passing* usually amounts to one meter (König, 2023, Rn. 7). However, depending on the circumstances, the required distance can also be wider or smaller. Among the most commonly considered examples are those in which the obstacle is another vehicle. *Prima facie*, a driver (or an AV) should detect the type of said vehicle, e.g., whether it is a truck, a bus or a car, whether one of its doors is open, or if there are people in the vehicle or around it. German judicial practice establishes more specific provisions concerning the minimal safety distance in such situations. For instance, in case a person is likely to exit or to open the door of a vehicle, drivers are usually expected to keep a distance of more than one meter when passing (Gutt, 2022, Rn. 14, König, 2023, Rn. 7)(cf. also Schauseil, 2011). Similarly, when passing by a bus, a garbage truck or construction machines, drivers have to take into account that people might suddenly walk onto the street. Hence, they are required to drive slow enough to be able to quickly stop if necessary, or to generally keep a larger safety distance, e.g., of 1,8-2 m (Heß, 2022a, Rn. 7-8, Bender, 2016, Rn. 8) (cf. also the decision BGHSt 13, 169). On the other hand, a distance of 50 cm may be enough if the road is particularly narrow (König, 2023, Rn. 7). These concrete standards could be implemented by individually assigning the respective safety distance to each manoeuvre, so that $Violates_Safety_Distance(m)$ is satisfied whenever the actual distance is smaller than the allowed distance. However, it is important to notice that these criteria are not absolute; they serve only as guidelines to help determine the minimal safety distance in a concrete situation.

This approach reveals a further problem: a review of the sources related to § 6 of the German Road Traffic Regulation can only reveal concrete requirements for a limited number of situations, i.e., the situations already considered by German courts or by legal dogmatics. Yet, specifying χ requires the definition of a safety distance for *all* possible situations. Thus, to avoid violating χ, the specific examples need to be generalized so

that safety distances are assigned to situations that have not been explicitly included. For example, case law and literature have not specifically addressed the distance required when passing a stationary delivery truck, which can be seen as analogous to passing a stationary garbage truck – since one could likewise expect that people might suddenly walk onto the street – and would therefore require a similar distance.

One approach to solving this issue is to gather characteristics of known cases and have the AV compare unknown cases to these standards. In the example above, the safety distance would then be the same as when passing a stationary garbage truck in all cases in which the sensory data for the obstacle and the surrounding pedestrians is sufficiently similar to the data associated with garbage trucks. Thus, an unlimited number of situations could be accounted for even with a limited number of sources. The assessment of a similarity predicate could be done by means of a logical formalism designed specifically for representing degrees of similarity and analogy. An example could be so-called *neighbourhood frames* (cf., e.g., Nortmann, 1989). A different approach could be to employ the visual form of the normative diagrams. If the values on each of the dimensions' scales can be comprised to a cardinal scale, distance measures like the euclidean distance or the Hamming distance may be employed to measure the similarity of different cases or the distance between a norm and a case. A smaller distance may be interpreted as a higher similarity. Of course, determining the optimal degree of similarity (in terms of both engineering and legal standards) and creating these orderings are challenging tasks that lie beyond the scope of the paper at hand.

6. Conclusion and Future Work

The normal form presented here is a valuable methodological tool for the complex and interdisciplinary task of formalising legal norms. Its structure allows for a multi-step and multi-level formalisation procedure. Starting with very high-level descriptions of the violation conditions of a norm – organised in a way that is based on legal theory, i.e., on the four dimensions of a norm's validity domain –, it facilitates that gradual further specification to more detailed descriptions. This framework is particularly flexible: with each further specification, a new formalism (e.g., different types of modal, temporal or deontic logic) may be employed according to the respective needs. Such a structure allows for a better understanding of the representation and implementation challenges one might face when formalising legal norms. Finally, especially when combined with normative diagrams, the normal form facilitates the visualisation of the legal norms to be formalised, as well as of more complex legal-theoretical phenomena.

An important future work topic concerns dealing with the formalisation of legal gaps, legal antinomies and of contrary-to-duty-situations within the framework of the normal form. In particular, situations in which at least one norm has to be violated, i.e., situations in which all possible manoeuvres in a set $\mathfrak{M}$ lead to some violation V_x of a norm $x \in \mathfrak{N}$, could be solved by establishing a priority degree between the violations. This priority degree could be based on elements of legal theory, e.g., the classic collision rules for solving legal antinomies (Bobbio, 1993, p. 218-222). A further topic for future work on theoretical aspects is the definition of specific criteria for determining the distance between different case-descriptions as well as between a case-description and a norm-description, which would serve as a basis for the formalisation of analogy arguments. Finally, more research on the particularities concerning the violation conditions of obligations (e.g., aspects concerning imperfect duties and supererogation) is also needed. Additionally, the visualisation of four-dimensional objects may be challenging to understand for humans as discussed by Steffes and Sasdelli, 2025. From a more technical perspective, the main topic for future work involves developing an interactive legal formalisation tool implementing the normal form framework presented, while also combining it with existing logical formalisms for legal knowledge representation and with methods of legal visualisation, e.g., with normative diagrams.

Data/Software Access Statement

For the generation of the images displayed in this paper the open source tool ViNo (https://github.com/bs-000/norm-visuals) was utilized.

Contributor Statement

Author 1: Conceptualisation, Formal Analysis, Methodology, Visualisation, Writing – Original Draft, Writing – Review & Editing. Author 2: Formal Analysis, Software, Visualisation, Writing – Original Draft, Writing –

Review & Editing. Authors 3-5: Investigation, Writing – Original Draft.

Use of AI

During the preparation of this work, the authors used no AI-Tools. The authors take full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Alexy, R. (1994). *Theorie der Grundrechte* (2nd ed.). Suhrkamp.

Bender, E. (2016). § 6. In P. König (Ed.), *Münchener Kommentar zum Straßenverkehrsrecht* (pp. 392–393). C.H.Beck.

Bobbio, N. (1993). *Teoria generale del diritto*. G. Giappichelli.

Brunschwig, C. (2014). On visual law: Visual legal communication practices and their scholarly exploration. In E. Schweighofer, M. Handstanger, H. Hofmann, F. Kummer, E. Primosch, G. Schefbeck, & G. Withalm (Eds.), *Zeichen und zauber des rechts. festschrift für friedrich lachmayer* (pp. 899–933). Editions Weblaw.

Carnein, M., Quiring, E., Haack, A., Möhring, A., & Becker, J. (2014). Laiengerechte Erzeugung von 3D-Animationen am Beispiel von textuellen Unfallbeschreibungen. *Jusletter IT*.

Carneiro, D., Novais, P., Andrade, F., Zeleznikow, J., & Neves, J. (2014). Online dispute resolution: An artificial intelligence perspective. *Artificial Intelligence Review*, *41*(2), 211–240. DOI: https://doi.org/10.1007/s10462-011-9305-z.

Cyras, V., & Lachmayer, F. (2023). *Essays on the visualisation of legal informatics*. Springer.

Dolata, M., & Schwabe, G. (2023). Moving beyond privacy and airspace safety: Guidelines for just drones in policing. *Government Information Quarterly*, *40*(4), 101874. DOI: https://doi.org/10.1016/j.giq.2023.101874.

Döring, M., Mikkelsen, K. S., Madsen, J. K., & Haug, K. B. (2024). Creating a workforce of fatigued cynics? a randomized controlled trial of implementing an algorithmic decision-making support tool. *Government Information Quarterly*, *41*(1), 101911. DOI: https://doi.org/10.1016/j.giq.2024.101911.

Engisch, K. (1985). *Einführung in das juristische Denken* (8th ed.). Verlag W. Kohlhammer.

Gabbay, D., Horty, J., Parent, X., van der Meyden, R., & van der Torre, L. (Eds.). (2013). *Handbook of deontic logic and normative systems, vol 1*. College Publications.

Gutt, S. (2022). § 6 StVO. In K. L. Haus, C. Krumm, & M. Quarch (Eds.), *Gesamtes Verkehrsrecht* (3rd ed.). Nomos.

Helle, M. (2021). § 6 StVO. In H.-P. Freymann & W. Wellner (Eds.), *juris PraxisKommentar Straßenverkehrsrecht* (2nd ed.). juris.

Heß, R. (2022a). § 2. In M. Burmann, R. Heß, K. Hühnermann, J. Jahnke, & K. Wimber (Eds.), *Straßenverkehrsrecht* (27th ed.). C.H.Beck.

Heß, R. (2022b). Vorbeifahren. In M. Burmann, R. Heß, K. Hühnermann, J. Jahnke, & K. Wimber (Eds.), *Straßenverkehrsrecht* (27th ed.). C.H.Beck.

Heyd, D. (Ed.). (2023). *Handbook of supererogation*. Springer.

Johnson, R., & Cureton, A. (2024). Kant's Moral Philosophy. In E. N. Zalta & U. Nodelman (Eds.), *The Stanford encyclopedia of philosophy* (Fall 2024). Metaphysics Research Lab, Stanford University.

Kelsen, H. (1979). *Allgemeine Theorie der Normen*. Manzsche Verlags- und Universitätsbuchhandlung.

Kelsen, H. (2017). *Reine rechtslehre* (2nd ed.). Mohr Siebeck.

Kessel, C. (2014). Kinder finden das Gesetz: Transparentes Recht für Kinder – Child-friendly Justice dank Visualisierung. *Jusletter IT*.

Kohlhase, M., Adrian, A., & Rapp, M. (2021). Context graphs for ampliative analogical legal reasoning and argumentation. *Jusletter IT*.

König, P. (2023). StVO § 6. In P. König & P. Dauer (Eds.), *Straßenverkehrsrecht* (47th ed.). C.H.Beck.

Lachmayer, F., & Cyras, V. (2021). Visualization of legal informatics. *Legal Knowledge and Information Systems - Proceedings of the 34th International Conference on Legal Knowledge and Information Systems – JURIX 2021*, 3–10. https://ebooks.iospress.nl/volumearticle/58523

Larsen, A. G., & Følstad, A. (2024). The impact of chatbots on public service provision: A qualitative interview study with citizens and public service providers. *Government Information Quarterly*, *41*(2), 101927. DOI: https://doi.org/10.1016/j.giq.2024.101927.

Leone, V., Caro, L. D., & Villata, S. (2022). Legal ontologies: An overview. In G. Casini, L. Robaldo, L. van der Torre, & S. Villata (Eds.), *Handbook of legal ai* (pp. 89–122). College Publications.

Lin, Y., & Althoff, M. (2022). Rule-compliant trajectory repairing using satisfiability modulo theories. *2022 IEEE Intelligent Vehicles Symposium (IV)*, 449–456. DOI: https://doi.org/10.1109/IV51971.2022.9827357.

Lindgren, I. (2024). Ironies of automation and their implications for public service automation. *Government Information Quarterly*, *41*(4), 101974. DOI: https://doi.org/10.1016/j.giq.2024.101974.

Maierhofer, S., Moosbrugger, P., & Althoff, M. (2022). Formalization of intersection traffic rules in temporal logic. *Proc. of the IEEE Intelligent Vehicles Symposium*. DOI: https://doi.org/10.1109/IV51971.2022.9827153.

McCloskey, M. J. (1998). Visualizing the law: Methods for mapping the legal landscape and drawing analogies notes and comments. *Washington Law Review*, *73*, 163–192.

Muff, F., & Fill, H.-G. (2021). Towards embedding legal visualizations in work practices by using augmented reality. *Jusletter IT*, 241–247.

Muff, F., Fill, H.-G., Kahlig, E., & Kahlig, W. (2022). Kontextabhängige rechtsvisualisierung mit augmented reality. *HDM Praxis der Wirtschaftsinformatik*.

Murray, M. D. (2021). Diagrammatics and the proactive visualization of legal information. *University of Arkansas at Little Rock Law Review*, *43*, 1–49.

Nawiasky, H. (1948). *Allgemeine Rechtslehre als System der rechtlichen Grundbegriffe*. Benziger & Co.

Nortmann, U. (1989). *Deontische Logik ohne Paradoxien. Semantik und Logik des Normativen*. Philosophia.

Palmirani, M., Governatori, G., Rotolo, A., Tabet, S., Boley, H., & Paschke, A. (2011). LegalRuleML: XML-Based Rules and Norms. In F. Olken, M. Plamirani, & D. Sottara (Eds.), *RuleML 2011: Rule-Based Modeling and Computing on the Semantic Web. 5th International Symposium, RuleMl 2011* (pp. 298–312). DOI: https://doi.org/10.1007/978-3-642-24908-2_30.

Raabe, O., Wacker, R., Oberle, D., Baumann, C., & Funk, C. (2012). *Recht ex machina*. Springer.

Röhl, K., & Ulbrich, S. (2007). *Recht anschaulich: Visualisierung in der juristenausbildung*. Halem.

Sasdelli, D., & Trivisonno, A. (2023). Normative diagrams as a tool for representing legal systems. *The Review of Socionetwork Strategies*, *17*. DOI: https://doi.org/10.1007/s12626-023-00144-0.

Satoh, K. (2023). Proleg: Practical legal reasoning system. In D. S. Warren, V. Dahl, T. Eiter, M. V. Hermenegildo, R. Kowalski, & F. Rossi (Eds.), *Prolog: The next 50 years* (pp. 277–283). Springer Nature Switzerland. DOI: https://doi.org/10.1007/978-3-031-35254-6_23.

Schauseil, T. (2011). Die Haftungsabwägung bei Ein- und Aussteigerunfällen. *MDR – Monatsschrift für Deutsches Recht*, 961–967.

Sergot, M. J., Sadri, F., Kowalski, R. A., Kriwaczek, F., Hammond, P., & Cory, H. T. (1986). The british nationality act as a logic program. *Commun. ACM*, *29*(5), 370–386. https://doi.org/10.1145/56%2089.5920

Steen, A., & Fuenmayor, D. (2022). Bridging Between LegalRuleML and TPTP for Automated Normative Reasoning. In G. Governatori & A.-Y. Turhan (Eds.), *Rules and reasoning* (pp. 244–260). Springer International Publishing.

Steffes, B., & Sasdelli, D. (2024). A legal visualisation tool using normative diagrams. *Legal Knowledge and Information Systems - Proceedings of the 37th International Conference on Legal Knowledge and Information Systems – JURIX 2024*, 395–397. https://ebooks.iospress.nl/volumearticle/71046

Steffes, B., & Sasdelli, D. (2025). Alternative Darstellungsformen Normativer Diagramme. *Jusletter IT*. DOI: https://doi.org/10.38023/51565951-d1ea-4767-877f-639456f882af.

Sutcliffe, G. (2017). The TPTP Problem Library and Associated Infrastructure. *Journal of Automated Reasoning*, *59*, 483–502.

Van Engers, T., Boer, A., Breuker, J., Valente, A., & Winkels, R. (2008). Ontologies in the legal domain. In H. Chen, L. Brandt, V. Gregg, R. Traunmüller, S. Dawes, E. Hovy, A. Macintosh, & C. A. Larson (Eds.), *Digital government: E-government research, case studies, and implementation* (pp. 233–261). Springer US. DOI: https://doi.org/10.1007/978-0-387-71611-4_13.

Virkar, S., Alexopoulos, C., Tsekeridou, S., & Novak, A.-S. (2022). A user-centred analysis of decision support requirements in legal informatics. *Government Information Quarterly*, *39*(3), 101713. DOI: https://doi.org/10.1016/j.giq.2022.101713.

Weinberger, C., & Weinberger, O. (1979). *Logik, Semantik, Hermeneutik*. C.H.Beck.

Wessels, U. (2002). *Die Gute Samariterin: Zur Struktur der Supererogation*. De Gruyter.

The Role of Regulatory Frameworks in Shaping E-Governance: Insights from Selected Case Studies

Zoran Jordanoski [a*]

[a] United Nations University - Operating Unit on Policy-Driven Electronic Governance (UNU-EGOV), Guimaraes, Portugal, jordanoski@unu.edu, https://orcid.org/0000-0003-1784-9038.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. As digital transformation accelerates globally, the quality of national regulatory frameworks has become a key determinant of effective e-governance. This paper investigates how regulatory maturity influences the development and implementation of digital government initiatives across eight countries. It introduces a three-tier classification: advanced, moderate, and early-stage, based on the scope of legal frameworks, operationalisation of digital enablers, and integration into public service delivery. Countries such as Belgium, Estonia, and Singapore demonstrate that coherent and enforceable legal ecosystems when paired with institutional coordination and technical infrastructure, achieve high digital governance performance. By contrast, fragmented frameworks constrain implementation and trust. Using cross-case comparison and internationally recognised indices (e.g., EGDI, OSI, EPI, GCI), the study validates this classification and identifies recurring barriers such as regulatory lag, institutional misalignment, operational and infrastructure gaps, and societal mistrust. The findings confirm that while legal maturity is foundational, institutional capacity, technical readiness, and public engagement are critical for inclusive and resilient digital transformation.

Keywords. Digital governance, E-Governance, Regulatory Maturity, Legal Framework, Digital Transformation.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1037

1. Introduction

E-governance has emerged as a cornerstone of modern public administration (Gil-Garcia et al., 2018; Heeks, 2002). It leverages digital technologies to transform the way government operates (Bannister & Connolly, 2011a; Cordella & Bonina, 2012), enhance public service delivery (Meyerhoff Nielsen, 2017; Meyerhoff Nielsen & Krimmer, 2015), increase transparency (Chauhan et al., 2008; López-López et al., 2018) and facilitate citizen engagement (Mahrer & Krimmer, 2005; Navarra & Cornford, 2003). Defined broadly, e-governance refers to the application of Information and Communication Technologies (ICTs) to transform government operations and interactions with citizens, businesses, and other stakeholders (Heeks, 2008; UNDESA, 2022). At its core, e-governance relies on key elements, such as electronic identification (eID) and trust services, interoperability and data exchange systems, electronic payments, and digital communication platforms. Additionally, essential elements include legal frameworks for accessing and reusing public sector information, data protection, and cybersecurity. Together, these frameworks establish the backbone of any transparent, secure, and resilient digital governance ecosystem.

These main elements are underpinned by legal frameworks that regulate their design, implementation, and operation (González et al., 2016; Papadopoulos & Kanellis, 2012; Veit & Huntgeburth, 2014). The quality of regulations is one of the factors determining the practical implementation of these elements and their functionality in practice (Bannister & Connolly, 2011b; Meyerhoff Nielsen & Jordanoski, 2020). Effective regulatory frameworks not only facilitate the implementation of digital solutions but also foster public trust, which is a critical enabler for e-governance adoption (OECD, 2020d). However, adopting a legal framework does not guarantee automatic results or compliance in practice (Jordanoski & Meyerhoff Nielsen, 2023).

Modern legal frameworks play an essential role in e-governance by enabling effective, secure, and transparent

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

service delivery while fostering innovation (Hasan et al., 2015). They also guide governments in adapting to emerging technologies through principles such as technological neutrality and flexibility, which are critical in managing rapid advancements and jurisdictional complexities (Gregory, 2002; Tojiev, 2024). Their adaptability ensures that public sector initiatives remain resilient and capable of meeting evolving societal and technological needs (Korvat, 2023; Park et al., 2016).

The objective of this paper is to examine the relationship between the maturity of regulatory frameworks and the quality of e-governance developments. It provides a high-level analysis of regulatory approaches adopted in Belgium, Botswana, Ecuador, Estonia, Jamaica, Kyrgyzstan, Kenya, and Singapore. It evaluates their practical outcomes, such as the rollout of adequate technical infrastructure, institutional systems, or frameworks. This analysis addresses the following research question: *How do the maturity levels of regulatory frameworks correlate with the development of e-governance in different countries?* While many existing studies focus on theoretical models or isolated national cases, this research offers comparative, empirical insights into how regulatory maturity shapes digital governance across diverse contexts.

The paper is structured as follows: the second section reviews the literature on the research subject. The methodology and how the study was conducted is presented in the third section. The study results and discussion are presented in the fourth section, while the conclusions and future work are included in the last section.

2. Literature Review

The Role of Regulatory Frameworks in E-Governance

Regulation plays a crucial role in shaping the development, implementation, and performance of digital government systems in every country (López-López et al., 2018; OECD, 2020b). The design and implementation of e-governance initiatives are directly influenced by existing legal and policy frameworks (Dovhan et al., 2022; Luna-Reyes et al., 2016). These frameworks provide the necessary legal basis for digital government projects (Luna-Reyes et al., 2016), defining the rules for data handling, service delivery, and citizen engagement. However, the absence of a comprehensive legal framework can lead to uncertainty, increased legal risks, and hinder the adoption of new technologies (Cordella & Bonina, 2012; Muliaro Wafula, 2012).

Effective regulation provides legal clarity, fosters trust, and ensures compliance with privacy and data protection requirements (Chatterjee & N.S., 2022; Hasan et al., 2019). For instance, regulatory frameworks for eID emphasise privacy and security, establishing robust requirements to address potential vulnerabilities in data sharing. Additionally, regulatory frameworks support interoperability and cross-border governance. For example, the experiences of Estonia and Singapore demonstrate how mature regulatory environments encourage both innovation and public adoption of digital government services (Lebid, 2021; Shkarlet et al., 2020). On a cross-border level, the European Health Data Space demonstrates how harmonised regulations can facilitate the secure and efficient exchange of patient health data among public agencies across all EU Member States (Schneider et al., 2024).

International standards and frameworks also significantly influence national regulatory approaches, particularly in areas such as web accessibility (Jordanoski & Meyerhoff Nielsen, 2023), data protection and cybersecurity (Ortega et al., 2023). Adopting these standards can foster interoperability among diverse e-governance systems (Wimmer et al., 2018). However, successful implementation depends not only on adoption but on the ability to adapt such standards to local contexts and administrative capacities. Moreover, the effectiveness of these regulations depends heavily on their enforcement mechanisms and institutional alignment, which vary across jurisdictions.

Despite widespread recognition of regulation's enabling role, the literature remains somewhat fragmented regarding comparative, empirical analyses across diverse country contexts. Most studies focus on either highly developed digital economies or normative frameworks, leaving a gap in understanding how regulation functions in practice across different governance environments.

Technological Advancements and Regulatory Challenges

Technological advancements often outpace regulatory development, creating significant challenges for governments (Dovhan et al., 2022; Luna-Reyes et al., 2016). One prominent challenge is integrating emerging technologies, such as AI and blockchain, within existing legal frameworks without causing fragmentation or inefficiency (Firdaus et al., 2024). Ensuring data privacy with rapid advancements in data analytics and AI remains a pressing issue (Mustafa et al., 2025). While fragmented regulations can undermine public trust and create governance gaps, overly rigid frameworks may hinder innovation. This highlights the need for flexible and adaptive approaches (He, 2011; Nyman-Metcalf, 2014).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The federated approach employed in Europe, which emphasises collaborative governance, serves as a potential model for harmonising regulations across regions with diverse legal and infrastructural landscapes (Krimmer et al., 2021). To remain relevant, regulations should be periodically reviewed and updated through stakeholder collaboration. For example, adaptive regulatory practices have been integral to digital transformation efforts in Estonia and Brazil (Franco, 2024; Okon, 2024). Maintaining a balance between innovation and regulation remains critical to avoiding both regulatory delays and stifling innovation (OECD, 2020b; Ortega et al., 2023). In this context, regulatory maturity should be viewed not only as a function of legal completeness or technical scope but also as a reflection of institutional adaptability and alignment with broader governance models. Legal systems must evolve parallel to complex digital infrastructures, requiring coordinated policy responses and long-term strategic planning.

This review provides the conceptual grounding for the study's core objective: to assess how the maturity of regulatory frameworks correlates with e-governance development across different country contexts. While previous literature has established the foundational importance of regulation, empirical studies examining its operational effectiveness through comparative, multi-country case analysis remain limited. This paper aims to address that gap through a structured, cross-country comparative analysis.

3. Methodology

A classical exploratory, qualitative, comparative case study methodology is applied to address the research gaps related to shaping e-governance through regulatory frameworks (Rohlfing, 2012; Yin, 2017). The approach is needed to understand the complex correlation between regulations and e-governance implementation. By analysing the regulatory practices of eight countries, this study aims to understand how regulations contribute to the development and implementation of e-governance. The research uses a theory-informed, evidence-driven comparative approach to identify patterns across cases while remaining attuned to local contexts (Thornberg, 2012).

Case selection

The study includes eight countries (in alphabetical order: Belgium (BE), Botswana (BW), Ecuador (EC), Estonia (EE), Jamaica (JM), Kenya (KE), Kyrgyzstan (KG), and Singapore (SG)) selected based on a combination of geographic, economic, and cultural diversity and varying degrees of e-governance maturity. The diversity of these cases ensures that the findings reflect a broad spectrum of regulatory capacities and implementation realities rather than being limited to high-income or digitally advanced economies. Case selection also considered the availability of documented legal frameworks, policy materials, and national e-governance initiatives. Table 1 presents the contextual factors, i.e. the key socioeconomic and connectivity indicators for the eight countries to support the comparative analysis that may shape digital governance capacity.

Tab. 1 – Socioeconomic (a-e) (CIA.gov, 2025) and connectivity indicators (f-i) (ITU, 2025).

Indicator	BE	BW	EC	EE	JM	KE	KG	SG
a) Population (millions, 2024 est.)	11.9	2.4	18.3	1,2	2.8	58,2	6.1	6.0
b) Territory (thousands, km^2)	30.5	581.7	283.5	45.2	10.9	580.3	199.9	719.0
c) Urbanisation (%) of total population (2023)	98.2	72.9	64.8	69.8	57.4	29.5	37.8	100
d) GDP (PPP) (billions, USD, 2023 est.)	756.6	46.7	260.2	58.2	29.2	314.5	45.5	754.7
e) GDP per capita (PPP) (thousands, USD, 2023 est.)	64.2	18.8	14.5	42.5	10.3	5.7	6.4	127.5
f) Individuals using the Internet (%)	94	77.3	69.7	91	82.4	40.8	79.8	96
g) Households with Internet access at home (%)	94.4	78.3	60.4	95	75.4	50.2	93.4	98.7
h) Active mobile broadband subscriptions per 100 inhabitants	94.9	108	59.4	210	66.7	59	175	164
i) Population covered by at least a 4G/LTE mobile network (%)	100	91	93.9	99	99	97	96.9	100

The socioeconomic profiles of the eight countries reveal significant disparities. High-income countries such as Singapore and Belgium operate in vastly different resource environments than lower-income peers like Kenya or Kyrgyzstan. These economic conditions directly influence the capacity of the governments to invest in national

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

digital infrastructure and establish robust regulatory oversight bodies, factors repeatedly shown to affect e-governance development. Population size and territorial spread also introduce implementation asymmetries. For instance, Kenya and Botswana have large geographic areas and highly rural populations, making connectivity rollouts and last-mile digital service delivery more logistically and financially demanding. In contrast, Singapore's dense urban environment and compact geography offer inherent efficiencies for digital service scaling.

Finally, while digital infrastructure is not the central focus of this study, it is a key enabling condition that shapes the operational feasibility of e-governance systems. In that regard, several countries demonstrate high levels of internet penetration, household connectivity, and mobile broadband subscriptions, indicating well-established digital infrastructure. These conditions suggest a strong baseline for the delivery and adoption of online government services. In other contexts, infrastructure access remains uneven. Lower household internet access rates, modest broadband subscription levels, and digital divides between urban and rural populations signal potential barriers to inclusive digital service deployment. While mobile network coverage is broadly high, approaching universal 4G availability in most countries, this does not automatically translate into effective usage.

Together, these structural factors help explain why legal reforms alone may not suffice, particularly in low- and middle-income countries. Instead, regulatory ambition must be accompanied by targeted policies that account for economic, geographic, and demographic constraints, ensuring that digital transformation strategies are realistic and inclusive.

Data Sources and Analytical Framework

The primary and secondary sources included official legislative texts, policy documents, official reports, and academic literature. The objective was to identify the common principles, discrepancies, and patterns across the selected jurisdictions. For that purpose, the study employed a cross-case comparative analysis, which enabled the evaluation of the common principles while considering the unique factors that influence regulatory effectiveness in each country.

The analysis focuses solely on legal frameworks that are applicable and went into effect before October 1st, 2024, and regulate fundamental e-governance elements, such as eID, trust services, interoperability, access to and reuse of public sector information, electronic payments, digital communications, data protection, and cybersecurity. The study excludes national procedural legislation governing administrative and judicial processes. It also omits the sectoral legislation governing service delivery across various sectors, such as health, education, social protection, and many others. These regulations, although significant, are excluded because each country has developed its unique service delivery ecosystem.

Due to the absence of globally comparable and methodologically consistent data on citizen uptake of government digital services, particularly outside of the European Union (EU) and the Organisation for Economic Co-operation and Development (OECD), this study adopts a basket of internationally recognised indices to serve as proxies for digital governance performance. These indices collectively capture the availability, quality, and usage of core e-governance systems, offering a multidimensional perspective to triangulate regulatory maturity. Specifically, the E-Government Development Index (EGDI), Digital Identity Readiness Index, Online Service Index (OSI), E-Participation Index (EPI), Open Government Data Index (OGDI), and Global Cybersecurity Index (GCI) were selected because of their relevance and cross-country comparability. Each index captures a key dimension of digital governance: the OSI assesses the availability and usability of online public services; the EPI reflects citizen engagement through digital platforms; the OGDI measures open data transparency; the Digital Identity Readiness Index evaluates the sophistication of national eID systems; and the GCI scores cybersecurity frameworks and institutional capacity. Together, these indicators provide a robust empirical foundation for assessing the real-world implementation and institutional effectiveness of digital governance frameworks.

However, the scope and methodology are not without limitations. The findings are context-specific and may not be universally applicable to all countries. Additionally, the study focuses primarily on regulatory frameworks adopted or applicable on the national level. This approach may not fully capture variations in federal or decentralised governance systems (e.g., Belgium). Nevertheless, the chosen methodology provides a strong foundation for examining the legal frameworks that provide valuable insights from good examples or legislative principles that can enhance the quality of the regulations.

4. Findings and Discussion

This section presents the main findings of the study and explores how the maturity of regulatory frameworks influences the development and implementation of e-governance across the eight countries. The analysis is structured around a three-tier maturity classification: advanced, moderate, and early-stage and is based on the scope of legal frameworks, the operationalisation of key digital enablers, and the degree of public service integration and citizen uptake.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4.1 Maturity Classification

To assess how the depth and operationalisation of legal frameworks influence e-governance performance, this study classifies the eight selected countries into three regulatory maturity categories: advanced, moderate, and early-stage. It is based not on international indices but on a triangulation of legal, institutional, and infrastructural indicators linked to implementing core e-governance components.

Table 2 highlights the classification framework assessing the maturity of regulatory frameworks in e-governance, which is based on three key criteria: (1) *the adoption and scope of legal frameworks*, (2) *the presence and operationalisation of core technical enablers (such as eID, digital signatures, payment systems, notification gateways, and data exchange infrastructure)*, and (3) *the degree of integration and uptake of the online public services*. This classification provided a basis for organising the countries into advanced, moderate, and early-stage maturity groups.

Tab. 2 - Classification criteria for the maturity of regulatory frameworks in e-governance.

Criterion	Advanced	Moderate	Early stage
Regulatory coverage	Comprehensive, up-to-date laws across all key e-governance areas.	Legal instruments adopted for most areas, with some coverage gaps or outdated laws.	Fragmented or partial legal frameworks; significant coverage gaps.
Implementation of key enablers	Fully deployed infrastructure (eID, interoperability, digital services, etc.).	Infrastructure partially rolled out; adoption inconsistent across sectors.	Systems not yet implemented, remain at planning or pilot stages.
Integration and uptake	High levels of citizen engagement, interagency integration, and service use.	Moderate engagement or integration; infrastructure not yet fully utilised.	Low uptake, limited service availability, or minimal system integration.

Based on these criteria, the countries were assessed using evidence from legal documents, institutional arrangements, and available implementation data. This initial classification reflects the degree to which each country's legal frameworks are both comprehensive and operationalised through technical systems and service integration. Belgium, Estonia, and Singapore are classified as having advanced maturity, having adopted comprehensive digital governance frameworks, implemented key enablers, and achieved broad institutional and citizen uptake. Ecuador and Kyrgyzstan fall under the moderate maturity category, having enacted most foundational legal instruments and initiated infrastructure development but still facing gaps in implementation or adoption. Finally, Botswana, Jamaica, and Kenya are considered to be in the early stages of maturity, where legal development remains partial or fragmented, and institutional or infrastructural limitations constrain the operationalisation of technical systems. This classification provides the foundation for the comparative analysis in the sections that follow.

4.2 Regulatory Maturity and Enablers Across Country Contexts

By using the three-tier maturity classification and combining the assessment of the legal-regulatory landscape with the operationalisation of digital enablers, the analysis reveals how regulatory maturity manifests in practice across diverse governance contexts. A comparative summary of key digital enablers is provided in Figure 1, while the e-governance regulatory blueprint of all eight countries is included in the Appendix.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

	Belgium	Estonia	Singapore	Ecuador	Kyrgyzstan	Botswana	Jamaica	Kenya
Digital Identity & Trust Services	Belgian eID, CSAM, SigningBox	Smart-ID, Mobile-ID, National eID card	Singpass app, National Digital Identity (NDI).	GOB.EC Mobile ID, FirmaEC digital signature platform	Chip-enabled ID, Unified ID System (ESI), Cloud E-Signature (CEL)	OneGov mobile app	National Identification System (NIDS – not yet operational)	eCitizen Gava Mkononi app
Data Exchange & Interoperability Platforms	BOSA Federal Service Bus (FSB)	X-tee Middleware and Unified eXchange Platform (UXP)	Government Data Architecture (GDA)	SINARDAP Interoperability Platform	Electronic Interoperability Center Tunduk (SMEV)	Not established	Not established	Not established
Digital Payments Infrastructure	Enabled (via eID & eBanking)	Integrated into state systems	Covered under Payment Services Act	Enabled (via integrated public platforms)	Enabled	Enabled	Enabled	Enabled
Secure Digital Messaging	eBox	Government digital inbox	Singpass notifications	Enabled (via GOB.EC and admin e-services)	Enabled (e.g., service portals)	Not established	Not established	Not established
Open Data Portals	data.gov.be	avaandmed.eesti.ee	data.gov.sg	datosabiertos.gob.ec	data.gov.kg	Not established	data.gov.jm	Not established
Data Protection Oversight	Institutional supervision: Belgian Data Protection Authority.	Institutional supervision: Data Protection Inspectorate.	Personal Data Protection Commission Singapore	Superintendent of Data Protection	State Agency for Personal Data Protection	Data Protection Commission	Information Commissioner	Office of the Data Protection Commissioner Kenya
Cybersecurity Coordination Body	Centre for Cyber Security Belgium	National Cyber Security Centre (NCSC-EE)	Cyber Security Agency of Singapore	Cybersecurity Committee under	State Committee for Information Technology and Communications.	Cyber Intelligence Agency	National Cybersecurity Authority (to be established)	Communications Authority of Kenya

Fig. 1 – Key enablers availability in Belgium, Estonia, Singapore, Ecuador, Kyrgyzstan, Botswana, Jamaica and Kenya

Advanced Maturity Contexts: Belgium, Estonia, and Singapore

The three countries classified as having advanced regulatory maturity have enacted comprehensive and coherent legal frameworks across all major pillars of digital governance. These countries illustrate distinct pathways to achieving regulatory maturity: Belgium through federated coordination within an EU-aligned legal framework, Estonia through legal minimalism paired with deep digital integration, and Singapore through centralised, forward-looking regulatory instrumentation.

Belgium has developed a robust and technically advanced legal ecosystem covering eID, trust services, open data, interoperability, cybersecurity, and data protection. As an EU member state, it aligns closely with supranational frameworks such as the eIDAS and General Data Protection Regulation (GDPR). The country's interoperability infrastructure is institutionalised through shared services managed by the Federal Public Service for Policy and Support (BOSA), which coordinates federal and regional implementation. Belgium's national eID is widely adopted and supports authentication, signatures, and secure access across public and private platforms (OECD, 2020c). However, despite its strong legal and technical foundation, Belgium faces persistent horizontal and vertical coordination challenges due to its complex federal structure. While interoperability frameworks are in place, implementation remains uneven across regions, and harmonisation continues to evolve (OECD, 2020c).

Estonia, also and EU member state, represents a highly integrated and centralised digital governance model rooted in a minimalist but enforceable legal framework. Laws such as the Public Information Act, the Cybersecurity Act, and the Digital Signature Act support core national enablers, including eID and the X-Road data exchange platform. These systems enable secure, real-time data sharing among more than 1,000 public and private organisations (Kotka et al., 2016; Krimmer et al., 2021). The legal infrastructure is tightly coupled with Estonia's technological architecture, ensuring flexibility and rapid legislative responsiveness. Over 99% of public services are available online, and citizen uptake is among the highest in the EU (e-Estonia, 2025). Estonia's ability to translate regulatory ambition into operational infrastructure illustrates the value of streamlined legislation that is fully embedded in the digital delivery ecosystem.

Finally, Singapore exemplifies a centralised and anticipatory model of digital governance. Its legal framework spans key areas such as digital identity, cybersecurity, and data governance and is enforced by dedicated agencies like the Cyber Security Agency of Singapore (CSA) and the Personal Data Protection Commission (PDPC). The Singpass system, used by over 4.5 million residents, provides secure, biometric-enabled access to more than 2,000 services across government and private sectors (GovTech Singapore, 2023). Underpinning this architecture are the Government Data Architecture and the Whole-of-Government Application Analytics (WOGAA), which enable interoperable data flows, predictive service delivery, and policy coherence (Smart Nation and Digital Government Office Singapore, 2024). Singapore's Electronic Transactions Act and Cybersecurity Act embody a forward-looking legal orientation that balances innovation with robust enforcement.

Across all three cases, there is a high degree of alignment between legal frameworks, institutional mandates, and technical implementation. These countries score consistently high in international indices such as the EGDI and the OECD's Digital Government Index (OECD, 2020a; UNDESA, 2024). Their experiences demonstrate that regulatory maturity can serve as a key enabler of digital government performance at scale when legal mandates are embedded within strategic governance models and backed by institutional capacity and long-term investment.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

These models also highlight the importance of integrating legal clarity with user-centric design, security, and cross-sector coordination.

Moderate Maturity Contexts: Ecuador and Kyrgyzstan

Ecuador and Kyrgyzstan represent countries with moderate regulatory maturity. Both countries have enacted legislation in core areas such as digital identity, data protection, and interoperability and introduced national systems to support digital transformation. However, their regulatory ambition is not yet matched by systemic institutional or technical readiness since both countries face persistent implementation, coordination, and public uptake challenges.

Ecuador has adopted a legal ecosystem that includes legislation on electronic transactions, digital signatures, data protection, and access to public information. These frameworks were largely formalised between 2010 and 2020 and have recently been extended to include provisions for interoperability and digital services. Oversight is provided by institutions such as the Telecommunications Regulation and Control Agency (ARCOTEL) and the Ministry of Telecommunications and the Information Society. Ecuador's technical efforts include the development of a Mobile ID system and a national digital signature platform. However, the practical integration of these enablers into service delivery remains limited. Ministries often operate in silos, with weak horizontal coordination and inconsistent enforcement of legal mandates (Apolo et al., 2020; OECD, 2023).

Ecuador's open data policy, while legally established, also suffers from uneven implementation. Some open government data portals are outdated or non-functional, and usage remains low due to gaps in awareness and infrastructure (World Bank, 2021). Similarly, while digital identity is legally recognised, its application across public services is minimal. These issues are combined by technical fragmentation and digital literacy barriers, especially among underserved populations.

Kyrgyzstan, in contrast, has approached digital governance as part of a broader administrative reform agenda. The country has adopted legal frameworks in digital identity, interoperability, cybersecurity, and data protection. One of its most ambitious initiatives is the Tunduk interoperability platform, which enables data exchange across state agencies and provides a technical backbone for integrated digital services. Tunduk has been internationally recognised as a promising digital enabler (e-Governance Academy, 2021), and some ministries have begun integrating it into their service architecture.

However, the operationalisation of Tunduk remains uneven. While legal structures are in place, enforcement mechanisms are weak, and integration is limited in scope. Regional disparities in institutional capacity and infrastructure continue to hamper consistent service delivery, particularly outside of urban centres (UNDP, 2021). In addition, digital literacy remains a barrier to uptake among citizens, limiting the effectiveness of otherwise functional platforms.

Together, Ecuador and Kyrgyzstan exemplify two distinct but overlapping trajectories within the moderate maturity of digital transformation. Ecuador demonstrates the risks of regulatory advancement without institutional follow-through, while Kyrgyzstan shows how infrastructure can outpace legal enforcement and citizen adoption. Both cases highlight the necessity of aligning legal frameworks with operational readiness, institutional coherence, and public engagement to convert digital ambition into sustainable governance outcomes.

Early-Stage Maturity Contexts: Botswana, Jamaica, and Kenya

Botswana, Jamaica, and Kenya represent countries in the early stages of regulatory maturity, where foundational digital reforms are underway but remain fragmented or underdeveloped. While all three have demonstrated political will and initiated national strategies for digital transformation, their legal frameworks often lack coherence, and operational enablers are either nascent or inconsistently implemented. These countries reflect distinct entry points into digital governance: Botswana through cautious regulatory rollout, Jamaica through identification-led reform, and Kenya through platform-driven service expansion without fully consolidated legislation.

Botswana has focused on incremental digital reforms, adopting key legislation such as data protection laws and developing strategic frameworks like the National ICT Policy (Maitlamo). However, critical legal instruments covering digital identity, trust services, interoperability, and secure digital communication are either missing or remain in preliminary stages. The SmartBots initiative has aimed to digitise selected public services, but institutional fragmentation and limited central oversight have slowed broader implementation (Government of Botswana, 2021; UNECA, 2023). Digital ID systems are still in pilot phases, and inter-agency coordination is weak. Open data practices are emerging but suffer from low levels of proactive disclosure and limited availability in machine-readable formats (Ndlovu, 2024). Botswana illustrates a legal and institutional environment that is evolving but lacks the depth and cohesion required for integrated digital governance.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Jamaica has taken a more targeted legislative approach centred on its Data Protection Act (2020) and the phased rollout of the National Identification System (NIDS). These initiatives form the backbone of Jamaica's legal architecture for digital governance, aiming to support secure, identity-based service delivery. However, enabling frameworks for interoperability, trust services, and digital signatures remain underdeveloped or unimplemented. The 2019 Supreme Court ruling, which declared the original NIDS legislation unconstitutional due to privacy concerns, highlighted public mistrust and the need for more robust legal safeguards (Caribbean Policy Research Institute (CAPRI), 2020). Although institutions like the Office of the Information Commissioner exist, they often operate with evolving mandates and limited capacity. Open data initiatives remain sporadic, with most public data either unpublished or not structured for reuse. Jamaica's experience underscores the importance of aligning legal reform with institutional capability and sustained public engagement to build trust and support uptake.

Lastly, Kenya presents a more complex but equally instructive case. The country has launched eCitizen, a major digital portal offering over 5,000 public services, and enacted the Data Protection Act (2019), positioning itself as a regional leader in service digitisation. However, its regulatory framework remains fragmented, with overlapping mandates across agencies and laws covering interoperability, trust services, and digital signatures (CIPESA, 2022; Nyangena et al., 2021). Efforts to introduce national digital ID systems, including Huduma Namba and the more recent Maisha Namba, have faced legal setbacks and public criticism over data protection and exclusion risks. Huduma Namba was suspended by the High Court in 2021 due to inadequate legislative safeguards (Njoya, 2023), and Maisha Namba has encountered similar pushback over insufficient consultation and transparency (Kennedy, 2025). Despite rapid service digitisation, Kenya's experience illustrates that platform expansion without legal and institutional consolidation can undermine public trust and impede sustainable progress.

Taken together, these cases highlight the vulnerabilities of early-stage digital governance contexts. While political support for digital reform exists, legal gaps, institutional fragmentation, and low levels of citizen trust hinder the full operationalisation of enablers. Early-stage countries risk uneven progress and increase the digital divide gap without targeted investment in comprehensive legal frameworks, coordinated governance structures, and public trust-building measures. These findings reinforce the importance of treating regulatory maturity not only as a legislative exercise but as a multidimensional condition grounded in institutional readiness, operational infrastructure, and societal inclusion.

4.3 Cross-Cutting Patterns and Performance Validation

This section synthesises key insights from the previous country analyses by examining how regulatory maturity correlates with broader digital governance outcomes. It shifts from country-level narratives to a more aggregated, cross-case perspective using internationally recognised indicators and longitudinal data. The aim is to empirically validate the maturity classification and identify common drivers and limitations of successful digital transformation.

Empirical Validation through Global Indices

To complement the maturity framework and deepen comparative insights, this section draws on five internationally recognised indices: the Digital Identity Readiness Index, OSI, EPI, OGDI, and the GCI. These indicators capture the operational capacity of digital systems across dimensions such as infrastructure, service availability, citizen engagement, data openness, and cybersecurity. Table 3 summarises country scores across these dimensions.

Tab. 3 – Relevant indicators (Global Digital Identity Index, 2024; ITU, 2024; UNDESA, 2024).

Indicator	BE	BW	EC	EE	JM	KE	KG	SG
Digital Identity Readiness Index	84	54.85	58.02	77.5	33.95	50.43	78.11	81.5
Online Service Index	0.72	0.40	0.89	0.99	0.57	0.78	0.60	0.98
E-Participation Index	0.50	0.27	0.88	0.96	0.44	0.52	0.47	0.96
Open Government Data Index	0.85	0.46	0.85	1.00	0.56	0.59	0.54	1.00
Global Cybersecurity Index	96.81	78.60	87,18	96,04	58.20	98.59	65.59	99.86

The indicators generally reinforce the maturity groupings outlined in Section 4.2. Advanced countries, Belgium, Estonia, and Singapore consistently score high across all categories. Estonia and Singapore are especially strong in service integration and digital ID, while Belgium performs well on open data and cybersecurity. These results illustrate that institutionalised legal frameworks when paired with operational infrastructure, predict stronger e-governance performance. On the other hand, moderate countries, such as Ecuador and Kyrgyzstan, display more uneven profiles. Ecuador performs relatively well in online services and open data, reflecting its emphasis on front-end platforms but scores lower in cybersecurity and institutional coherence. Kyrgyzstan performs comparatively better in digital ID, partly due to the Tunduk platform, but lags in service integration and infrastructure. Finally,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

early-stage countries, Botswana, Jamaica, and Kenya, generally score lower across most indices. Kenya stands out slightly with a higher GCI score, indicating relative strength in cybersecurity institutions, but remains behind in legal coherence and service integration. These patterns reinforce the broader argument that while legislative reform is a necessary condition, it is insufficient without robust institutions, systems, and citizen trust.

Longitudinal Trends in the EGDI

In addition to cross-sectional comparisons, the E-Government Development Index (EGDI) provides a longitudinal view of each country's trajectory between 2014 and 2024 (Figure 2).

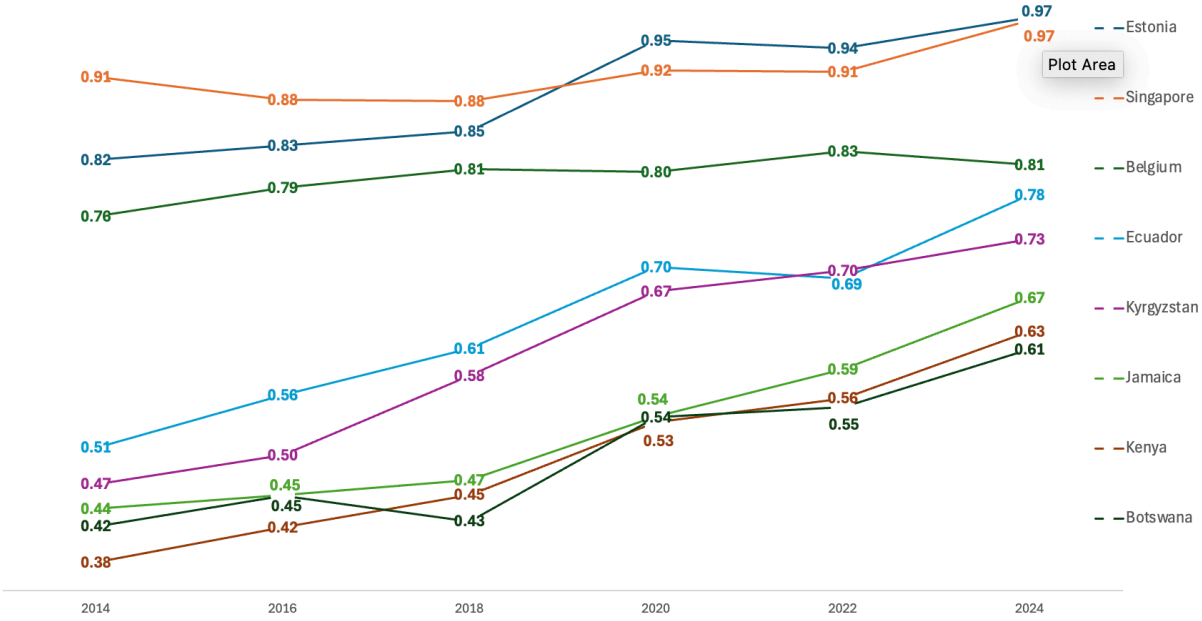


Fig. 2 – E-Government Development Index 2014-2024 (UNDESA, 2025).

Evidently, Estonia and Singapore show sustained progress, with Estonia increasing from 0.85 to 0.97 and Singapore maintaining consistently high scores. These gains are tied to iterative legal updates and investments in whole-of-government architectures. Moderate countries, such as Ecuador and Kyrgyzstan, have demonstrated steady improvement. Ecuador increased from 0.51 to 0.78, supported by platform expansion and external technical assistance. Kyrgyzstan rose from 0.47 to 0.73, reflecting the impact of institutional innovation, policy borrowing, and the rollout of Tunduk.

In contrast, early-stage countries show slower or inconsistent gains. Kenya improved from 0.38 to 0.63 due to its expanding service platforms, but progress is constrained by institutional fragmentation. Botswana and Jamaica exhibit only marginal growth, illustrating the limitations of uncoordinated or under-resourced reform. Interestingly, while classified as advanced, Belgium shows only modest growth (0.76 to 0.81), suggesting that decentralised governance may impede long-term progress despite early regulatory leadership.

Key Cross-Cutting Patterns

Three overarching insights emerge from the cross-country synthesis:

- **Legal frameworks are foundational but insufficient without institutional suppor**t: Advanced countries show that comprehensive legal frameworks embedded in operational systems, such as Estonia's X-Road and eID, enable secure data flows and cross-sector integration (Kotka et al., 2016; Krimmer et al., 2021). However, moderate countries like Ecuador and Kyrgyzstan reveal that legal adoption without enforcement, capacity, and uptake delivers limited outcomes (Bannister & Connolly, 2011b; OECD, 2023). This confirms existing research suggesting that the mere existence of laws does not guarantee compliance or transformation unless supported by enforcement mechanisms and institutional readiness (Bannister & Connolly, 2011b; Jordanoski & Meyerhoff Nielsen, 2023).

- **Institutional capacity and infrastructure determine the impact of regulation**: The implementation gap is widest in moderate and early-stage contexts. Ecuador's legal basis for interoperability is undermined by fragmented governance (Apolo et al., 2020), while Kyrgyzstan's infrastructure investments remain underutilised (UNDP, 2021). By contrast, advanced countries pair regulation with

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

long-term investments in technical and organisational infrastructure (Heeks, 2008). This supports the argument that regulatory maturity must be paired with governance capacity and adequate financing to deliver meaningful digital outcomes (OECD, 2020b).

- **Regulatory maturity is closely linked to interoperability and service integration**: Countries with legal mandates for data exchange and authentication, like Estonia and Belgium, show high levels of integration and service coherence (Bruijn, 2021; Kotka et al., 2016). These frameworks are embedded into public administration, enabling seamless, cross-agency services. In early-stage contexts, the absence of such frameworks leads to siloed systems and duplicative service delivery, limiting scalability and trust (Dovhan et al., 2022; Wimmer et al., 2018).

These findings confirm that regulatory maturity is a strong predictor of e-governance performance but not a guarantee. Countries with established legal frameworks and well-embedded digital enablers consistently outperform those where reform remains fragmented or under-resourced. This cross-cutting synthesis reinforces the value of legal-regulatory maturity as a diagnostic lens while highlighting the risks of symbolic compliance in contexts where enforcement and technical infrastructure are lacking.

4.4 From Regulation to Realisation: Barriers to Effective Implementation

While regulatory maturity is a critical enabler of digital governance, it does not, on its own, guarantee meaningful implementation. Across the eight countries studied, several cross-cutting constraints continue to obstruct the translation of legal frameworks into operational digital ecosystems. These barriers underscore the need for a holistic approach that aligns legal ambition with institutional capacity, infrastructure readiness, and societal inclusion. These include:

- **Legal and Institutional Misalignment:** One of the most persistent challenges is fragmented governance and siloed legal mandates. In countries such as Kenya and Botswana, overlapping responsibilities and weak inter-ministerial coordination have delayed the adoption of shared platforms and hindered the enforcement of national digital strategies. Ecuador faces similar issues, where the lack of vertical alignment between national and subnational regulations has resulted in duplicative efforts and inefficiencies. These patterns reflect broader structural weaknesses, where legal reforms are not sufficiently supported by inter-agency collaboration or clearly defined institutional mandates (Nyman-Metcalf, 2014; OECD, 2020a).

- **Operational and Infrastructure Gaps:** Digital transformation also hinges on robust infrastructure and sustainable investment. In many early-stage countries, inadequate digital infrastructure, such as limited connectivity, fragmented identity systems, or insecure data hosting environments, impairs the rollout of legally mandated systems. Botswana and Kenya exemplify this dynamic, where the technical infrastructure lags behind strategic plans. Even where policies are well-articulated, their implementation is often delayed due to fiscal constraints or reliance on donor funding. Without adequate financing and a long-term maintenance strategy, legal frameworks risk becoming aspirational rather than actionable (OECD, 2020b).

- **Societal Readiness and Trust:** Even the most coherent legal and technical systems depend on societal trust and digital literacy to gain traction. In Jamaica, for instance, the National Identification System (NIDS), though legally established, has faced significant public opposition due to privacy concerns and insufficient consultation. (Caribbean Policy Research Institute (CAPRI), 2020) Similarly, Kenya's Huduma Namba and Maisha Namba initiatives were suspended or contested on legal grounds, with civil society raising concerns over exclusion risks and inadequate data safeguards (Kennedy, 2025; Njoya, 2023). These examples underscore that institutional design must be coupled with public engagement and transparent governance. Without these elements, uptake remains low, and compliance is limited even in legally sound systems (Grigorescu et al., 2016; Sanjay Jadhav, 2023).

Finally, across all maturity levels, governments face growing difficulties in responding to rapid technological change. While Singapore has begun adapting its legal frameworks to accommodate emerging technologies such as AI and fintech, most countries remain reactive, contributing to regulatory lag and oversight gaps (Firdaus et al., 2024; OECD, 2020b). This mismatch between innovation cycles and legislative evolution highlights the need for more agile, anticipatory regulatory design.

5. Conclusion and Future Work

This paper examined how the maturity of regulatory frameworks correlates with the development of e-governance across a diverse set of countries. While regulatory frameworks are indispensable for enabling secure, efficient, and resilient digital government systems, their effectiveness depends on broader structural and institutional

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

conditions. The findings confirm that legal design alone is insufficient unless matched by operational capacity, coordinated governance, and public engagement. As digital transformation accelerates globally, the ability of governments to align legal innovation with institutional capacity and societal needs will remain a decisive factor in shaping the future of digital public administration.

Drawing from a cross-case comparative analysis of eight jurisdictions, the findings confirm that comprehensive, coherent, and enforceable regulatory environments are closely associated with more advanced e-governance outcomes. Countries with mature legal systems, such as Belgium, Estonia, and Singapore, have successfully implemented key digital enablers, achieved high levels of interoperability, and fostered institutional and citizen trust in digital services. This conclusion is further supported by comparative analysis using internationally recognised indicators, which offer empirical validation of the observed regulatory maturity classifications. In contrast, jurisdictions with fragmented or underdeveloped regulatory frameworks face persistent challenges related to implementation, enforcement, and scalability. These barriers, ranging from legal fragmentation to enforcement gaps and infrastructure constraints, demonstrate the need for regulatory maturity to be understood as both a legal and operational condition.

This research introduces an empirically grounded, three-tier classification of regulatory maturity (advanced, moderate, and early-stage) based on legal scope, system operationalisation, and institutional integration. By combining qualitative analysis with internationally recognised indicators (e.g., EGDI, OSI, EPI, GCI), the study offers a replicable framework for diagnosing regulatory readiness across diverse national contexts. It also serves as a practical benchmarking tool for policymakers, enabling the identification of regulatory gaps and supporting targeted reforms aligned with national capabilities and digital ambitions.

Future research could extend this analysis by examining the influence of global and regional legal frameworks, such as the EU's eIDAS, GDPR, and NIS2, the OECD's digital governance principles, or emerging global standards on Artificial Intelligence, in shaping domestic regulatory ecosystems. Also, further work could examine the effects of regulatory design at subnational or federal levels, particularly in countries with decentralised governance structures, such as Belgium, Australia, or India. Longitudinal studies could also help clarify how legal frameworks adapt to technological change and whether regulatory evolution leads to sustained governance outcomes. Understanding how legal frameworks evolve over time and how they respond to emerging technologies will be essential for designing future-ready digital governance systems.

Acknowledgement

- **Funding or Grant:** This document is a result of the project "INOV.EGOV-Digital Governance Innovation for Inclusive, Resilient and Sustainable Societies / NORTE-01-0145-FEDER-000087", supported by the Norte Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (EFDR).
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Apolo, D., Melo, M., Solano, J., & Aliaga-Sáez, F. (2020). Pending issues from digital inclusion in Ecuador: challenges for public policies, programs and projects developed and ICT-mediated teacher training. *Digital Education Review*, *37*, 130–153. https://doi.org/10.1344/der.2020.37.130-153

Bannister, F., & Connolly, R. (2011a). *Transformation and public sector values*. na.

Bannister, F., & Connolly, R. (2011b). Trust and transformational government: A proposed framework for research. *Government Information Quarterly*, *28*(2), 137–147. https://doi.org/10.1016/j.giq.2010.06.010

Bruijn, H. (2021). *The Governance of Privacy: Privacy as Process: The Need for Resilient Governance*. https://doi.org/10.5117/9789463729673

Caribbean Policy Research Institute (CAPRI). (2020). *Who am I? The People dem NIDS*.

Chatterjee, S., & N.S., S. (2022). Artificial intelligence and human rights: a comprehensive study from Indian legal and policy perspective. *International Journal of Law and Management*, *64*(1), 110–134. https://doi.org/10.1108/IJLMA-02-2021-0049

Chauhan, R., Estevez, E., & Janowski, T. (2008). A model for policy interventions in support of electronic governance. *Proceedings of the 2nd International Conference on Theory and Practice of Electronic Governance*, 199–205. https://doi.org/10.1145/1509096.1509135

CIA.gov. (2025). *The World Factbook*. Https://Www.Cia.Gov/the-World-Factbook/.

CIPESA. (2022). *State of Freedom. in Afraica*.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Cordella, A., & Bonina, C. M. (2012). A public value perspective for ICT enabled public sector reforms: A theoretical reflection. *Government Information Quarterly*, *29*(4), 512–520. https://doi.org/10.1016/j.giq.2012.03.004

Dovhan, V., Yunyk, I., Kurchyn, O., Zhupnyk, V., & Moskalenko, S. (2022). Building Legal Mechanisms for Electronic Governance Development. *Cuestiones Políticas*, *40*(73), 172–191. https://doi.org/10.46398/cuestpol.4073.08

e-Estonia. (2025). *e-Estonia: Facts & Figures*. Https://E-Estonia.Com/Facts-and-Figures/.

e-Governance Academy. (2021). *Supporting Service-Oriented e-Government Interoperability*.

Firdaus, D. U. F. binti, Roslan, N. A. bin, Saferdin, W. F. H. binti W. M., Zulkarnain, I. F. binti, & Samasu, N. F. binti. (2024). AI Integration in Malaysian Public Administration for Improved Governance. *International Journal of Research and Innovation in Social Science*, *VIII*(IX), 3799–3812. https://doi.org/10.47772/IJRISS.2024.8090316

Franco, F. S. R. (2024). Brazilian Federal Public Administration, open data, technologies and the right to Information. *Brazilian Journal of Law, Technology and Innovation*, *2*(1), 140–192. https://doi.org/10.59224/bjlti.v2i1.140-192

Gil-Garcia, J. R., Dawes, S. S., & Pardo, T. A. (2018). Digital government and public management research: finding the crossroads. *Public Management Review*, *20*(5), 633–646. https://doi.org/10.1080/14719037.2017.1327181

Global Digital Identity Index. (2024). *Digital Identity Readiness Index*. Https://Digitalidentityindex.Com.

González, L., Echevarría, A., Morales, D., & Ruggia, R. (2016). An E-government Interoperability Platform Supporting Personal Data Protection Regulations. *CLEI Electronic Journal*. https://doi.org/10.19153/cleiej.19.2.7

Government of Botswana. (2021). *SmartBots*. Https://Smartbots.Gov.Bw.

GovTech Singapore. (2023). *Singpass and National Digital Identity Statistics*.

Gregory, J. (2002). Solving Legal Issues in Electronic Government: Jurisdiction, Regulation, Governance. *Canadian Journal of Law and Technology*, *1*(3).

Grigorescu, A., Lupu, M.-M., Iancu, A. A., Tuca, M. V., Vatamatescu, M. E., Andrei, A. G., Daniel, P., Săvulescu, C., Iordache, L., Dincă, D. V., Antonovici, C. G., Dumitrescu, A., Dumitru, B. D., Popescu, M.-L., & Popa, F. (2016). *Comparative Public Administration and Management – Good Governance and Regulatory Quality in the 21st Century*. https://api.semanticscholar.org/CorpusID:155423230

Hasan, M. M., Anagnostopoulos, D., Kousiouris, G., Stamati, T., Loucopoulos, P., & Nikolaidou, M. (2019). An Ontology based Framework for E-Government Regulatory Requirements Compliance. *International Journal of E-Services and Mobile Applications*, *11*(2), 22–42. https://doi.org/10.4018/IJESMA.2019040102

Hasan, M. M., Loucopoulos, P., Anagnostopoulos, D., & Nikolaidou, M. (2015). Regulatory requirements compliance in e-Government service development. *2015 18th International Conference on Computer and Information Technology (ICCIT)*, 254–259. https://doi.org/10.1109/ICCITechn.2015.7488078

He, Z. (2011). The Legal Regulations of E-Government. *2011 International Conference on Management and Service Science*, 1–4. https://doi.org/10.1109/ICMSS.2011.5999430

Heeks, R. (2002). *Reinventing Government in the Information Age* (R. Heeks, Ed.). Routledge. https://doi.org/10.4324/9780203204962

Heeks, R. (2008). eGovernment for development: Success and Failure in eGovernment Projects. *Institute for Development Policy and Management (IDPM), University of Manchester. Http://Www. Egov4dev. Org/Egovdefn. Htm*.

ITU. (2024). *Global Cybersecurity Index 2024*.

ITU. (2025). *DataHum*. Https://Datahub.Itu.Int.

Jordanoski, Z., & Meyerhoff Nielsen, M. (2023). The challenge of web accessibility: an evaluation of selected government websites and service portals of high, middle and low-income countries. *Proceedings of the 16th International Conference on Theory and Practice of Electronic Governance*, 101–110. https://doi.org/10.1145/3614321.3614343

Kennedy, C. (2025, March 13). *Legal Challenge Targets Kenya's New Digital ID System Over Rights Concerns*.

Korvat, O. (2023). Development of Electronic Governance to a Digital Ecosystem. *Law and Innovations*, *2 (42)*, 41–45. https://doi.org/10.37772/2518-1718-2023-2(42)-5

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Kotka, T., del Castillo, C. I. V. A., & Korjus, K. (2016). Estonian e-Residency: Benefits, Risk and Lessons Learned. In A. Kő & E. Francesconi (Eds.), *Electronic Government and the Information Systems Perspective* (pp. 3–15). Springer International Publishing.

Krimmer, R., Dedovic, S., Schmidt, C., & Corici, A.-A. (2021). Developing Cross-border E-Governance: Exploring Interoperability and Cross-border Integration. In N. Edelmann, C. Csáki, S. Hofmann, T. J. Lampoltshammer, L. Alcaide Muñoz, P. Parycek, G. Schwabe, & E. Tambouris (Eds.), *Electronic Participation* (pp. 107–124). Springer International Publishing.

Lebid, O. (2021). E-governance of the economy of the future: world experience and prospects of Ukraine. *Ekonomika APK*, *324*(10), 98–110. https://doi.org/10.32317/2221-1055.202110098

López-López, V., Iglesias-Antelo, S., Vázquez-Sanmartín, A., Connolly, R., & Bannister, F. (2018). e-Government, Transparency & Reputation: An Empirical Study of Spanish Local Government. *Information Systems Management*, *35*(4), 276–293. https://doi.org/10.1080/10580530.2018.1503792

Luna-Reyes, L. F., Picazo-Vela, S., Luna, D. E., & Gil-Garcia, J. R. (2016). Creating Public Value through Digital Government: Lessons on Inter-Organizational Collaboration and Information Technologies. *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 2840–2849. https://doi.org/10.1109/HICSS.2016.356

Mahrer, H., & Krimmer, R. (2005). Towards the enhancement of e-democracy: identifying the notion of the 'middleman paradox.' *Information Systems Journal*, *15*(1), 27–42. https://doi.org/10.1111/j.1365-2575.2005.00184.x

Meyerhoff Nielsen, M. (2017). eGovernance frameworks for successful citizen use of online services: A Danish-Japanese comparative analysis. *JeDEM - EJournal of EDemocracy and Open Government*, *9*(2), 68–109. https://doi.org/10.29379/jedem.v9i2.462

Meyerhoff Nielsen, M., & Jordanoski, Z. (2020). Digital transformation, governance and coordination models: A comparative study of Australia, Denmark and the Republic of Korea. *The 21st Annual International Conference on Digital Government Research*, 285–293. https://doi.org/10.1145/3396956.3396987

Meyerhoff Nielsen, M., & Krimmer, R. (2015). *Reuse of Data for Personal and Proactive Service: An Opportunity Not Yet Utilised*.

Muliaro Wafula, J. (2012). *ICT Policy and Strategies: Towards E-Governance and Sustainable Development: The Case of East African Community and Kenya*. https://api.semanticscholar.org/CorpusID:109059170

Mustafa, G., Rafiq, W., Jhamat, N., Arshad, Z., & Rana, F. A. (2025). Blockchain-based governance models in e-government: a comprehensive framework for legal, technical, ethical and security considerations. *International Journal of Law and Management*, *67*(1), 37–55. https://doi.org/10.1108/IJLMA-08-2023-0172

Navarra, D., & Cornford, T. (2003). *A Policy Making View of E-Government Innovations in Public Governance.*

Ndlovu, T. (2024). Botswana showcases e-government's privacy pitfalls Ndlovu. *Digital Rights Southern Africa*, *2*, 6–11.

Njoya, S. (2023, December 7). Kenya: High Court Suspends Digital ID, Citing Data Protection Concerns. *Https://Www.Wearetech.Africa/En/Fils-Uk/News/Tech/Kenya-High-Court-Suspends-Digital-Id-Citing-Data-Protection-Concerns*.

Nyangena, J., Rajgopal, R., Ombech, E. A., Oloo, E., Luchetu, H., Wambugu, S., Kamau, O., Nzioka, C., Gwer, S., & Ndiritu Ndirangu, M. (2021). Maturity assessment of Kenya's health information system interoperability readiness. *BMJ Health & Care Informatics*, *28*(1), e100241. https://doi.org/10.1136/bmjhci-2020-100241

Nyman-Metcalf, K. (2014). e-Governance in Law and by Law. In T. Kerikmäe (Ed.), *Regulating eTechnologies in the European Union: Normative Realities and Trends* (pp. 33–51). Springer International Publishing. https://doi.org/10.1007/978-3-319-08117-5_3

OECD. (2020a). *Digital Government Index*. https://doi.org/10.1787/4de9f5bb-en

OECD. (2020b). *Going Digital integrated policy framework*. https://doi.org/10.1787/dc930adc-en

OECD. (2020c). *OECD Development Co-operation Peer Reviews: Belgium 2020*. OECD. https://doi.org/10.1787/026f1aad-en

OECD. (2020d). *The OECD digital government policy framework*. https://doi.org/10.1787/f64fed2a-en

OECD. (2023). *Digital Government Review of Latin America and the Caribbean*. OECD. https://doi.org/10.1787/29f32e64-en

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Okon, S. U. (2024). Enhancing Transparency and Accountability in Public Service through Open Data Initiatives: Insights from Estonia and Policy Recommendations for the United States. *Asian Journal of Economics, Business and Accounting*, *24*(9), 328–349. https://doi.org/10.9734/ajeba/2024/v24i91496

Ortega, E., Tran, M., & Bandeen, G. (2023). AI Digital Tool Product Lifecycle Governance Framework through Ethics and Compliance by Design†. *2023 IEEE Conference on Artificial Intelligence (CAI)*, 353–356. https://doi.org/10.1109/CAI54212.2023.00155

Papadopoulos, T., & Kanellis, P. (2012). *Public Sector Reform Using Information Technologies*. IGI Global. https://doi.org/10.4018/978-1-60960-839-2

Park, S., Kim, S., Kim, B., Kim, D., & Kwon, H. (2016). Characteristics of the Legal Framework of Korea in the Age of Data and Looking Forward - from Media Theory Point of View. *International Journal of Software Engineering and Its Applications*, *10*(5), 109–124. https://doi.org/10.14257/ijseia.2016.10.5.11

Rohlfing, I. (2012). *Case Studies and Causal Inference: An Integrative Framework*. https://api.semanticscholar.org/CorpusID:117082449

Sanjay Jadhav, S. (2023). Impact of the Right to Information Act by Regulating Transparency in Corruption of India. *International Journal of Science and Research (IJSR)*, *12*(2), 285–290. https://doi.org/10.21275/MR23129125420

Schneider, J.-P., Erny, J., & Enderlein, F. (2024). Collaborative Governance Structures for Interoperability in the EU's new data acts. *European Journal of Risk Regulation*, 1–12. https://doi.org/10.1017/err.2024.46

Shkarlet, S., Oliychenko, I., Dubyna, M., Ditkovska, M., & Zhovtok, V. (2020). Comparative analysis of best practices in e-Government implementation and use of this experience by developing countries. *Administratie Si Management Public*, *34*, 118–136. https://doi.org/10.24818/amp/2020.34-07

Smart Nation and Digital Government Office Singapore. (2024). *Smart Nation 2.0: A Thriving Digital Future for All*.

Thornberg, R. (2012). Informed Grounded Theory. *Scandinavian Journal of Educational Research*, *56*(3), 243–259. https://doi.org/10.1080/00313831.2011.581686

Tojiev, O. (2024). Laying the legal groundwork for digital governance. *International Journal of Law, Justice and Jurisprudence*, *4*(1), 06–08. https://doi.org/10.22271/2790-0673.2024.v4.i1a.86

UNDESA. (2022). *UN E-Government Survey 2022*.

UNDESA. (2024). *UN E-Government Survey 2024*.

UNDESA. (2025). *UN E-Government Knowledge*. Https://Publicadministration.Un.Org/Egovkb/En-Us/Data-Center.

UNDP. (2021). *Entry points for digital transformation in Kyrgyzstan*.

UNECA. (2023). *Botswana Establishes SmartBots Lab to Drive Innovation and Digital Transformation*. Https://Www.Uneca.Org/Stories/Botswana-Establishes-Smartbots-Lab-to-Drive-Innovation-and-Digital-Transformation.

Veit, D., & Huntgeburth, J. (2014). Legal Aspects of Digital Service Delivery. In D. Veit & J. Huntgeburth (Eds.), *Foundations of Digital Government: Leading and Managing in the Digital Era* (pp. 51–66). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-38511-7_4

Wimmer, M. A., Boneva, R., & di Giacomo, D. (2018). Interoperability governance: a definition and insights from case studies in Europe. *Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age*. https://doi.org/10.1145/3209281.3209306

World Bank. (2021). *Digital Government Readiness Assessment (DGRA) toolkit*.

Yin, R. K. (2017). *Case Study Research and Applications: Design and Methods* (Sixth). SAGE Publications.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Appendix

Tab. – E-Governance Regulatory Landscape in Belgium, Estonia, Singapore, Ecuador, Kyrgyzstan, Botswana, Jamaica and Kenya.

	Belgium	Estonia	Singapore	Ecuador	Kyrgyzstan	Botswana	Jamaica	Kenya
eID and Trust services	Regulation (EU) No 910/2014 (eIDAS Regulation); Regulation (EU) 2024/1183 (eIDAS 2.0) Law relating to population registers, identity cards, ...; Law on Electronic identification.	Identity Documents Act; Electronic Identification and Trust Services for Electronic Transactions Act.	Electronic Transactions Act	Law for the Digital and Audiovisual Transformation and its General Regulations: Law on Identity and Civil Data Management; Administrative Code; Law on Electronic Commerce, Signature and Data Messages.	Law on Electronic Governance; Law about Electronic Signature; Regulation on the Unified Identification System.	National Registration Act; Electronic Communication and Transaction Act; Electronic Records (Evidence) Act and Regulations.	National Identification and Registration Act (NIRA); Electronic Transactions Act.	Information and Communications Act; Electronic Certification and Domain Name Administration Regulation; Registration of Persons Act; Regulations and Data Protection Regulations.
Interoperability & Data Exchange	Regulation (EU) 2024/903 (Interoperable Europe Act); European Interoperability Framework. Law ... on establishing an Infrastructure for Spatial Information in the European Community (INSPIRE); Law guaranteeing the principle of a single collection of data...; Belgium Interoperability Framework (Belgif).	Public Information Act; Regulation on Exchange Layer of Information System (X-Road); Estonian Interoperability Framework.	Public Sector Governance Act (PSGA); Government Data Architecture (GDA).	Law of the National System of Public Data Registrations; Interoperability Guidelines in the Executive Function, Technical Standard for Interoperability Public Data Registries; Government Interoperability Technical Standard.	Law on E-Governance; Decree on the Requirements for the interaction of information systems in the Electronic Interaction System Tunduk.	No regulation	No regulation (only PSG Manual (ICT Policies, Standards & Guidelines)	No regulation (only Government Enterprise Architecture Framework)
E-payments	EU Directive 2015/2366 (Payment Services Directive (PSD2) Law on the statute and supervision of payment institutions and electronic money institutions...	Administrative Procedure Act; Payment Institutions and Electronic Money Institutions Act.	Payment Services Act	Law on Electronic Commerce, Signature and Data Messages.	Law on the payment system.	Electronic Communication and Transaction Act	Electronic Transactions Act	Information and Communications Act
Digital Post	Law on Electronic Communications	Administrative Procedure Act	Electronic Transactions Act; Public Sector Governance Act (PSGA).	Law for the Optimisation and Efficiency of Administrative Procedures; Law on E-Commerce, Signature and Data Messages.	Law on E-Governance; Administrative-Procedure Code; Decree on Urgent Measures to Enhance the Implementation of Digital Technologies in Public Administration.	Electronic Communication and Transaction Act	Electronic Transactions Act	Information and Communications Act
Access to and reuse of Public Sector Information	Regulation (EU) 2018/1724 (Single Digital Gateway Regulation); Regulation (EU) 2018/1807 (free flow of non-personal data across the EU); Regulation (EU) 2022/868 (Data Governance Act). Law on the Right of Access to Administrative Documents; Law on the Reuse of Public Sector Information	Public Information Act	No regulation	Law on Transparency and Access to Public Information and Open Data Policy.	Law on Guarantees and Freedom of Access to Information; Law about access to information held by state bodies and local self-government bodies.	Freedom of Information Bill	Access to Information Act Open Data Policy.	Access to Information Act
Data Protection	Regulation (EU) 2016/679 (General Data Protection Regulation (GDPR)) Law on establishing the Data Protection Authority; Law on the Protection of Private Life with regard to the Processing of Personal Data.	Personal Data Protection Act	Personal Data Protection Act; Public Sector Governance Act (PSGA); Spam Control Act.	Law on the Protection of Personal Data	Law about personal information	Data Protection Act	Data Protection Act	Data Protection Act
Cybersecurity	Regulation (EU) 2019/881 (EU Cybersecurity Act); EU Directive 2022/2555 (Network and Information Security Directive (NIS2)) Law on the Establishment of a Security Framework for Information Systems Having General Interest	Cybersecurity Act	Computer Misuse Act; Cybersecurity Act; Instruction Manual for Infocomm Technology and Smart Systems (ICT&SS) Management.	Penal Code; Cybersecurity Policy.	Law on the protection of state secrets n.210; Decree on the Requirements for the protection of information contained in databases of state information systems n. 762.	Cybercrime and Computer-Related Crimes Act	Cybercrimes Act	Information and Communications Act; Computer Misuse and Cybercrimes Act.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 14: Organizational Factors, Adoption Issues, and Value Creation of Digital Government

Track Description

The adoption and implementation of new ICTs by public organizations have been influenced by organizational factors such as resource availability (i.e., funding, infrastructure, technological knowledge, and personnel), leadership, trust, stakeholder involvement, organizational structure and culture, as well as inter-organizational dynamics. Similarly, the adoption of ICTs in government and society has had significant impacts on the organizational processes, effectiveness, and innovativeness of public organizations, as well as on the new governance structure of government and societal impacts. This track aimed to gather research that examines the organizational factors that influence the adoption and implementation, and investigates the impacts, especially the value creation, of new and emerging innovative technologies such as smart city, artificial intelligence, data analytics, big data, open data, social media, citizen-centric technologies, and other novel technologies, as well as theories and practices of adopting innovative policies and practices to facilitate the strategic use of various ICTs by public organizations.

Track Chairs

M. Ahn, UMass Boston, United States of America
L. F. Luna-Reyes, University at Albany, United States of America
J. Zhang, Clark University, Main, United States of America
C. Hinnant, Florida State University, United States of America

Contents

Enhancing Public Procurement Through GRC Management: Navigating the Evolving EU Regulatory Landscape 845
A. Schmitz and M. Wimmer

Generation of public value through the adoption of government blockchain networks: The analysis of the Brazilian federal government 860
M. F. M. Bourguignon and M. A. Macadar

Integrating VR/AR and AI-Chatbots in the Public Sector: Barriers and Synergies 875
R. Palombo, J. Westermann, and J. F. Pröschold

Multi-level Collaborative Governance Framework for Designing Accountable AI Systems for Emergency Management 886
Y.-C. Chen, C.-H. Tsai, and E. Zendejas

Rethinking AI Readiness: A Framework for LMICs with Argentina as Case Study 896
L. M. G. Bolia

The wallet demarcation problem: developing a taxonomy for classifying digital wallets 910
B. Lukkien, M. de Reuver, and N. Bharosa

Unleashing Public Sector Innovation: Exploring the Impact of Big Data Analytics and Value-Driven Capabilities on Digital Governance 925
S. B. Egala, A.-H. S. Alhassan, and J. A. Boakye

Using ICT to Patch the Shortcomings of New Public Management in a Post-Communist Welfare State 939
S. Sosnowski

Why broadband availability differs across states in the U.S.?: Exploring the role of state administrative capacity 952
H. Astuti, C. Stratton, and C. Hinnant

Enhancing Public Procurement Through GRC Management: Navigating the Evolving EU Regulatory Landscape.

Andreas Schmitz [a*], *Maria A.* Wimmer [a]

[a] Research Group E-Government, Faculty of Computer Science, University of Koblenz, Koblenz, Germany, {andreasschmitz | wimmer}@uni-koblenz.de, 0000-0002-8460-1027 (Wimmer)

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. The increasing complexity of the extensive regulatory frameworks in the European Union (EU) creates significant challenges for public procurement processes. Besides the existing Public Procurement Directives, new regulations, such as the Corporate Sustainability Reporting Directive (CSRD), the Corporate Supply Chain Due Diligence Directive (CSDDD), and the EU Taxonomy Regulation introduce intricate compliance requirements that strain existing procurement standards and systems. This paper explores the pivotal role of Governance, Risk, and Compliance (GRC) frameworks as enablers of legal interoperability and process optimization in this evolving landscape. The research first develops an overview matrix categorizing EU regulations from 2021 to 2027 based on their relevance and impact on public procurement. Building on this foundation, a second matrix maps tailored solution components to core challenges posed by high impact regulations, identifying critical areas requiring intervention. Synthesizing these findings, the paper proposes enhancements to current standards for electronic public procurement. These include extending the European Single Procurement Document (ESPD), introducing standalone reporting formats, and leveraging GRC software to manage compliance complexities. The study highlights the importance of integrating GRC frameworks with scalable, AI-driven solutions to foster legal interoperability and operational resilience. It therewith offers actionable insights for policymakers, for practitioners in the public procurement processes, and for researchers.

Keywords. Regulation, GRC, Interoperability

Research paper, DOI: https://doi.org/10.59490/dgo.2025.978

1. Introduction

Governance, Risk, and Compliance (GRC) are increasingly important for managing organizational frameworks, optimizing business processes, and ensuring adherence to a rapidly evolving regulatory landscape (Racz, Weippl, Seufert, et al., 2010). In an era shaped by resource scarcity, stringent environmental requirements, and demographic transformations, effective governance has emerged as a cornerstone for leveraging available resources efficiently while mitigating risks through compliance with clear and enforced regulations (Racz, Weippl, & Seufert, 2010). These principles are particularly significant within the European Union (EU), where the regulatory environment is becoming increasingly complex (Knill & Liefferink, 2021).

The EU has introduced several large-scale regulations to address pressing societal and environmental concerns. Notably, the Corporate Sustainability Reporting Directive (CSRD) (Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 Amending Regulation (EU) No 537/2014, 2022) seeks to enforce comprehensive environmental accountability, while the Supply Chain Due Diligence Act (Directive - EU - 2024/1760 - EN - EUR-Lex, 2024) mandates rigorous governance and transparency across supply chains. Complementary policies targeting carbon emissions, anti-money laundering, human rights protection, and whistleblower safeguards further underscore the criticality of compliance frameworks (Directive - 2019/1937 -

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

EN - Eu Whistleblowing Directive - EUR-Lex, 2019; Latest Update on Anti-Money Laundering and Countering the Financing of Terrorism Legislative Package - European Commission, 2024; Regulation - 2020/852 - EN - Taxonomy Regulation - EUR-Lex, 2020; Regulation - 2022/2554 - EN - DORA - EUR-Lex, 2022; Regulation - 2022/2560 - EN - EUR-Lex, 2022; Regulation - 2023/956 - EN - Cbam Regulation - EUR-Lex, 2023; Regulation - 2024/2847 - EN - EUR-Lex, 2024). Together, these regulatory advancements impose increased obligations on organizations to align their operational models with legal and ethical standards (Ionel Zamfir, 2020).

Public procurement, a sector already navigating an intricate web of legal and procedural requirements, is heavily affected by this regulatory transformation (Mohungoo et al., 2020). The intricate interplay between compliance and operational efficiency presents a dual challenge: meeting the new regulatory demands without compromising the inclusivity and functionality of procurement processes (Sonntagbauer & Bodiroza, 2009). The existing complexities in public procurement often dissuade private actors, particularly small and medium enterprises, from participation, stifling competition and innovation (Di Mauro et al., 2020; Flynn, 2018). To address these challenges, both contracting agencies (CAs) in the public sector and economic operators (EOs) participating in the public procurements must adopt comprehensive GRC frameworks that balance compliance imperatives with procedural efficiency (Vicente & Mira Da Silva, 2011). Multiple challenges on the maintenance of legal interoperability also have to be addressed (European Commission, 2017; Schmitz & Wimmer, 2023). Furthermore, implications of legal frameworks on current and future standards in public procurement need to be taken into account early (Guijarro, 2009).

This paper investigates the growing importance of GRC in public procurement and its potential role as an enabler of interoperability, along with the implications of new and forthcoming EU regulations. It delivers the following key contributions:

1. **Regulation matrix with an overview of new and recent EU regulations:** A structured matrix categorizing key EU regulations from 2021–2027 evaluates their relevance and potential impact on public procurement. By analyzing their regulatory requirements, the matrix highlights focus areas such as sustainability, supply chain due diligence, and carbon footprint assessments in public procurement procedures.

2. **Matrix mapping solution components and recommendations for the adoption of identified regulations:** Using the insights from the regulation matrix, the paper develops a second matrix mapping tailored solution components to core challenges in implementing these regulations. We develop actionable guidance for public administrations and economic operators. And we emphasize the role of GRC systems in achieving compliance and operational efficiency.

3. **Identification of gaps and enhancement potentials in the current standardization landscape:** We synthesize the two matrices and identify critical gaps in existing procurement standards, such as the need for standardized reporting formats and enhanced interoperability mechanisms. We propose enhancements, such as extending the ESPD and creating standards, to address these gaps and ensure regulatory alignment and process optimization.

Through these contributions, we emphasize the pivotal role of GRC as an enabler of regulatory adherence, legal interoperability, and process optimization. By integrating GRC principles with the established frameworks of interoperability, it is possible to mitigate the cascading effects of regulatory changes on procurement processes (Kalusivalingam et al., 2022). The paper aims to guide stakeholders in developing a more resilient and adaptive procurement ecosystem that addresses both compliance requirements and operational efficiency by means of structured GRC management.

The paper is structured as follows: Chapter 2 describes the research design. Chapter 3 elaborates on the theoretical background of related research topics based on academic literature. Chapter 4 presents an overview of relevant regulations, while chapter 5 proposes potential solutions to overcome the challenges of each high-impact regulation. Chapter 6 explores the impact on the standardization landscape. Finally, chapter 7 and 8 provide a discussion, closing thoughts, and future research needs.

2. Methodology and research design

This study employs Design Science Research (DSR) to explore and address the challenges of Governance, Risk, and Compliance (GRC) in public procurement. DSR is particularly suited for this research as it combines theoretical analysis of scientific literature (rigour cycle) and needs from practice (relevancy cycle) with solution development (design cycle) (Hevner & Chatterjee, 2010; Hevner et al., 2004). Three key questions guide this research:

1. **Which recent and upcoming EU regulations are most relevant to public procurement processes?**

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2. **How can Contracting Authorities (CAs) and Economic Operators (EOs) effectively comply with these regulations while maintaining operational efficiency?**

3. **What are the impacts of these regulations on existing procurement standards, and how can those standards be enhanced to ensure compliance and interoperability?**

We systematically examined these questions through three interlinked research cycles along DSR, which build upon one another to integrate theoretical insights with practical needs. The first research cycle establishes the foundational state of the art by conducting a comprehensive review of academic literature and EU regulatory frameworks based on Webster and Watson (Webster & Watson, 2002). In total, 47 scientific sources and 8 regulatory sources were selected for analysis. We divided them into three categories: theoretical grounding (28 sources), regulation-focused studies (15 sources), and methodological references (2 sources).

The literature review employed a multi-step filtering process to ensure quality and relevance. Theoretical sources, initially numbering 143, were filtered through abstract and conclusion screening, followed by full-text evaluation, resulting in a final selection of 28 sources. Regulation-based studies began with 73 identified documents, which were screened in a similar way, leading to a final set of 15 sources. The search process utilized keywords such as "interoperability," "standardization," "public procurement," and "GRC" across databases including SCOPUS, Web of Science, and ScienceDirect.

In parallel, corresponding to the relevancy cycle in the DSR approach, EU regulations were analyzed through official documentation, legislative drafts, and European Commission policy analyses. Focus was on recent and upcoming regulations with high potential impact on public procurement. Key themes, such as environmental accountability, supply chain transparency, and legal harmonization, were identified and structured into a regulation matrix that categorized and evaluated their relevance.

The authors, with academic expertise in public procurement and regulatory interoperability, synthesized regulatory requirements and scientific findings to develop two practical artifacts: (1) a regulation impact matrix and (2) a solution mapping matrix. These are not merely summaries, but conceptual tools designed to support strategic implementation and compliance decisions in public procurement. The development of these artifacts aligns with the design cycle of Design Science Research and aims to bridge theory with practice by proposing actionable, replicable solutions.

The second research cycle builds on the insights from the regulation matrix by developing a second matrix that maps solution components to the core challenges posed by emerging EU regulations. This matrix serves as a practical artifact, providing actionable guidance for CAs and EOs to adopt the identified regulations effectively. Furthermore, the related legal publications and scientific sources are mapped to the corresponding findings.

The third research cycle synthesizes the findings of the first two matrices to identify critical gaps in existing procurement standards and proposes targeted enhancements. Research cycle two and three are mostly motivated by the design cycle of DSR, taking into account rigorous and relevant findings from the previous research steps.

3. Theoretical Background on Interoperability, GRC and Public Procurement

3.1 Interoperability

Interoperability is fundamental to public procurement, enabling seamless interaction between systems, organizations, and regulations (Gascó, 2012). It encompasses technical, semantic, organizational, and legal dimensions, each contributing to efficient information exchange and compliance (Kalogirou et al., 2020). The European Interoperability Framework (EIF) emphasizes the legal layer as the highest level of interoperability, ensuring regulatory alignment across jurisdictions and profoundly influencing the other three dimensions (European Commission, 2017; Kouroubali & Katehakis, 2019).

The legal layer is particularly critical in public procurement. Public procurement laws and policies are shaping how the procurement process must look like and how actors need to collaborate. Further new harmonized regulations, such as the Corporate Sustainability Reporting Directive (CSRD) and the Supply Chain Due Diligence Act, establish a unified framework for accountability and sustainability (Baumüller & Sopp, 2021; Sönnichsen & Clement, 2020). These gain importance also regarding awarding criteria (Sönnichsen & Clement, 2020). Misaligned regulations can hinder collaboration, creating inefficiencies and increased compliance costs (Guijarro, 2007). The EIF's emphasis on standardized legal instruments addresses these challenges, fostering consistent application across member states. Beyond the legal layer, interoperability depends on organizational, semantic, and technical standards, and on their successful alignment and integration. Organizational processes must align with regulatory requirements,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

such as standardized evaluation criteria for sustainability (Schmitz et al., 2023). Semantic interoperability must ensure consistent understanding of data through common vocabularies and formats, critical for accurate reporting under directives like the CSRD (Wimmer et al., 2018). Technical interoperability relies on compatible systems and protocols, exemplified by the Peppol framework, which facilitates efficient data exchange in procurement. Interoperability is not static but evolves with regulatory and technological changes (Hellberg & Grönlund, 2013). Therefore, a closer look on interoperability along new regulations and GRC is advisable.

3.2 Governance, Risk, and Compliance (GRC)

Governance, Risk, and Compliance (GRC) has emerged as an essential framework for organizations navigating increasingly complex regulatory environments (Racz, Weippl, & Seufert, 2010). At its core, GRC integrates three interrelated functions: governance, which involves the alignment of organizational strategies and goals (Haugh & Bedi, 2023); risk management, which focuses on identifying, assessing, and mitigating potential threats; and compliance, which ensures adherence to laws, regulations, and internal policies. Together, these functions support in achieving organizational resilience and accountability while optimizing processes and resource allocation (Racz et al., 2010).

Recent research underscores the growing significance of GRC as a driver of regulatory adherence and operational efficiency. The introduction of regulations, such as the Corporate Sustainability Reporting Directive (CSRD) and the Supply Chain Due Diligence Act, further stress the need for robust GRC frameworks (Di Natale & Cordella, 2023). These frameworks are not only tools for compliance but also enablers of strategic decision-making, offering insights into risk exposure and areas requiring optimization. Organizations with integrated GRC systems can proactively manage risks and adapt to changing regulatory landscapes, gaining a competitive advantage (Zamfir, 2020).

Both public and private sectors benefit significantly from effective GRC management. Public administrations leverage GRC frameworks to maintain transparency and accountability while managing limited resources. For example, GRC processes help optimize procurement workflows, ensuring compliance with sustainability criteria and minimizing risks of regulatory breaches. Similarly, EOs utilize GRC systems to streamline reporting obligations, enhance supply chain oversight, and mitigate financial and reputational risks. In times of resource and personnel scarcity, the importance of GRC becomes even more pronounced. Efficient GRC management enables organizations to prioritize critical risks and deploy targeted measures, reducing administrative burdens while maintaining compliance. Optimizing GRC processes fosters greater organizational agility, allowing stakeholders to address emerging challenges effectively (Racz et al., 2010).

3.3 Public Procurement

Public procurement plays a pivotal role in public sector operations, accounting for a significant proportion of government expenditure across the EU (Siapera et al., 2023). As a highly regulated domain, it is directly influenced by legal interoperability, which ensures consistency and alignment of regulations across jurisdictions (Gualdi & Cordella, 2022). The European Interoperability Framework (EIF) identifies the legal layer as a critical enabler for achieving seamless procurement processes, emphasizing the importance of harmonized legal instruments to facilitate cross-border collaboration and compliance (Kalogirou et al., 2020).

The legal layer's impact on public procurement becomes particularly evident in the context of evolving EU regulations. Policies such as the Corporate Sustainability Reporting Directive and the Supply Chain Due Diligence Act introduce new criteria for supplier evaluation, requiring public administrations to integrate sustainability and accountability metrics into procurement decisions. These regulations highlight the dependency of procurement processes on clear and enforceable legal frameworks, which serve to reduce ambiguities and promote transparency (Hummel & Bauernhofer, 2024; Zamfir, 2020).

Academic research underscores the importance of governance, risk, and compliance (GRC) management in addressing the complexities of public procurement (Di Mauro et al., 2020; Okoye et al., 2024). GRC frameworks provide public administrations with the tools to navigate regulatory requirements effectively while optimizing procurement workflows (Racz, Weippl, & Seufert, 2010). By incorporating GRC principles, public administrations can mitigate risks, such as non-compliance or supply chain disruptions, and enhance the overall integrity of procurement processes (Vicente & Da Silva, 2011). The introduction of GRC management in public procurement also offers significant opportunities for improvement. Success factors identified in the literature include the use of standardized evaluation criteria (Qiao & Cummings, 2003; Siapera et al., 2023), enhanced interoperability of data systems (Abraham et al., 2019), and stakeholder collaboration (Ruijer, 2021). Their translation from policies to practice, a common challenge in e-procurement, could benefit from it as well (Hardy & Williams, 2008).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3.4 Synthesis of the interplay between GRC, interoperability and public procurement

The interplay between GRC, interoperability and public procurement demonstrates a cohesive relationship, where each concept reinforces the others. Regulations, as the driving force behind modern public procurement practices, are intricately tied to the legal layer of interoperability. This layer ensures that regulatory frameworks are harmonized across jurisdictions, fostering consistency in procurement standards and processes.

GRC frameworks are pivotal in bridging the gap between regulatory mandates and operational execution. Their integration into procurement practices provides a structured approach to compliance, enabling CAs and EOs to manage risks effectively while adhering to stringent regulations. By embedding GRC processes into the legal interoperability layer, organizations can streamline regulatory implementation, mitigate non-compliance risks, and optimize resources.

The close interconnection between these concepts underscores the necessity of further research and practical advancements in GRC as a supporting mechanism for regulatory implementation. Effective GRC frameworks not only facilitate compliance but also enhance interoperability by ensuring that procurement standards remain aligned with legal requirements and technical capabilities.

4. Evaluation of upcoming EU Regulations relevant to Public Procurement

Section 4 provides a comparative overview of relevant EU-Regulations that are planned or released in the timeframe from 2021-2027. Based on this overview, an evaluation of the regulations in regard to their expected impact on public procurement is conducted. Regulations with an expected high impact on public procurement are further analysed and put into perspective of findings from literature and current procurement procedures.

4.1 Overview of EU-Regulations impacting Public Procurement

In **Tab. 1**, we summarize key EU regulations and directives from 2021 to 2027, we categorize their areas of impact and provide an assessment of the expected impact of each regulation on public procurement. Regulations that exhibit no direct implications for public procurement processes are categorized with low impact. Regulations that necessitate changes in the behaviour of actors involved in public procurement procedures or influence the formal procurement processes are rated with medium impact. Regulations that significantly affect procurement content, standards, or processes—requiring the adoption of new frameworks or substantial adjustments—are rated with high impact.

The selection of the regulations is based on their legal scope, implementation timeline (2021–2027), and direct or indirect influence on public procurement procedures. Relevance was assessed based on whether a regulation introduces new reporting requirements, modifies procurement standards, or alters evaluation criteria for suppliers. While all listed regulations have some level of impact, the three with the most substantial and systemic implications—CSDDD, CSRD (in conjunction with the EU Taxonomy), and CBAM, are explored in greater detail in subsections 4.2 to 4.4. These were chosen because they require significant adaptations to current standards, and these introduce complex reporting and governance demands. Besides conducting a systematic analysis of these regulations, the authors consider themselves knowledgeable in the public procurement regulatory field, as they are collaborating in different research and standardization projects and initiatives at European and national level in Germany for more than a decade. They are members of the German "Cooperation Project on Digital Procurement"[1] funded by the German IT Planning Council, along which this research has evolved. Subsequently, we outline the main aspects of each identified EU regulation impacting public procurement in the EU.

The Regulation (EU) 2022/2560 on foreign subsidies aims to address distortions in the internal market caused by external subsidies. Public procurement processes require greater scrutiny of bids, particularly from non-EU entities, to ensure compliance with anti-subsidy measures. This will enhance fairness in procurement but may also increase administrative burdens in the processes.

The Digital Operational Resilience Act (DORA) introduces stringent cybersecurity standards for financial institutions and service providers. Public procurement will need to include robust cybersecurity criteria in tender specifications for ICT services, potentially raising procurement costs while strengthening system resilience.

[1] https://digitale-beschaffung.de/, last accessed 26th April 2025

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 - Overview of recent and upcoming EU regulations impacting public procurement across Europe.

Name/Subject of, number, and reference to regulation	Date of Planning	Date of Implementation	Summary Description of the Regulation	Category	Expected impact on public procurement
Regulation on foreign subsidies distorting the internal market (EU) 2022/2560 (Regulation - 2022/2560 - EN - EUR-Lex, 2022)	2022	December 2022	Addresses foreign subsidies that distort the internal market, ensuring fair competition.	Market Competition	Medium
Digital Operational Resilience Act (DORA) 2022/2554 (Regulation - 2022/2554 - EN - DORA - EUR-Lex, 2022)	2022	January 2025	Enhances digital operational resilience for the financial sector, improving ICT risk management and stronger cybersecurity standards for financial institutions.	Cybersecurity	Medium
Corporate Sustainability Due Diligence Directive (CSDDD) 2024/1760 (Directive - EU - 2024/1760 - EN - EUR-Lex, 2024; LkSG, 2021)	2021	January 2023 (DE), 2026 (EU-wide)	Mandates human rights and environmental due diligence in supply chains, promoting greater accountability in global supply chains; increased compliance requirements.	Sustainability	High
Whistleblower Protection Directive (2019/1937) (Directive - 2019/1937 - EN - Eu Whistleblowing Directive - EUR-Lex, 2019)	2019	2022-2023	Protects whistleblowers reporting breaches of EU law, encouraging transparency and accountability.	Governance	None
Corporate Sustainability Reporting Directive (CSRD) 2022/2464 (Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 Amending Regulation (EU) No 537/2014, 2022)	2021	January 2023 (Phased until 2026)	Expands sustainability reporting requirements for companies. Increased transparency in corporate sustainability performance.	Sustainability	High
EU Taxonomy Regulation 2020/852 (Regulation - 2020/852 - EN - Taxonomy Regulation - EUR-Lex, 2020)	2020	2022 (ongoing updates)	Provides a classification system for environmentally sustainable activities. Guides investments toward sustainable activities and supports green transitions.	Sustainability	High
EU Legislative Package on AML/CFT (Latest Update on Anti-Money Laundering and Countering the Financing of Terrorism Legislative Package - European Commission, 2024)	2021	2025-2026	Creates a centralized AML Authority and unifies AML/CFT measures across the EU. Stronger oversight and harmonized rules for combating money laundering and terrorist financing.	Financial Integrity	Medium
Carbon Border Adjustment Mechanism (CBAM) 2023/956 (Regulation - 2023/956 - EN - Cbam Regulation - EUR-Lex, 2023)	2021	October 2023	Introduces carbon pricing for imports to prevent carbon leakage. Encourages adoption of cleaner production methods and aligns global standards with EU policies.	Sustainability	Medium
Cyber Resilience Act 2024/2847 (Regulation - 2024/2847 - EN - EUR-Lex, 2024)	2022	2027	Requires manufacturers to integrate cybersecurity throughout product lifecycles.	Cybersecurity	Medium

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The Supply Chain Due Diligence Act (and its EU-wide counterpart under the Corporate Sustainability Due Diligence Directive) requires companies to identify and mitigate human rights and environmental risks in their supply chains. This regulation will reshape public procurement by necessitating strict sustainability and ethical sourcing criteria, particularly for global supply chains. These criteria should be integrated into existing standards or require new standards with a structured format.

The Whistleblower Protection Directive enhances transparency and has no apparent impact on procurement procedures.

The Corporate Sustainability Reporting Directive (CSRD) expands corporate sustainability reporting requirements. This will indirectly influence procurement by encouraging contracting authorities to prioritize suppliers with detailed sustainability disclosures. Managing these report obligations is complex and very data intensive. It therefore needs to be supported by some kind of structured approach.

The EU Taxonomy Regulation provides a classification framework for environmentally sustainable activities, significantly impacting sectors such as construction, energy, and transportation. Public procurement processes need to be aligned with these standards, prioritizing suppliers and projects that support the EU's environmental objectives. An integration into existing procurement standards would be paramount for efficient implementation.

The EU Legislative Package on AML and CFT aims to combat money laundering and terrorist financing by strengthening oversight and harmonizing anti-money laundering measures across member states. Public procurement authorities will need to enhance due diligence processes, incorporating stricter prequalification checks and ongoing monitoring of contracts to mitigate financial crime risks. However this can likely already be achieved by extending some corresponding criteria, that are already part of the ESPD.

The Carbon Border Adjustment Mechanism (CBAM) introduces carbon pricing on imports to prevent carbon leakage. Public procurement will need to incorporate carbon footprint assessments into tender evaluations, especially in high-emission sectors, thereby promoting the use of low-carbon goods and services. Adjusting procurement standards to reflect these assessments in a structured form might be pivotal.

The Cyber Resilience Act mandates cybersecurity measures across the lifecycle of digital products, influencing procurement in technological domains. Contracting authorities must include cybersecurity requirements in contracts for digital goods and services, which could raise costs but will enhance security and resilience.

Finally, the EU Packaging Regulation 2025 promotes sustainable materials and efficient packaging solutions. Public procurement authorities will need to prioritize suppliers adhering to circular economy principles and resource efficiency, aligning with the EU's broader sustainability goals.

Based on the above assessment, the CSDDD, CSRD & EU-Taxonomy, and CBAM will have the highest impact on procurement procedures. These will likely necessitate changes to existing standards or the development of new standards. We, therefore, focus on these high-impact critical regulations in the subsequent subsections 4.2-4.4.

4.2 Corporate Supply Chain Due Diligence Directive (CSCDDD)

Literature has shown that risk management is a critical aspect of global supply chain management, as it addresses the uncertainties and challenges posed by economic policies, globalization, and disasters, which significantly affect organizational financial performance and national economies (Gurtu & Johny, 2021). Effective risk management in international supply chains requires a nuanced understanding of the unique economic, infrastructural, and geopolitical dynamics of each region. Businesses must prioritize tailored strategies that leverage advanced technologies and local collaborations to build resilience and ensure the smooth functioning of supply networks (Okoye et al., 2024). The voluntary approach to corporate social responsibility in supply chains, while initially promising, has proven insufficient to address the systemic issues of human rights violations, environmental degradation, and governance challenges in developing countries. Multinational companies often operate in contexts where weak regulatory frameworks fail to enforce accountability, allowing exploitative practices to persist (Weihrauch et al., 2023).

The Corporate Supply Chain Due Diligence Directive (CSDDD) represents a transformative regulatory measure aimed at fostering accountability and sustainability within global supply chains. Initially introduced in Germany, the CSDDD has influenced broader European Union (EU) initiatives to mandate corporate responsibility for human rights and environmental impacts along their entire supply chains. The regulation requires companies to identify, assess, and mitigate risks associated with human rights violations, child labor, and environmental degradation, emphasizing due diligence obligations that extend beyond direct suppliers to include indirect supply chain actors

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

(*Directive - EU - 2024/1760 - EN - EUR-Lex*, 2024). These combined factors make a structured GRC-Management paramount to cover the requirements set out by the CSDDD.

Moreover, the Act's emphasis on supply chain transparency necessitates enhanced interoperability among procurement systems (Schilling-Vacaflor & Gustafsson, 2024). Public administrations will require standardized tools and data formats to verify supplier compliance, potentially leveraging frameworks such as Peppol to facilitate the exchange of due diligence documentation. Economic operators, on the other hand, must invest in supply chain monitoring technologies and reporting mechanisms to provide verifiable evidence of compliance and risk based compliance systems (Gervais et al., 2023). While the CSDDD enhances accountability and ethical practices, it also introduces challenges, including increased administrative burdens and compliance costs. Smaller suppliers may face particular difficulties in meeting the requirements, potentially limiting their participation in public procurement (Smit et al., 2021). To address these issues, capacity-building initiatives and collaborative approaches between public administrations and private sector actors will be critical.

4.3 Corporate Sustainability Reporting Directive (CSRD) and the EU Taxonomy Regulation

The Corporate Sustainability Reporting Directive (CSRD) and the EU Taxonomy Regulation collectively represent a significant shift in how organizations disclose and evaluate their environmental, social, and governance (ESG) performance. The CSRD expands upon the existing Non-Financial Reporting Directive (NFRD), mandating comprehensive sustainability reporting for a wider range of companies, including small and medium-sized enterprises (SMEs) that meet specific thresholds. The EU Taxonomy complements the CSRD by providing a standardized classification system to assess the environmental sustainability of economic activities, offering a clear framework for evaluating alignment with the EU's climate and environmental objectives (Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 Amending Regulation (EU) No 537/2014, 2022; Regulation - 2020/852 - EN - Taxonomy Regulation - EUR-Lex, 2020).

In the context of public procurement, the CSRD and EU Taxonomy have far-reaching implications. Public administrations will need to integrate sustainability criteria into procurement workflows, requiring suppliers to provide detailed ESG performance data as part of the qualification process. This shift aligns procurement practices with broader EU objectives, such as achieving carbon neutrality and promoting sustainable development. Furthermore, this is a development towards less strictly awarding based on financial criteria, which has been long awaited by literature (Qiao & Cummings, 2003; Sönnichsen & Clement, 2020). However, it also places additional compliance obligations on economic operators, necessitating robust governance, risk, and compliance (GRC) frameworks to manage ESG reporting effectively (Hummel & Bauernhofer, 2024).

The requirement for standardized sustainability data under the EU Taxonomy highlights the critical role of interoperability. Public administrations will need interoperable systems to process and verify ESG data, ensuring consistency and comparability across suppliers. Economic operators, in turn, must adopt technologies that facilitate accurate data collection and reporting, reducing the risk of non-compliance. While these regulations drive progress toward sustainability, they also introduce challenges, including increased administrative workloads and potential barriers for smaller suppliers. Capacity-building initiatives and collaborative efforts will be essential to ensure equitable participation in public procurement processes.

4.4 Carbon Border Adjustment Mechanism (CBAM)

The Carbon Border Adjustment Mechanism (CBAM) is a pivotal regulatory tool introduced by the European Union (EU) to address carbon leakage and promote global climate objectives. CBAM imposes a carbon price on imports from non-EU countries that do not meet the EU's stringent emissions reduction standards. Initially focusing on sectors such as cement, iron and steel, aluminum, fertilizers, and electricity, the regulation aims to level the playing field for EU industries subject to the Emissions Trading System (ETS), while encouraging international partners to adopt greener practices (Regulation - 2023/956 - EN - Cbam Regulation - EUR-Lex, 2023).

For public procurement, CBAM presents both opportunities and challenges. The inclusion of carbon pricing in procurement evaluations aligns with the EU's broader sustainability goals, incentivizing the selection of suppliers with lower carbon footprints. Public administrations will need to integrate CBAM criteria into procurement frameworks, necessitating the assessment of carbon-related metrics during the supplier qualification and evaluation phases. This shift emphasizes the need for transparent and interoperable systems capable of verifying and reporting carbon emissions data accurately.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 2 – Solution Mapping Matrix.

Regulation	Solution	EO / CA	Description	Sources
CBAM	GRC-Software and solutions	EO	GRC software enables economic operators to monitor, calculate, and report carbon emissions to comply with CBAM requirements. It simplifies the management of cross-border trade data and ensures accurate adjustment calculations.	(Ambec, 2022; Lim et al., 2021; Racz, Weippl, & Seufert, 2010; Racz, Weippl, Seufert, et al., 2010; Regulation - 2023/956 - EN - Cbam Regulation - EUR-Lex, 2023; Vicente & Mira Da Silva, 2011)
CBAM	Development of new standardized approaches and data specifications	CA	CAs can develop standardized data templates and formats to streamline reporting and evaluation processes for carbon emissions, facilitating compliance with CBAM during procurement.	(Ambec, 2022; Gal & Rubinfeld, 2018; Lim et al., 2021; *Regulation - 2023/956 - EN - Cbam Regulation - EUR-Lex*, 2023; Schmitz & Wimmer, 2023; Siapera et al., 2023)
EU-Taxonomy	GRC-Software and solutions	EO	EOs can implement GRC tools to assess activities against EU-Taxonomy criteria, ensuring compliance and readiness for classification and reporting obligations tied to sustainable finance.	(Hummel & Bauernhofer, 2024; Racz, Weippl, & Seufert, 2010; Racz, Weippl, Seufert, et al., 2010; Regulation - 2020/852 - EN - Taxonomy Regulation - EUR-Lex, 2020; Vicente & Mira Da Silva, 2011)
EU-Taxonomy	Usage of qualification methods (e.g. ESPD)	CA	CAs can utilize qualification methods like the ESPD to assess suppliers' alignment with the EU-Taxonomy framework, ensuring sustainable activities are prioritized in procurement. This would necessitate the extension of said standards to incorporate EU Taxonomy-related criteria.	(Hummel & Bauernhofer, 2024; Qiao & Cummings, 2003; *Regulation - 2020/852 - EN - Taxonomy Regulation - EUR-Lex*, 2020; Siapera et al., 2023; Telles, 2017)
CSRD	GRC-Software and solutions	EO	EOs can deploy GRC software to automate and verify the accuracy of sustainability reports, improving data integrity and compliance with CSRD obligations.	(Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 Amending Regulation (EU) No 537/2014, 2022; Hummel & Bauernhofer, 2024; Racz, Weippl, & Seufert, 2010; Racz, Weippl, Seufert, et al., 2010; Vicente & Mira Da Silva, 2011)
CSRD	Development of new standardized approaches and data specifications	Both	Developing standardized reporting templates would help EOs to align with CSRD requirements by enabling structured sustainability disclosures that meet regulatory standards. At the same time, it would make it easier for CAs to verify the compliance.	(Gal & Rubinfeld, 2018; Schmitz & Wimmer, 2023; Siapera et al., 2023; Vicente & Mira Da Silva, 2011) (Hummel & Bauernhofer, 2024)
CSDDD	Usage of qualification methods (e.g. ESPD)	Both	EOs can adopt ESPD or equivalent qualification tools to demonstrate compliance with CSDDD obligations, such as human rights due diligence and environmental risk assessments.	(Directive - EU - 2024/1760 - EN - EUR-Lex, 2024; LkSG - Nichtamtliches Inhaltsverzeichnis, 2021; Gervais et al., 2023; Gurtu & Johny, 2021; Okoye et al., 2024; Schilling-Vacaflor & Gustafsson, 2024; Telles, 2017; Weihrauch et al., 2023)
CSDDD	GRC-Software and solutions	EO	EOs can use GRC tools to ensure and monitore adherence to CSDDD obligations, ensuring effective implementation of due diligence across supply chains.	(Directive - EU - 2024/1760 - EN - EUR-Lex, 2024; LkSG - Nichtamtliches Inhaltsverzeichnis, 2021; Gervais et al., 2023; Gurtu & Johny, 2021; Okoye et al., 2024; Racz, Weippl, & Seufert, 2010; Racz, Weippl, Seufert, et al., 2010; Schilling-Vacaflor & Gustafsson, 2024; Smit et al., 2021; Vicente & Mira Da Silva, 2011; Weihrauch et al., 2023)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Economic operators involved in public procurement must adapt to the CBAM framework by investing in emissions tracking and reporting capabilities. Suppliers from non-EU countries face additional compliance obligations, potentially increasing the cost of imported goods. While these measures promote sustainable practices, they may also limit the participation of smaller suppliers or those from regions with less developed regulatory frameworks. Despite these challenges, CBAM offers significant potential to drive systemic change. By internalizing the environmental costs of carbon-intensive products, the mechanism fosters innovation in cleaner production methods (Ambec, 2022). Other Authors argue that CBAM is not economically viable because of increased costs (Lim et al., 2021). To address compliance complexities and support equitable participation, capacity-building initiatives and international collaboration will be essential.

5. Implementation of regulations

The effective implementation and management of emerging EU regulations requires robust governance, risk, and compliance (GRC) processes. GRC frameworks provide a structured approach to navigate complex regulatory landscapes, ensuring that both public administrations and economic operators (EOs) can comply with legal requirements while optimizing resources and mitigating risks. By integrating GRC processes, organizations can manage regulatory obligations systematically, aligning compliance efforts with broader strategic goals.

To create the solution matrix in **Tab. 2**, we cross-referenced the findings from the regulation matrix in **Tab. 1** with solution approaches identified in the literature. Challenges were grouped by recurring themes (e.g., data complexity, reporting burdens), and solution mechanisms were mapped using both academic sources and implementation guidelines from EU institutions. This mapping supports targeted implementation planning and represents a core design artifact in our DSR approach. Successful implementation of the identified solutions depends not only on technical feasibility but also on organizational adoption. Public agencies must manage change effectively by training procurement officers, aligning internal workflows, and building trust in GRC-based tools. Resistance to change, especially in resource-constrained municipalities, remains a critical barrier that must be addressed alongside technical innovation.

6. Impact on current standards

The introduction of new EU regulations, particularly the Corporate Sustainability Reporting Directive (CSRD), the Corporate Supply Chain Due Diligence Directive (CSDDD), and the EU Taxonomy Regulation, has revealed several gaps in existing public procurement standards. The gaps primarily stem from the increased complexity and specificity of the reporting requirements introduced by these regulations onto public procurement. To ensure effective compliance, both Economic Operators (EOs) and Contracting Authorities (CAs) must address these challenges while avoiding inefficiencies and inconsistencies in the procurement process. The enhancement proposals presented in this section were developed by analysing the specific challenges identified in the regulation and solution matrices. Each proposed measure directly corresponds to at least one major gap found in procurement standardization and was assessed against feasibility and scalability criteria by the authors of this paper, which were also discussed along different meetings with the cooperation partners in the Cooperation Project Digital Procurement.

6.1 Gaps in the current standardization landscape

The CSRD and CSDDD require organizations to provide detailed sustainability and due diligence reports. However, these regulations fail to define standardized formats for generating and sharing such reports. For instance, while the European Sustainability Reporting Standards (ESRS) under the CSRD provide a comprehensive legal framework, they are highly complex and challenging to implement. Larger organizations with robust compliance mechanisms may struggle with the requirements but be able to tackle them somehow. However, for Small and Medium Enterprises (SMEs), these obligations may appear insurmountable due to the intricate technical details and lack of clear guidelines.

The lack of standardization impacts not only the EOs. CAs and auditors responsible for evaluating these reports face significant data governance related challenges, including: Inconsistent Data Quality; Process Inefficiency; Lacking transparency and system interoperability. Without standardized reporting formats, data from EOs will likely vary in quality, completeness, and structure. The lack of consistency and traceability in data reporting raises concerns about transparency and accountability in public procurement. Existing procurement standards, such as the European Single Procurement Document (ESPD), are not designed to handle the complexity of these new regulatory requirements. While ESPD contains related criteria, its current structure would be overburdened by the volume and specificity of the information required by the new regulations.

6.2 Potential solutions and enhancements to the status quo – a roadmap

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

To address the gaps in current procurement standards and meet the demands of new EU regulations such as the CSRD, CSDDD and EU Taxonomy, it is essential to introduce targeted updates and complementary solutions. These measures must not only enhance the adaptability of existing frameworks but also streamline compliance processes for both EOs and CAs. The following roadmap provides an integrated approach by outlining potential solutions and their corresponding benefits:

1. **Utilizing the ESPD Framework:** The European Single Procurement Document (ESPD) is well-positioned to serve as a foundation for integrating new regulatory requirements, especially for EO qualification. However, to accommodate obligations under the CSRD, CSDDD, and EU Taxonomy, the ESPD must be extended to include new qualification criteria. These criteria should address critical areas such as sustainability reporting, human rights due diligence, and environmental risk assessments. This adaptation would ensure that the ESPD remains a versatile tool for managing the increasing complexity of procurement standards without fundamentally altering its core structure.

2. **Specialized Standards for Complex Reporting Criteria:** Given the high complexity of the reporting requirements introduced by the new regulations, it is advisable to create distinct, standardized formats for each type of report. For example, sustainability reports aligned with the ESRS could be simplified for usability by SMEs, while supply chain due diligence templates and environmental impact assessments could be standardized to ensure consistency across industries. These standalone standards would mitigate the risk of overwhelming the ESPD structure and ensure a clear and manageable reporting process for EOs and CAs.

3. **Integration Through Evidence Documents:** To facilitate the seamless inclusion of these complex reports within procurement workflows, standardized reports should be treated as evidence documents. These technical documents could be attached to the ESPD during the pre-award phase, providing CAs with all necessary information while preserving the integrity of existing procurement processes. This approach would enable automated processing and verification of evidence documents, reducing administrative burdens and enhancing evaluation efficiency.

4. **Leveraging GRC Software Solutions**: The technical intricacies of the new reporting obligations necessitate the use of advanced Governance, Risk, and Compliance (GRC) software. These tools can assist EOs in generating compliant reports with consistent data quality and accuracy. Additionally, GRC solutions can support CAs by enabling efficient evaluation of submitted reports, improving data governance, and ensuring compliance with the regulatory framework. Such software solutions should be designed with interoperability in mind, ensuring seamless integration with existing procurement systems and standards.

5. **Alignment with the Pre-Award Process:** The design of new standards and reporting templates must align closely with the pre-award phase of public procurement. By doing so, the data collected and reported by EOs can be directly applied to qualification and evaluation criteria, minimizing redundancies and streamlining compliance efforts. This alignment would ensure that new regulatory requirements are embedded into procurement workflows without disrupting operational efficiency.

7. Discussion

In this paper, we offer three primary contributions: First, we identify and categorize EU regulations from 2021–2027 based on their impact on public procurement, forming the basis of a structured regulation matrix. Second, we map these regulations to solution components that illustrate how GRC systems can address regulatory challenges. Third, we propose enhancements to current procurement standards, particularly the ESPD, and outline a roadmap for integrating GRC into future procurement workflows. Together, these contributions show how GRC frameworks can enable legal interoperability, operational resilience, and regulatory compliance.

While supply chain management has been extensively researched over decades, sustainability and ESG topics are comparatively underexplored, reflecting their recent emergence in regulatory and industry priorities. GRC systems are critical enablers of interoperability, particularly legal interoperability, by aligning governance, risk, and compliance processes across jurisdictions. However, a significant challenge lies in the fragmented nature of existing approaches, which either address GRC generically or narrowly focus on specific regulatory topics. This lack of integration underscores a research gap: the need for comprehensive frameworks that combine domain-specific expertise with advanced technological solutions.

While overall the topic of upcoming regulations might seem like a future issue, which has minimal impact on current procurement procedures, its substantial impact over the next few years should not be underestimated. Growing scarcity of resources, demographic challenges, and the raising necessity for regulations make a solid GRC management as outlined in this paper paramount to meet the challenges of tomorrow. As the transformation and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

practical implementation of standards has proven to be a lengthy process, this research highly advocates to start the important development steps towards integrating GRC management into interoperability design now. Beyond technical solutions, this study underscores the need for organizational readiness in adopting GRC frameworks. Stakeholders across public procurement systems—IT managers, compliance officers, procurement leads—must align on shared goals, data protocols, and evaluation criteria. Future work should, therefore, assess how varying organizational capacities affect GRC adoption and outcomes in different EU member states.

8. Conclusion and further research needs

This paper has investigated new and recent EU regulations, and how regulatory dependencies affect public procurement and interoperability. We identified GRC solutions as critical enablers for efficient adoption of regulations and legal interoperability. As core contributions, we developed a matrix of EU-regulations and an assessment of their impact on public procurement. Based on this analysis a second matrix has been developed to map potential solution components to the core challenges associated with highest impact on public procurement. Finally, we synthesized the findings of both matrixes into three concrete gaps, which current standards will face when trying to adopt the new regulations. Furthermore, five enhancements were put forward to the current standardization landscape that might help to overcome these gaps.

While the paper produced a good initial structured overview of future challenges, research gaps, and potential solutions, the individual solution components are not discussed in the needed degree of detail. The application of GRC and interoperability design for topics like CSRD, CSDDD etc. is a very complex topic and has to be addressed by separate studies individually. Furthermore, the proposed harmonization of domain expert knowledge and technical solutions requires further specification.

Future research can build on the findings of this study to address the limitations of this research. First, the development of a scalable GRC framework that prioritizes interoperability is essential to enable efficient regulatory compliance across different sectors and jurisdictions. Second, research should explore how to effectively integrate domain-specific expertise with technical solutions to create adaptable and practical compliance mechanisms. Third, the application of artificial intelligence to both the development and auditing of regulatory reports represents a promising but underutilized area, with potential to streamline reporting processes and improve evaluation accuracy. Finally, focused studies on individual regulatory packages, such as the CSRD or CSDDD, are needed to address their unique requirements and implications for public procurement. This will be instrumental in fostering legal interoperability, improving compliance processes, and ensuring that public procurement systems remain robust and adaptive in the face of ongoing regulatory changes. A promising avenue for future research lies also in the application of artificial intelligence (AI) for sustainability reporting and regulatory evaluation. AI systems could enhance the quality and consistency of data-driven reports, automate compliance checks, and generate actionable insights for procurement officers. However, this requires further exploration, especially regarding data governance, bias mitigation, and SME accessibility.

Acknowledgement

This research is partially conducted along the “Cooperation Project in Public Procurement”. The authors are particularly grateful for the fruitful discussions within the teams of the different partners from the Federal Ministry of the Interior, the Federal Procurement Agency, and the Federal States Bremen, North Rhine-Westphalia and Rhineland-Palatinate. The opinions presented in this paper are solely those of the authors.

Funding

The “Cooperation Project in Digital Public Procurement” was partially funded by the IT Planning Council and FITKO in the time frame of 2023 – 2025.

Contributor Statement

Conceptualization: AS; Data Curation: AS; Formal Analysis: AS; Funding Acquisition: AS, MAW; Investigation: AS; Methodology: AS; Project Administration: MAW; Supervision: MAW; Validation: MAW; Visualization: AS; Writing – Original Draft: AS; Writing – Reviewing & Editing: MAW.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Abraham, R., Schneider, J., & Vom Brocke, J. (2019). Data governance: A conceptual framework, structured review, and research agenda. International Journal of Information Management, 49, 424–438. https://doi.org/10.1016/j.ijinfomgt.2019.07.008

Ambec, S. (2022, September). The european union's carbon border adjustment mechanism: Challenges and perspectives [Monograph]. TSE Working Paper. http://tse-fr.eu/pub/127382

Baumüller, J., & Sopp, K. (2021). Double materiality and the shift from non-financial to European sustainability reporting: Review, outlook and implications. Journal of Applied Accounting Research, 23(1), 8–28. https://doi.org/10.1108/JAAR-04-2021-0114

Di Mauro, C., Ancarani, A., & Hartley, T. (2020). Unravelling SMEs' participation and success in public procurement. Journal of Public Procurement, 20(4), 377–401. https://doi.org/10.1108/JOPP-03-2018-0013

Di Natale, L., & Cordella, A. (2023). ESGTech: Guiding ESG Regulation and Digital Governance. https://hdl.handle.net/10125/102871

Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 Amending Regulation (EU) No 537/2014, EP, CONSIL, 322 OJ L (2022). http://data.europa.eu/eli/dir/2022/2464/oj/eng

Directive—2019/1937—EN - eu whistleblowing directive—EUR-Lex. (2019). https://eur-lex.europa.eu/eli/dir/2019/1937/oj/eng

Directive—EU - 2024/1760—EN - EUR-Lex. (2024). https://eur-lex.europa.eu/eli/dir/2024/1760/oj/eng

European Commission. (2017). New European interoperability framework: Promoting seamless services and data flows for European public administrations. DG Informatics. https://data.europa.eu/doi/10.2799/78681

Flynn, A. (2018). Investigating the implementation of SME-friendly policy in public procurement. Policy Studies, 39(4), 422–443. https://doi.org/10.1080/01442872.2018.1478406

Gal, M. S., & Rubinfeld, D. L. (2018). Data Standardization. New York University Law Research, 94.

Gascó, M. (2012). Approaching E-Government Interoperability. Social Science Computer Review, 30(1), 3–6. https://doi.org/10.1177/0894439310392181

Gervais, E., Kleijn, R., Nold, S., & van der Voet, E. (2023). Risk-based due diligence in supply chains: The case of silver for photovoltaics. Resources, Conservation and Recycling, 198, 107148. https://doi.org/10.1016/j.resconrec.2023.107148

Gualdi, F., & Cordella, A. (2022). Techno-legal entanglements as new actors in the policy-making process. http://hdl.handle.net/10125/79631

Guijarro, L. (2007). Interoperability frameworks and enterprise architectures in e-government initiatives in Europe and the United States. Government Information Quarterly, 24(1), 89–101. https://doi.org/10.1016/j.giq.2006.05.003

Guijarro, L. (2009). Semantic interoperability in eGovernment initiatives. Computer Standards & Interfaces, 31(1), 174–180. https://doi.org/10.1016/j.csi.2007.11.011

Gurtu, A., & Johny, J. (2021). Supply Chain Risk Management: Literature Review. Risks, 9(1), Article 1. https://doi.org/10.3390/risks9010016

Hardy, C. A., & Williams, S. P. (2008). E-government policy and practice: A theoretical and empirical exploration of public e-procurement. Government Information Quarterly, 25(2), 155–180. https://doi.org/10.1016/j.giq.2007.02.003

Haugh, T., & Bedi, S. (2023). Valuing Corporate Compliance (SSRN Scholarly Paper 4380918). Social Science Research Network. https://doi.org/10.2139/ssrn.4380918

Hellberg, A.-S., & Grönlund, Å. (2013). Conflicts in implementing interoperability: Re-operationalizing basic values. Government Information Quarterly, 30(2), 154–162. https://doi.org/10.1016/j.giq.2012.10.006

Hevner, A., & Chatterjee, S. (2010). Design Science Research in Information Systems. In A. Hevner & S. Chatterjee, Design Research in Information Systems (Vol. 22, pp. 9–22). Springer US. https://doi.org/10.1007/978-1-4419-5653-8_2

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. MIS Quarterly, 28(1), 75–105.

Hummel, K., & Bauernhofer, K. (2024). Consequences of sustainability reporting mandates: Evidence from the EU taxonomy regulation. Accounting Forum, 48(3), 374–400. https://doi.org/10.1080/01559982.2024.2301854

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Kalogirou, V., Stasis, A., & Charalabidis, Y. (2020). Adapting national interoperability frameworks beyond EIF 3.0: The case of Greece. Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance, 234–243. https://doi.org/10.1145/3428502.3428536

Kalusivalingam, A. K., Sharma, A., Patel, N., & Singh, V. (2022). Enhancing Corporate Governance and Compliance through AI: Implementing Natural Language Processing and Machine Learning Algorithms. International Journal of AI and ML, 3(9), Article 9. https://cognitivecomputingjournal.com/index.php/IJAIML-V1/article/view/73

Knill, C., & Liefferink, D. (2021). The establishment of EU environmental policy. In Environmental Policy in the EU (4th ed.). Routledge.

Kouroubali, A., & Katehakis, D. G. (2019). The new European interoperability framework as a facilitator of digital transformation for citizen empowerment. Journal of Biomedical Informatics, 94, 103166. https://doi.org/10.1016/j.jbi.2019.103166

Latest update on Anti-money laundering and countering the financing of terrorism legislative package—European Commission. (2024). https://finance.ec.europa.eu/news/latest-update-anti-money-laundering-and-countering-financing-terrorism-legislative-package-2024-04-24_en

Lim, B., Hong, K., Yoon, J., Chang, J.-I., & Cheong, I. (2021). Pitfalls of the EU's Carbon Border Adjustment Mechanism. Energies, 14(21), Article 21. https://doi.org/10.3390/en14217303

LkSG - nichtamtliches Inhaltsverzeichnis. (2021). https://www.gesetze-im-internet.de/lksg/

Mohungoo, I., Brown, I., & Kabanda, S. (2020). A Systematic Review of Implementation Challenges in Public E-Procurement. In M. Hattingh, M. Matthee, H. Smuts, I. Pappas, Y. K. Dwivedi, & M. Mäntymäki (Eds.), Responsible Design, Implementation and Use of Information and Communication Technology (pp. 46–58). Springer International Publishing. https://doi.org/10.1007/978-3-030-45002-1_5

Okoye, C. C., Ofodile, O. C., Tula, S. T., Nifise, A. O. A., Falaiye, T., Ejairu, E., & Addy, W. A. (2024). Risk management in international supply chains: A review with USA and African Cases. Magna Scientia Advanced Research and Reviews, 10(1), 256–264. https://doi.org/10.30574/msarr.2024.10.1.0024

Qiao, Y., & Cummings, G. (2003). The use of qualifications-based selection in public procurement: A survey research. Journal of Public Procurement, 3(2), 215–249. https://doi.org/10.1108/JOPP-03-02-2003-B004

Racz, N., Weippl, E., & Seufert, A. (2010). A Frame of Reference for Research of Integrated Governance, Risk and Compliance (GRC). In B. De Decker & I. Schaumüller-Bichl (Eds.), Communications and Multimedia Security (Vol. 6109, pp. 106–117). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-13241-4_11

Racz, N., Weippl, E., Seufert, A., & Vienna, T. (2010). A process model for integrated IT governance, risk, and compliance management. Proceedings of the Ninth Baltic Conference on Databases and Information Systems (DB&IS 2010), Business, Computer Science, 155–170.

Regulation—2020/852—EN - taxonomy regulation—EUR-Lex. (2020). https://eur-lex.europa.eu/eli/reg/2020/852/oj/eng

Regulation—2022/2554—EN - DORA - EUR-Lex. (2022). https://eur-lex.europa.eu/eli/reg/2022/2554/oj/eng

Regulation—2022/2560—EN - EUR-Lex. (2022). https://eur-lex.europa.eu/eli/reg/2022/2560/oj/eng

Regulation—2023/956—EN - cbam regulation—EUR-Lex. (2023). https://eur-lex.europa.eu/eli/reg/2023/956/oj/eng

Regulation—2024/2847—EN - EUR-Lex. (2024). https://eur-lex.europa.eu/eli/reg/2024/2847/oj/eng

Ruijer, E. (2021). Designing and implementing data collaboratives: A governance perspective. Government Information Quarterly, 38(4), 101612. https://doi.org/10.1016/j.giq.2021.101612

Schilling-Vacaflor, A., & Gustafsson, M.-T. (2024). Towards more sustainable global supply chains? Company compliance with new human rights and environmental due diligence laws. Environmental Politics, 33(3), 422–443. https://doi.org/10.1080/09644016.2023.2221983

Schmitz, A., Siapera, M., Prentza, A., & Wimmer, M. (2023). Harmonization in eProcurement: Design of a Holistic Solution Model for Pre-award Procedures (pp. 18–33). https://doi.org/10.1007/978-3-031-41138-0_2

Schmitz, A., & Wimmer, M. A. (2023). Framework for interoperable service architecture development. Government Information Quarterly, 40(4), 101869. https://doi.org/10.1016/j.giq.2023.101869

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Siapera, M., Schmitz, A., Andriana, P., & Maria, Wimmer. (2023). Closing the gap: Leveraging data for seamless integration between pre-award and post-award in public procurement.

Smit, L., Holly, G., McCorquodale, R., & Neely, S. (2021). Human rights due diligence in global supply chains: Evidence of corporate practices to inform a legal standard. The International Journal of Human Rights, 25(6), 945–973. https://doi.org/10.1080/13642987.2020.1799196

Sönnichsen, S. D., & Clement, J. (2020). Review of green and sustainable public procurement: Towards circular public procurement. Journal of Cleaner Production, 245, 118901. https://doi.org/10.1016/j.jclepro.2019.118901

Sonntagbauer, P., & Bodiroza, M. (2009). Pan European Public E-Procurement Online (PEPPOL): Challenges of Implementing European Wide Solutions. 853–862.

Telles, P. (2017). The European Single Procurement Document (SSRN Scholarly Paper 2969066). https://papers.ssrn.com/abstract=2969066

Vicente, P., & Mira Da Silva, M. (2011). A Conceptual Model for Integrated Governance, Risk and Compliance. In R. King (Ed.), Active Flow and Combustion Control 2018 (Vol. 141, pp. 199–213). Springer International Publishing. https://doi.org/10.1007/978-3-642-21640-4_16

Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Quarterly, 26(2), xiii–xxiii.

Weihrauch, D., Carodenuto, S., & Leipold, S. (2023). From voluntary to mandatory corporate accountability: The politics of the German Supply Chain Due Diligence Act. Regulation & Governance, 17(4), 909–926. https://doi.org/10.1111/rego.12501

Wimmer, M. A., Boneva, R., & di Giacomo, D. (2018). Interoperability governance: A definition and insights from case studies in Europe. Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age, 1–11. https://doi.org/10.1145/3209281.3209306

Zamfir, I. (2020). Towards a mandatory EU system of due diligence for supply chains. European Parliament. https://www.europarl.europa.eu/RegData/etudes/BRIE/2020/659299/EPRS_BRI(2020)659299_EN.pdf

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Generation of public value through the adoption of government blockchain networks: The analysis of the Brazilian federal government

Milber Fernandes Morais Bourguignon[a*], *Marie Anne* Macadar[b]

[a] Brazilian Development Bank – BNDES, milber@gmail.com, ORCID 0000-0002-1615-9230.

[b] COPPEAD Graduate School of Business, Federal University of Rio de Janeiro – UFRJ, marie.macadar@coppead.ufrj.br, ORCID 0000-0003-2744-5352.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. This paper analyses the generation of public value through the adoption of government blockchain networks by different entities of the Brazilian federal government. To this end, the theory of Public Value in Electronic Government is used, with the approach proposed by Twizeyimana & Andersson (2019) with six dimensions of analysis. The method is a multiple case study with the three Brazilian blockchain networks: RBB, RNDS and PIER, which are at different stages of development. The results indicate the governance is a common challenge identified, and exchanging information with other networks is seen as a way of learning and developing the own models. Indeed, the already implemented government blockchain networks (RNDS and PIER) generate public value in the six dimensions and that the RBB has the potential to generate public value in the same dimensions. Furthermore, the choice of blockchain technology was an efficient solution for PIER and RNDS when compared to other technologies available at the time. The RBB was created to be an infrastructure for the development of other blockchain artifacts, to later house applications using the same technology. Governance challenges and balance between participants are crucial aspects in the development of networks. While RBB, a top-down initiative (governance development prior to applications) seeks a stable balance, the hierarchical deployment of PIER and RNDS allows for faster progress of deployment and development of applications on these networks. The paper has limitations in analysing public value from the perspective of public managers and not from co-creation with citizens. As future research, we suggest approaching the cases from the perspective of innovation theories and an investigation of the blockchain ecosystem in government in Brazil.

Keywords. government blockchain network, public-value, e-government, case study.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.979

1. Introduction

The 2008 financial crisis, among other things, sparked a global sense of distrust (De Filippi et al., 2020). In the same year blockchain technology was introduced to the world with the launch of Bitcoin, and it was quickly identified that beyond its use in digital currencies, the technology had potential applications in electronic documents, such as identities, smart contracts, and property titles (Ølnes, Ubacht & Janssen, 2017).

Bitcoin and other blockchain-based systems were presented as a reliable alternative to existing financial institutions and even governments (De Filippi et al., 2020). In other words, the technology emerged as a mechanism for generating trust between people, regardless of any institution. Studies show the potential for use in governments, with the possibility of gains in efficiency, effectiveness, increased transparency, greater public participation, higher data reliability, among others (Ølnes, Ubacht & Janssen, 2017; Khan, Arshad & Khan, 2020; Allessie et al., 2019; Aristidou & Marcou, 2019).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Governments worldwide have shown interest in the technology, especially for expected improvements in transparency, governance, and resource distribution (Batubara, Ubacht & Janssen, 2018). Beyond the applications and artifacts developed in blockchain, some countries have started to develop their own governmental networks, aiming to be platforms for blockchain applications.

Examples of these networks are the multi-country Alastria (mostly European states) and Lacchain (Latin America), BSN - Blockchain-based Service Network (China), and in Brazil, RBB (Brazil Blockchain Network), PIER (Regulatory Entities Information Integration Platform), and RNDS (National Health Data Network). In Academia there are studies on the characteristics of blockchain and potential applications in government, case studies, artifact design, and governance discussions (Christidis & Devetsikiotis, 2016; Ølnes, Ubacht & Janssen, 2017; Zheng et al., 2017; Batubara, Ubacht & Janssen, 2018; Allessie et al., 2019; Scholl & Rodríguez-Bolívar, 2019; Alketbi, Nasir & Abu Talib, 2020).

However, specific studies on governmental blockchain networks are still limited, demonstrating that research on this topic still does not cover the reality of seeking to implement the technology in governments. Additionally, papers on blockchain in government lack theories that help explain the phenomena, representing a significant gap in the Electronic Government literature (Atzori, 2018; Covarrubias & Covarrubias, 2021; Falwadiya & Dhingra, 2022).

In this context, the aim of this paper is to identify the public values generated through the adoption of governmental blockchain networks at the federal level in Brazil. With a positivist approach, this paper presents a multiple case study of the three federal governmental networks in Brazil that utilize blockchain technology: RBB, PIER, and RNDS. More specifically, the phenomenon under study is the blockchain networks of federal public administration entities in Brazil for their own and/or third-party applications, whether governmental entities or not.

The paper employs the theory of Public Value in Electronic Government utilizing the framework proposed by Twizeyimana & Andersson (2019), which suggests six dimensions associated with public value generation: Improved Public Services, Improved Administrative Efficiency, Open Government Capabilities, Improved Ethical Behaviour and Professionalism, Improved Trust and Confidence in Government, and Improved Social Value and Well-Being. Interviews were conducted with nineteen participants who worked on the implementation of the cited networks, and consultations were made to documents and institutional websites.

The results indicate that blockchain governmental networks can generate public value even before their full implementation, as by bringing stakeholders together in the process, value generation can already be identified in the dimension of improvement in administrative efficiency, with greater collaboration, cooperation, and improved communication among entities. Other dimensions such as the improvement of public services, enhanced ethical behaviour and professionalism, increased trust in government, and better social value and well-being were also identified in the implemented networks PIER and RNDS.

The paper is divided into six sections. This first section introduces the topic, presenting the main concepts. In the next section, the Literature Review is presented, highlighting the main research gaps. Section 3 presents the Method, detailing the multiple case study. Next, Section 4 presents the description of each one of the cases. Section 5 shows the results analysis. The last Section presents the Conclusion, including final considerations, limitations, and suggestions for future research.

2. Literature Review

2.1 Public Value and Electronic Government

Just as New Public Management (NPM) supplanted traditional public administration in the 1980s and 1990s, the concept of public value emerged as the response that many scholars sought for a new approach to government management, incorporating the necessary aspects for its practical and theoretical implementation as a replacement for NPM (Bryson, Crosby & Bloomberg, 2014). Public Value, as a public administration paradigm, was originated in educational disciplines at Harvard University, later gaining new interpretations with Mark Moore in the mid-1990s. Moore emphasized that public managers should make decisions while simultaneously acting collaboratively to generate outcomes that create value for the public (Hilgers & Ihl, 2010; Williams & Shearer, 2011; Cordella & Bonina, 2012).

Public value, in the context of public administration, can be understood as a counterpoint or alternative to NPM (Van Veenstra, 2012; Stoker, 2006). In NPM, the citizen is merely seen as a client; however, in the Public Value paradigm, individual preferences are considered essential for constructing the public interest, rather than being reduced to mere consumer preferences (Alford & O'Flynn, 2009).

To create public value, individuals must be able to express their preferences and needs, enabling the government

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

to leverage technology to enhance its capacity to deliver what citizens need and desire. In this process services are provided, and public value is created (Lopes, Luciano & Macadar, 2018). For the real perception of public value requires its creation first, which can be attained through the benefits derived from adopting a given service (Alshibly & Chiong, 2015). On the other hand, another perspective suggests that public value creation can be based on collective benefits rather than necessarily being of personal perspective (Alford & O'Flynn, 2009).

From a perspective in which public value creation is government-driven rather than necessarily co-created with citizens, Twizeyimana & Andersson (2019) conducted a literature review proposing six dimensions associated with public value and e-government: improved public services; greater administrative efficiency; Open Government (OG) capabilities; enhanced ethical behaviour and professionalism; increased trust in government; and improved social value and well-being. These dimensions can be categorized into three broader public value dimensions: enhanced public services, improved administration, and increased social value.

Regarding research on public value and e-government, Twizeyimana & Andersson (2019) identified a lack of studies on the value of e-government in developing countries, highlighting the need for further research at different levels of government. Additionally, Lopes, Luciano & Macadar (2018) assert that the topic of public value remains underexplored in Brazilian research and government services.

2.2 Blockchain and Government Networks

Regulatory and legal issues related to the principles of public administration must be respected to ensure the validation and proper use of blockchain technology by the public sector. Beyond digital currency applications, smart contracts enable government operations to benefit from increased transparency, trust, efficiency, reduced corruption, cost reduction, fraud prevention, decreased manipulation, and enhanced resilience and security (Ølnes, Ubacht & Janssen, 2017).

Blockchain is a distributed public ledger in which all transactions are stored in blocks, with new blocks continuously added. Security is based on asymmetric cryptography and distributed consensus algorithms, typically characterized by decentralization, persistence, anonymity, and auditability (Zheng et al., 2017). Blockchain technology is expected to play an increasingly important role in global economic recovery and the development of the digital economy following the pandemic (Yang et al., 2022).

Ølnes, Ubacht & Janssen, 2017 (2017) argue that blockchain technology can be applied beyond the private sector to government operations. They compiled a list of the primary benefits of adopting blockchain applications in government, which include transparency, trust, efficiency, reduced corruption, cost reduction, fraud and manipulation prevention, increased resilience, and improved security. However, the authors emphasize that these benefits are unlikely to be achieved simultaneously.

Governments can leverage blockchain to transform how they manage data and interact with citizens. This technology is particularly suitable for the digitization of government services, and its potential to enhance efficiency is a key driver of adoption (Saxena et al., 2022). Although still in its early stages, efforts have been made by governments to implement blockchain in public services across different domains: government-to-government (G2G), government-to-business (G2B), and government-to-citizen (G2C). These initiatives aim to streamline processes, strengthen security, enhance transparency, and improve privacy in e-government services (Lykidis et al., 2021).

Governmental blockchain networks are characterized by an infrastructure developed by public entities, serving as a foundation for government-related applications. Such networks are being adopted in various countries worldwide. According to Stockton (2020), the main obstacle to blockchain adoption has been the cost and complexity of setting up a platform, making the emergence of networks such as China's BSN (Blockchain-Based Network) or similar solutions inevitable.

Some notable examples of these networks are listed as follow. Alastria is an association open to all types of companies and organizations, including public entities, with the mission to engage various sectors and contribute to the creation of a diversified innovation ecosystem. Participants collaborate on both network infrastructure and application development (Alastria, 2021). Another significant example is LACChain, a global alliance comprising various blockchain stakeholders and led by the Inter-American Development Bank's Innovation Lab (BID Lab). LACChain focuses on fostering blockchain adoption in Latin America and the Caribbean, promoting financial inclusion, consumer protection, and market integrity (Lacchain, 2021).

The European Blockchain Services Infrastructure (EBSI) is another relevant initiative. Established in 2018, EBSI connects blockchain nodes across 29 countries (EU member states, Norway, and Liechtenstein) along with the European Commission. Its vision is to leverage blockchain to develop cross-border services for public administrations and their ecosystems, ensuring information verification and reliable service delivery. Since 2020,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

EBSI has been implementing a distributed blockchain network across Europe to support applications focused on various use cases (EBSI, 2021; Falwadiya & Dhingra, 2022).

The Argentinean Federal Blockchain Network (BFA) was created in 2018, with validation nodes operated by public institutions (such as universities) and private companies (Ramirez-Escudero, 2021). The BFA is an open, multi-service, and participatory platform designed to integrate services and applications that drive technological innovation and collaborative governance. Key use cases include public procurement, academic certificates, financial guarantees, and food trade (BFA, 2022).

Specifically in Brazil, three blockchain networks are under development at the federal level. PIER is an initiative launched in April 2020 by the Central Bank of Brazil (BACEN), the Superintendence of Private Insurance (SUSEP), and the Securities and Exchange Commission (CVM). Its objective is to facilitate the exchange of information among these institutions (BACEN, 2022; SUSEP, 2022). The RNDS, led by the Ministry of Health, serves as a repository for citizens' health records, integrating health-related data and supporting the management of healthcare services across different levels of care (Datasus, 2020). The RBB, developed through a Technical Cooperation Agreement between The Brazilian Development Bank (BNDES) and the Federal Court of Accounts (TCU) was designed as a nationwide infrastructure. RBB aims to serve as a platform for developing applications of public interest (BNDES, 2022).

This growing adoption of blockchain by governments highlights its potential to improve transparency, efficiency, and security in public administration. However, its successful implementation requires overcoming technological, financial, and regulatory challenges, as well as fostering collaboration between government entities, the private sector, and civil society.

3. Method

The method of this paper is the case study, incorporating document analysis and in-depth interviews with key participants involved in the implementation of blockchain government networks, which includes public managers, academics, market professionals, and other experts. The case study method fits for the objective of exploring contemporary phenomena within a societal context, and it is particularly relevant when the phenomenon under study is broad and complex, requiring a holistic and in-depth analysis (Yin, 2018). The methodological framework follows the approaches outlined by Yin (2018) and Eisenhardt (1989).

The object of study in this research is the phenomenon defined in this paper as governmental blockchain networks. Blockchain applications, by definition, are network artifacts; however, the mere adoption of a blockchain application by a government does not imply that it is using a network in its strictest sense or fully embracing the technology's main principles. Thus, this study focuses specifically on developments that explicitly identify themselves as networks. Consequently, blockchain applications confined to a single institution or lacking the intent to integrate multiple entities are not considered within the scope of this research. The study, therefore, examines self-declared blockchain networks in federal level of the public administration in Brazil, designed for both proprietary and third-party applications, whether governmental or non-governmental entities. Three blockchain networks at different stages of development were selected in the Brazilian context: PIER, RNDS, and RBB.

There are some reasons for choosing these three networks. First, they are all existent government networks in Brazil at federal level, which can produce rich comparison, once they are at the same regulatory and legal environment and face common challenges. Second, as studies comparing blockchain networks are scarce in the literature, this movement seems to be prudent in the theorical contributions. Third, the authors had an easier access to the interviewers as they are residents in Brazil.

The PIER, developed by the Central Bank of Brazil (BACEN), was officially launched in April 2020 to facilitate the exchange of information between the Superintendence of Private Insurance (SUSEP), the Central Bank (BACEN), and the Securities and Exchange Commission OF Brazil (CVM). Its primary function is to integrate data from regulatory bodies and streamline authorization and registration processes within the financial system (SUSEP, 2022). PIER enables financial institutions to receive responses from regulatory agencies more swiftly and efficiently (BACEN, 2022).

The RNDS serves as a document repository for storing citizens' health information, establishing a federated interoperability layer that supports the development of various health applications, such as the Brazilian Electronic Health Record (Datasus, 2020). The RNDS represents an innovative approach to health data management, storing information in virtual cloud-based containers using blockchain technology. It works as a repository for retrospective, real-time, and prospective patient data in digital format (Datasus, 2020).

The RBB was originated as a project in the BNDES to establish a nationwide blockchain infrastructure. The network aims to integrate all three branches of government—executive, legislative, and judiciary—along with federal

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

agencies, state, and municipal entities. Its objective is to provide a robust infrastructure that enables both public and private actors to develop and operate blockchain-based applications of public interest (BNDES, 2022).

3.1 Respondents and coding

The respondents of the research were individuals involved in the implementation and management of the networks. More specifically, interviews were conducted with the technical managers responsible for each network, as well as the managerial staff overseeing these networks. This approach incorporated perspectives on both the execution and organizational aspects of the networks. Based on recommendations from some interviewees, individuals from entities associated with the networks were also interviewed, as they could provide clarifications on decisions that impacted the network. All interviews were conducted by the first author as the sole interviewer. The first interview took place on December 12, 2022, and the last on February 10, 2023.

All meetings were held virtually via the Microsoft Teams platform, with recording and transcription features enabled. The meetings were conducted individually, with an average duration of forty-six minutes. The only exceptions were the meetings involving teams from the Central Bank and SUSEP. In these two meeting the participants requested to join simultaneously. In total, 19 individuals were interviewed, each representing a specific network, holding mid-level management positions or high levels of technical responsibility.

The interviews were recorded, transcribed, and analysed using coding, thematic analysis, and data tabulation. The transcription was initially read with open coding, followed by a second stage where these codes were grouped into final categories, as outlined below:

i)Origin: This topic includes themes related to the emergence of each network, including the motivation behind its creation, the reasons for its specific structure, its objectives, and other relevant aspects.

ii) Background and conditioning factors: This section addresses the circumstances preceding the networks' emergence, such as the conditions in which they were developed, the antecedents that enabled their creation, the willingness and capacity of the teams, internal leadership, technical aspects, and internal decision-making.

iii) Interinstitutional relations: This item identifies the partnerships and interactions established among the network actors, such as the creation of connections and dialogues essential for network formation.

iv) Leadership: Although networks assume a balance between participating entities, network governance remains a critical issue. It was identified that the networks exhibited some form of leadership, making this aspect fundamental to understanding Brazilian networks.

v) Governance and technical aspects: In line with the literature review, governance emerged as a key issue in the interviews. Additionally, governance is often associated with specific technical choices, and this section explores the relationship between these two concepts. The analysis highlights the technical decisions made within the networks that relate to governance themes.

vi) Outcomes and lessons learned: benefits and other gains obtained through the networks, as well as the lessons learned so far and those projected for the near future.

vii) Associated costs and challenges: This item evaluates the financial and non-financial costs associated with the networks, as well as other difficulties encountered throughout their evolution.

viii) Current status: A summary of the current state and operational dynamics of the network.

Other cross-cutting themes emerged in the research, were coded and analysed, but are not presented in this paper.

4. Cases Description

The RBB emerged from BNDES initiatives in blockchain (BNDES, 2022). According to Interviewee 1, the first actions related to blockchain at BNDES began with the development of a Token and, over time, the possibility of the project evolving into the creation of a network. The network was founded based on a Technical Cooperation Agreement between BNDES and TCU, at an event held on May 30, 2022 (TCU, 2022).

The RNDS emerged as a solution to a data integration problem in the public health sector. Interviewee 6 highlighted that the choice of blockchain was due to the greater adherence of the technology to the proposed objectives for the health network. It was initially conceived to be a system to integrate patients' health data, giving them access to doctors and the government. But still in its development, it had to undergo a transformation in its conception, due

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

to the Covid-19 Pandemic crisis. Thus, the structure was first used for the national registry of Covid-19 vaccines and tests. Interviewee 11 highlighted that there was a demand from the Ministry of Health to integrate health data, and the team concluded that the blockchain solution would be the most appropriate. However, at the same time, it quickly ceased to be regional and became federal, without time for pilot tests. Due to this urgency, Interviewee 12 mentioned that in this environment of rush and need for quick responses amid the Pandemic, the network was put into operation.

The first experience with blockchain at the Central Bank was a positioning paper of the IT team. This division conducted research on DLTs analysing possible use cases and examining some of the platforms available to develop prototypes of a settlement system by the Central Bank (Burgos et al., 2017). Interviewee 7 mentioned that PIER emerged as an initiative of the Central Bank to share relevant information, such as company registration data, financial information, market information, and other information that may be useful for the supervision and regulation process of the regulatory entities of the financial system. The following table presents the comparison between the networks.

Tab. 1 – Case study comparative analysis

Theme/ Network	RBB	RNDS	PIER
Creation	Infrastructure for the development of blockchain applications by public interest entities.	Solution for healthcare data integration.	Solution for exchanging information from financial system regulatory entities – automation between regulators.
Blockchain use in the network	Technology as the center of the development strategy.	Better adherence to the proposed objectives. Blockchain as a central part of the network, but with other associated technologies.	Better adherence to the proposed objectives. Complementary technologies for participant interface.
Formalization of network constitution	Technical Cooperation Agreement between BNDES and TCU with the later adhesion of the other participants.	Enforcement through normative acts of the federal government.	Technology established based on the previous relationship between institutions.
Conditions for the emergence of the network	Internal innovation project, with institutional sponsorship from senior management, which allowed for deeper insights into the topic. Coordination with other entities interested in the topic. Institutional sponsorship from other public administration entities for a national blockchain network. Other government entities with technical knowledge of blockchain. BNDES expertise in relations with public and private entities. Possible role as BNDES financier.	Pre-existing digital strategy and identification of blockchain as a suitable technology for the development of activities. Previous failed technological attempts that brought knowledge for implementation.	Pre-existing digital strategy and identification of blockchain as a suitable technology for the development of activities. Production of technical knowledge by teams (positioning paper) analysing technology and its applicability in Central Bank actions. Prior knowledge of processes to be digitized.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Network Guiding Artifact	The network as a platform for developing other blockchain applications.	System for exchanging health information.	System for exchanging information from financial sector regulators.
Leadership	Shared.	Centralized.	Centralized.
Dialogue between network entities and power balance	Negotiation between entities for the best development of the network. Search for the lack of hierarchy between participants.	Guidance on the use of the Ministry for other entities and the respective provision of infrastructure. Existence of hierarchy among participants.	Negotiation between the Central Bank and other entities. Despite no hierarchy between entities, the conditions had a kind of enforcement for the adoption of the network by SUSEP and CVM. BACEN as the leader.
Development	Internal resources without hiring.	Internal resources: taking advantage of pre-existing cloud and service provision contracts.	Internal resources without hiring.
Governance	Public-permissioned network. Negotiation between entities to define by consensus how costs and resources will be shared. Technology presupposes another modus operandi of work, in which assets and operations are consensual and divided, which marks an opposition to the current centralization of involved entities.	Private network. Operating and sharing model defined by a single entity. Emergency implementation of the network meant that certain technical and governance aspects were left aside.	Private network. Operating and sharing model defined by a single entity. Network governance is more of a control by BACEN than a negotiation between the various parties that make it up, since the bank is the main actor and leader of the network.
Nodes	Distributed among participants physically. Each entity is responsible for its infrastructure. Exchange of knowledge between entities.	Even 3 for each participant, all in the same cloud structure. Ministry responsible for state infrastructure initially.	Distributed among participants, both physically and in the cloud. Each entity is responsible for its infrastructure. Central Bank with the role of technical advisor of other entities.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Benefits	Infrastructure that allows application development. Possibility of sharing developments and reducing costs. Exchange of information between participants. Encouraging use for public administration, internal discussion in court, positive media and the message to public managers that they can seek innovation. Potential cost reduction due to the pre-defined environment and exchange of developments. Encouraging the use of blockchain for other public sector entities. Intra-institutional: positive media, internal debate with other departments and improvement of the image of the bodies (as supporters of innovation). Technological capacity, coordination with other entities and creation of an environment for innovation.	Application of blockchain in the context of health data in government. Federalization of distributed data: data is placed on the network according to local standards and the system allows the consolidation of information. Covid-19 crisis response tool. Availability of the national covid-19 vaccination card in a timely manner. Centralization of Covid-19 exam and vaccine data, with rapid consolidation of information. Taking advantage of previous developments for new applications. Data infrastructure. Provision of information to the end user. Greater auditability of health expenditure (verification by citizens of medication use, for example). Learning to use cloud technology. Decentralized data consolidation at lower cost than other technologies.	Greater speed of response to the end user when appointing people to positions in financial institutions, for example. Less bureaucracy between entities. Agile dialogue between entities. Availability of teams for other intellectual activities. Fewer manual processes and associated rework risks. Auditability of processes. Institutional learning of in-depth theoretical and new practical knowledge that could be used for regulation in the future. Learning about blockchain technology that can help the development of Real Digital.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Costs	No financial outlay, development by an internal team. Infrastructure costs assumed by each entity. Insignificant infrastructure values. Network with effective return in the medium/ long term.	Taking advantage of internal contracts for network development. Allocation of consultants who would already be available to the Ministry. Use of a pre-existing cloud contract. Blockchain costs approximately 1/3 of an alternative. High initial cost for the Ministry, but later each state would assume its infrastructure cost. RNDS cost around 10% of the costs of previous similar projects.	No financial outlay, development by an internal team. Infrastructure costs assumed by each entity. Insignificant infrastructure values. Insignificant deployment values.
Difficulties	Cultural: initial acceptance by different public administration bodies. Articulation between entities and assembly, governance and establishment of consensus for decisions. Convincing technical areas to business (and decision-making) areas to join the network.	Definition of standards for information exchange. Rapid system implementation requiring quick responses. Lack of time to make a pilot. Difficulty implementing the “undo” or reversal system. Lack of adequate testing environment.	Reduced team for development and deployment. Reduced budget of resources for developing innovation projects. Responsibility for maintenance and support in partner environments. SUSEP and CVM in lower stages the technology knowledge.
Current status	Network founded. Under development, with the definition of governance and adhesion of new partners.	After a hacker attack on the cloud where the network was hosted, the network was resumed using another technology, which is still in force today. There is no prospect of a resumption of blockchain technology.	Network in operation according to initial forecast.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Learned lessons	Training and education within the institutions themselves, leaving technical environments and passing through other areas aiming at embracing innovation. Better for government applications to run on non-full public networks. It also applies to the development of networks	Need for communication and awareness among other actors, even if the application is enforced. A hybrid solution, which has local and cloud servers, designed to work in multiclouds. Applications of the size of RNDS require a maintenance and support team available to support them.	Top-down systems with the provision of technical support increase the speed of implementation but can limit the knowledge transfer. In-house system for experimentation in other uses (real digital).
Expected results in the future	Applications' development. Robust governance model.	Reactivation of the blockchain network. Electronic medical record with patient history available in real time to network participants. Consolidated history of information for patients and doctors, available in real time.	Possibility for the network to receive other applications, such as the SUSEP system directly with the user Knowledge and mastery of technology for other applications. Practical, operational knowledge of technology.

5. Results Analysis

The following table presents the KPIs, and dimensions identified for each of the networks in this research, characterizing them as a subset of the complete framework of Twizeyimana & Andersson (2019). Due to the different stages of the networks, there is a distinction between the public values identified and the potential public values that may be generated in the future by the networks.

Tab. 2 – Public values' KPIs

Public Value	**Identified**			**Potential**		
Improved Public Services	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
provision of services to citizens		**X**	**X**	**X**		
increased quality of public information and services		**X**	**X**	**X**		
enabled transparency, participation, and collaboration in the delivery of public services		**X**				
Improved Administrative Efficiency	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
cost-reduction		**X**	**X**			
reduced bottleneck and queues in the delivery of services to citizens		**X**	**X**	**X**		
better collaboration, cooperation, and better communication	**X**	**X**	**X**	**X**		
increased transparency, participation, and inclusiveness		**X**	**X**	**X**		
maintained accurate and durable records			**X**	**X**	**X**	

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Open Government capabilities	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
improved public engagement and well-informedness		**X**		**X**		**X**
improved public control and influence on government actions and policies		**X**				
Improved Ethical Behavior and Professionalism	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
increased citizens' access to government information and services		**X**				
maintenance of accurate durable records			**X**	**X**	**X**	
Improved Trust and Confidence in Government	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
better delivery of public services		**X**	**X**	**X**		
increased quality of public services		**X**	**X**	**X**		
Improved Social Value and Well-Being	**RBB**	**RNDS**	**PIER**	**RBB**	**RNDS**	**PIER**
achievement of better outcomes in areas of peace, security, poverty reduction, **public health**, high employment, low crime rates, clean streets, improved environment and better educational achievements.		**X**				
a more flexible, pervasive, and cost-effective public sector (e.g., provision of online applications and transactions)		**X**	**X**	**X**		

In each dimension of the framework, at least two KPIs of public valuer were identified. From an initial perspective, it is evident that the RBB, due to not being operational and lacking any use cases in operation, only indicates achievement in one KPI within the dimension of Improved Administrative Efficiency. However, it is the network with the greatest potential for the development of new KPIs, as a total of eleven indicators were identified across all dimensions of public value.

Each of the networks, individually, has at least one KPI in each of the six dimensions. In all analysed networks it was identified the generation of public values across all six dimensions. This suggests that, potentially, once a government assesses the suitability of implementing a governmental blockchain network, it will generate public value.

In the dimension “Improved Public Services”, both the RNDS and PIER were able to deliver new services in e-government. The RBB considers this value as one of its objectives. Similarly, RNDS and PIER reported perceived improvements in the quality of the information provided about their services. PIER achieved this by centralizing data from different agencies onto a single platform, while RNDS managed to federalize health data. Regarding transparency and collaboration in public service delivery, only RNDS shows be able to deliver this value, allowing citizens to track their health data, including medications, and report any discrepancies within the system.

In “Improved Administrative Efficiency”, four KPIs were simultaneously identified by all three networks: reduced bottleneck and queues in the delivery of services to citizens, better collaboration, cooperation, and better communication, increased transparency, participation, and inclusiveness, and maintained accurate and durable records. This result suggests that enhanced administrative efficiency, characterized by quicker processes, team collaboration, and citizen participation, are public values that can be strongly achieved through blockchain networks.

The dimension “Improved Administrative Efficiency was the only one in which an already identified public value was identified for the RBB. Even in the pilot phase the communication among the parties already ensures greater collaboration, cooperation, and improved communication among the entities. This KPI is also considered potential for this network, because once implemented, these processes can take place within the network.

Regarding cost reduction, RNDS indicated that the blockchain solution was less expensive than previous attempts, and PIER stated that the system freed up analysts from handling bureaucratic tasks to engage in more valuable activities. Both RNDS and PIER have shown that the networks generated efficiency in processes, delivering more services with fewer resources employed. They utilized pre-existing resources, but this KPI does not account for additional associated costs, such as training and the allocation of teams or the work hours dedicated before the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

network's implementation.

On the KPI of "reduced bottleneck and queues in the delivery of services to citizens ", according to interviewees, if it were not for RNDS, there would have been no timely response regarding vaccination data at the onset of the pandemic. For PIER, this KPI meant the reduction of bureaucratic hurdles between regulatory bodies. Throughout the interviews, it became clear that the network serves as an efficient means to exchange data and an excellent locus for collaboration among entities. In terms of transparency, RNDS managed to provide greater visibility of information among entities and to the public, consolidating federal data. In contrast, PIER achieved this only among the entities that are part of the platform.

Regarding the KPI of accurate and durable records, RNDS demonstrated how the principles of the technology must be respected, even in a pilot phase. A network based on technology that anticipates data distribution, which is strongly resistant to hacking attacks, suffered losses due to a cloud attack rather than an attack on the network itself. This could compromise the data related to COVID tests and vaccinations. From this experience, the potential of the network was identified should it resume using blockchain technology and implement distributed nodes. In contrast, PIER possesses data integrity and distributed backups.

The networks still do not appear ready to develop the capacities for open government. Only RNDS has a system for public engagement (allowing citizens to verify their data and access aggregated information), thereby facilitating greater public control. RBB and PIER have the potential to develop this capacity within their activities. Thus, in the dimension of Ethical Behaviour, RNDS meets the KPI of greater access for citizens to government information and services. As previously explained, only PIER has demonstrated the maintenance of durable and accurate records, but this is a desired capability for the other two networks.

In the dimension "Improved Trust and Confidence in Government" both RNDS and PIER deliver better services on the blockchain than when these same services were on other systems, providing better service and improved quality in outcomes. The RBB is indicated to have this potential in its actions. Regarding "Improved Social Value and Well-Being", RNDS and PIER, as observed, alongside RBB potentially, utilize online transactions, making the public sector more flexible. However, when analysing specific sectors, only RNDS delivers value in the KPI of better health outcomes.

6. Conclusion

Following the public value framework in electronic government presented by Twizeyimana & Andersson (2019), the implementation of government blockchain networks at the federal level can generate the following public values: improvement of public services; greater administrative efficiency; improving open government capabilities; better ethical and professional behaviour; greater trust in government; and improving social value and well-being.

Theoretically, between networks there should be a balance between all participants. But what was verified with the research is that they all developed with one entity being the driver of the network. This was seen in PIER, RBB and RNDS, with the driving forces, respectively, being the Central Bank of Brazil, BNDES and the Ministry of Health. PIER is the only one that proposes to be strictly for federal level entities, being specifically for regulatory entities of the Federal Executive Branch. However, both RBB and RNDS, from the beginning and in their objective, have a multilevel characteristic.

The RBB, more directly, was structured to encompass federal, state and municipal entities, with the desire for this institutional variability. The RNDS, on the other hand, positioned itself as a network led by the Union, through the Ministry of Health, centralizing data from the Union itself, the 26 states and the Federal District. It is important to highlight that connection with municipal entities would be desirable, but this would not fit into the network. In this way, the possibility would be for the state entity to replicate the data federalization structure for its municipalities.

Concerning the networks implementation, when conducted top-down (where governance defines the artifact rather than the artifact defining the governance of the network), there seems to be greater potential for balanced role evolution among participating entities, as observed in the development of RBB. Conversely, when implemented within a hierarchical structure (where a company defines governance, thus establishing the conditions of the network), implementation occurs more rapidly, as seen in PIER and RNDS. This issue of balance versus speed is an aspect that could be explored in future research. Additionally, the more decentralized aspects the network possesses, the greater the need for interaction to facilitate its creation. However, even when there is a central entity driving the network's development, it is essential to establish a communication system for information sharing and training of other elements.

This work developed the study of the generation of public value from the perspective of public managers, experts and those who worked on the creation of government networks. The results obtained are robust within the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Brazilian context, and the authors believe that these findings may be applicable in other countries or subnational entities. However, it is essential to conduct further research to determine whether such conditions are indeed confirmed in different scenarios. As a limitation, the paper doesn't consider the perspectives of public values being generated in joint creation between government entities and citizens. As a sequence, studies are suggested that encompass this perspective, in which citizens can be studied and the generation of values can be jointly evaluated. In this way, studies can be quantitative in nature, with the definition of indicators, which evaluate with the general population i) whether they have the same impressions as public managers or ii) whether the expected public values are in fact identified by the general population.

For future work the authors suggest the following research. This paper was developed through the theoretical lens of Public Value in Electronic Government, but during the process other opportunities were identified from other perspectives that were not explored in the literature used. For example, innovation theories can be used to analyse the development and implementation of technology in the public sector, including for the cases cited here. Furthermore, economic theories can also be evaluated for technology adoption. Finally, as this paper is restricted to the Brazilian case, future works can bring networks from other countries or even a cross-country analysis.

Acknowledgement

The Author 1 is grateful to Brazilian Development Bank – BNDES, their workplace, for the support provided throughout the research phase. He would also like to thank all the interviewees who kindly dedicated their time and shared information for the interviews that made this research possible.

Contributor Statement

Author 1: conceptualization, data curation, formal analysis, investigation, methodology, project administration, validation, writing the original draft, review, and editing).

Author 2: conceptualization, formal analysis, methodology, validation, writing – review, and editing).

Use of AI

During the preparation of this work, the authors used Open IA ChatGPT, Microsoft CoPilot and Google Translator to translate the text from Portuguese to English. After using these tools, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

ALASTRIA. (2021, October 15). *La Red*. https://alastria.io.

Alford, John; O'flynn, Janine. (2009). Making sense of public value: Concepts, critiques and emergent meanings. *Intl Journal of Public Administration*, v. 32, n. 3-4, p. 171-191.

Allessie, David; Janssen, M.; Ubacht, J.; Cunningham, S.; e Van Der Harst, G. (2019). The consequences of blockchain architectures for the governance of public services: A case study of the movement of excise goods under duty exemptions. *Information Polity*, v. 24, n. 4, p. 487-499.

Alshibly, H.; Chiong, R. Customer empowerment: Does it influence electronic government success? A citizen-centric perspective. (2015). *Electronic Commerce Research and Applications*, 14(6), 393-404.

Aristidou, Christiana; Marcou, Evdokia. (2019). Blockchain standards and government applications. *Journal of ICT Standardization*, p. 287–312-287–312.

Atzori, M. (2018). Blockchain Governance and The Role of Trust Service Providers: The TrustedChain (R) Network. *Journal of the British Blockchain Association,* 1(1), 55–65, 2018. https://doi.org/10.31585/jbba-1-1-(3).

BACEN. (2022, 10 January). Banco Central do Brasil. Notícias. https://www.bcb.gov.br/detalhenoticia/431/noticia.

Batubara, F. Rizal; Ubacht, Jolien; Janssen, Marijn. (2018). Challenges of blockchain technology adoption for e-government: a systematic literature review. In: Proceedings of the 19th *Annual International Conference on Digital Government Research: Governance in the Data Age*. p. 1-9.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

BFA. *Blockchain Federal Argentina*. (2022, January 10). https://bfa.ar/.

BRASIL. (2022, January 10). *Constituição*. Constituição da República Federativa do Brasil de 1988**.** Disponível: http://www.planalto.gov.br/ccivil_03/Constituicao/Constituicao.htm.

Burgos, Aldenio de Vilaca; Oliveira Filho, Jose Deodoro de; SUARES, Marcus Vinicius Cursino & ALMEIDA, Rafael Sarres de. (2017). *Distributed ledger technical research in Central Bank of Brazil*. Central Bank of Brazil. Brasilia - DF, Brazil. 31st August 2017

Bryson, John M.; Crosby, Barbara C.; Bloomberg, Laura. (2014). Public value governance: Moving beyond traditional public administration and the new public management. *Public Administration Review*, v. 74, n. 4, p. 445-456.

Christidis, K.; Devetsikiotis, M. (2016). Blockchains and Smart Contracts for the Internet of Things. ***IEEE Access*.** vol. 4, pp. 2292-2303. Doi: 10.1109/ACCESS.2016.2566339.

Cordella, A.; Bonina, C. M. (2012). A public value perspective for ICT enabled public sector reforms: A theoretical reflection. *Government Information Quarterly*, 29(4), 512-520.

Cordella, A.; e Paletti, A. (2018). ICTs and Value Creation in Public Sector: Manufacturing Logic vs Service Logic. *Information Polity* 23: 125–41. https://doi.org/10.3233/ip-170061.

Covarrubias, Jersain Zadamig L.; Covarrubias, Irving Norehem L. (2021), *Different types of government and governance in the blockchain*. Journal of Governance and Regulation, 10(1), 8–21. https://doi.org/10.22495/jgrv10i1art1

DATASUS. MINISTÉRIO DA SAÚDE (2020, March 15). *A estrada para transformação digital do SUS.* https://datasus.saude.gov.br/wp-content/uploads/2020/05/DATASUS-29-ANOS-Book-das-realiza%C3%A7%C3%B5es-de-2019-a-2020-A-Estrada-para-aTransforma%C3%A7%C3%A3o-Digital-do-SUS.pdf.

DE FILIPPI, Primavera; MANNAN, Morshed; REIJERS, Wessel. (2020). Blockchain as a confidence machine: The problem of trust & challenges of governance. *Technology in Society*. Vol. 62. 101284. ISSN 0160-791X. https://doi.org/10.1016/j.techsoc.2020.101284.

EBSI. (2021, October 15). *European Blockchain Services Infrastructure*. https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/EBSI.

Eisenhardt, K.M. (1989). Building Theories from Case Study Research. *Academic Management Review*, 14, 532-550.

Falwadiya, Himanshu; Dhingra, Sanjay. (2020). Blockchain technology adoption in government organizations: A systematic literature review. *Journal of Global Operations and Strategic Sourcing*.

Hilgers, Dennis; Ihl, C. (2010). Citizensourcing: applying the concept of open innovation to the public sector. *International Journal of Public Participation*, v. 4, n. 1, p. 67- 88.

Khan, K. M.; Arshad, J.; Khan, M. M. (2018). Secure digital voting system based on blockchain technology. *International Journal of Electronic Government Research*, 14 (1), 53-62.

Khan, K. M.; Arshad, J.; Khan, M. M. (2020). Investigating performance constraints for blockchain based secure e-voting system. *Future Generation Computer Systems-the International Journal of eScience*, 105, 13–26.

Lacchain. (2021, November 11). *Inicio*. https://www.lacchain.net/home .

Lopes, K. M. G.; Luciano, E. M.; Macadar, M. A. (2018). Criando Valor Público em Serviços Digitais: uma proposta de conceito. *Revista Gestão*.Org. v. 16, Edição Especial. p. 207-221. ISSN 1679-1827

Ølnes, Svein; Ubacht, Jolien; Janssen, Marijn. (2017). Blockchain in government: Benefits and implications of distributed ledger technology for information sharing. *Government Information Quarterly*, v. 34, n. 3, p. 355-364.

Saxena, S.; Shao, D.; Nikiforova, A.; Thapliyal, R. (2022). Invoking blockchain technology in e-government services: a cybernetic perspective. *Digital Policy, Regulation and Governance.* 24(3), 246–258. https://doi.org/10.1108/DPRG-10-2021-0128

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Scholl, Hans Jochen; Rodríguez-Bolívar, Manuel Pedro. (2019). Regulation as both enabler of technology use and global competitive tool: The Gibraltar case. *Government Information Quarterly,* v. 36, n. 3, p. 601-613.

Stoker, G. Public value management a new narrative for networked governance? (2006). *The American review of public administration***,** 36(1), 41-57.

SUSEP. Superintendência de Seguros Privados. (2022, January 10). *Nova plataforma para intercâmbio de informações entre SUSEP, Bacen e CVM*. http://www.susep.gov.br/setores-susep/noticias/noticias/com-tecnologia-blockchain-nova-plataforma-para-intercambio-de-informacoes-entre-susep-banco-central-e-cvm-proporciona-mais-seguranca-agilidade-e-menor-custo.

TCU. (2022, November 7). TCU e BNDES lançam Rede Blockchain Brasil e definem próximos passos. *Notícias*. https://portal.tcu.gov.br/imprensa/noticias/tcu-e-bndes-lancam-rede-blockchain-brasil-e-definem-proximos-passos .

Twizeyimana, Jean Damascene; & Andersson, Annika. (2019). The public value of E-Government–A literature review. *Government information quarterly*, v. 36, n. 2, p. 167-178.

Van Veenstra, A. F. E. (2012). IT-induced public sector transformation. TU Delft, *Delft University of Technology*.

Williams, I.; Shearer, H. (2011). Appraising Public Value: Past, Present and futures**.** *Public Administration*, 89(4), 1367–1384.

Yang, Y.; Shi, Y.; Wang, T. (2022). Blockchain Technology Application Maturity Assessment Model for Digital Government Public Service Projects. *International Journal of Crowd Science*, 6(4), 184194. https://doi.org/10.26599/IJCS.2022.9100025

Yin, Robert K. (2018). Case Study Research and Applications**.** *Design and Methods*. 6th edition. Los Angeles, Sage.

Zheng, Z.; Xie, S.; Dai, H-N.; Chen, X.; e Wang, H. (2018). Blockchain challenges and opportunities: A survey. *International Journal of Web and Grid Services*, v. 14, n. 4, p. 352-375.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Integrating VR/AR and AI-Chatbots in the Public Sector: Barriers and Synergies

Raphael Palombo [a] , *Jan* Westermann [b*], *Jette Friederike* Pröschold [c]

[a] Digital Public, University of Bremen, Bremen, Germany, palombo@uni-bremen.de, 0009-0002-2423-8382.

[b] Digital Public, University of Bremen, Bremen, Germany, westerma@uni-bremen.de, 0009-0009-3004-1982.

[c] University of Bremen, Bremen, Germany, proescho@uni-bremen.de, 0009-0001-8952-3902.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Public administrations are increasingly confronted with demands for greater citizen engagement and a shortage of qualified professionals. The adoption of emerging information and communication technologies (ICTs) is often shaped by organizational factors such as resource availability, leadership, and interorganizational dynamics. As digital transformation accelerates, virtual technologies, particularly virtual reality (VR) and augmented reality (AR), offer promising opportunities to enhance administrative processes through immersive and augmented environments. However, the integration of these technologies remains complex and presents numerous applicational challenges.

This study investigates the barriers to VR/AR adoption in the public sector, with a particular focus on organizational and adaptation-related issues. Additionally, it explores the potential of AI-powered chatbots to mitigate these barriers. To that end, a deductive thematic analysis was conducted on a sample of 104 VR/AR projects. The study further examines the synergies between VR/AR systems and AI chatbots.

The findings provide a foundational understanding of the applicational barriers associated with VR/AR integration in public administrations, highlighting challenges related to infrastructure, human–computer interaction, system stability, financial constraints, and complexity. While AI-powered chatbots show potential in addressing several of these issues, the study emphasizes the importance of designing both technologies as complementary systems to enhance effectiveness, efficiency, and user experience.

Keywords. VR/AR, Conversational AI, Chatbot, Public Sector, Smart City
Research paper, DOI: https://doi.org/10.59490/dgo.2025.977

1. Introduction

Public administrations have come into a new era of captivating changes and technological advancements (Lnenicka et al., 2024). Innovative digital technologies offer new potential to address upcoming challenges, such as the high need for qualified specialists and the growing demand for citizen communication and involvement (Cortés-Cediel et al., 2023). Virtual technologies, including VR and AR, are promising rising technologies which could allow to introduce a new type of virtual citizenship. Discussed as a foundational layer for an omnipresent virtual internet, the metaverse increasingly appears to be an imminent rather than distant application (Ricoy-Casas, 2023). Virtual reality (VR) refers to technologies, which shutdown the reality and create a virtual environment to the eyes of a human participant. On the other hand, augmented reality (AR) refers to technologies, which enhance the field of view of a user (Suh & Prophet, 2018). Currently, both technologies show potential in a variety of fields where information needs to be vividly visualized (Renu, 2021). From virtual city tours, digital twins, to participation. Several cases exist, which use the technology to vividly display projects and public processes to the people (Suh & Prophet, 2018). In science-fiction movies, these virtual worlds are often populated with artificial inhabitants, such as virtual intelligent avatars or intelligent AI-companions (Ricoy-Casas, 2023). Already today, we encounter almost daily interaction with virtual avatars or conversational agents, such as Microsoft Cortana, Google Gemini, or ChatGPT (Casheekar et al., 2024). Known under the umbrella term chatbots, these are engaging tools which can

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

help to close the communication gap between citizens and administration through engaging and almost human like natural conversations (Androniceanu, 2023; Yeh et al., 2019).

In contrast to virtual and visualizing communication tools, such as VR and AR, chatbots can independently have a verbal or textual conversation with a human (Dwivedi et al., 2021). Recent chatbot systems implement AI algorithms. These systems have the ability to learn from real-time input and learn to adapt to it (Abbas et al., 2023). Chatbots have demonstrated applicability in scenarios that demand extensive and diverse verbal interactions. (Cortés-Cediel et al., 2023). For public administration, this shows to be effective in settings where a large number of citizen requests need to be processed. To this point, chatbots in public administrations have primarily been used for simple requests. However, the accessibility of more complex systems, including Large Language Models (LLMs), shows potential for more advanced settings. With these new opportunities, a chatbot could guide citizens through VR/AR-environments and assist citizens in a new and engaging way (Dwivedi et al., 2022).

A combination of both VR and AR technologies could be a powerful new way of citizen engagement (Dwivedi et al., 2022). However, currently only a few projects implement both technologies in an operationalizable way (Suh & Prophet, 2018). These projects are often experimental or require a noticeable effort (Hwang et al., 2024; Lnenicka et al., 2024). Therefore, it is still questionable if a combination of both technologies is applicable in the public sector in the present and future. Therefore, we want to investigate current VR/AR projects, identify challenges, and highlight the potential of a combination in the given fields. The findings of our paper are both valuable for science and public administrations, analysing the potential of a technological combination. The research questions of this paper are consequently:

RQ1: What are the current barriers of VR/AR adoption in the public sector?
RQ2: How can AI-powered chatbots help to reduce barriers in VR/AR adoption in the public sector?

To answer the research questions, we first outline the theoretical background on VR/AR and highlight the potential of AI-Chatbot applications in the public sector. We also present a first given state on the combination of both technologies for public services. When the theoretical context is given, we present our methodology of a deductive thematic analysis on the basis of 104 VR/AR projects in the public sector. We outline the codebook for the analysis of potential barriers to VR/AR adoption in the public sector. Based on this, the findings of our analysis are presented. We discuss the potential to address current barriers in VR/AR adoption with an AI-Chatbot combination and present our conclusions as well as limitations and possible future research.

2. Theoretical Background

Immersive technologies blur lines between physical and virtual worlds, creating a sense of presence and engagement for users (Suh & Prophet, 2018). Widely available in the consumer market, head-mounted displays (HMDs) are one prominent example of these technologies. These devices, worn on the head, immerse users in a virtual environment (VE) by stimulating their senses, allowing them to interact with virtual objects and representations (Cassani et al., 2020). In contrast, augmented reality covers a broader range of devices and applications. A major breakthrough in the commercial adoption of AR came with the release of the mobile app Pokémon Go in 2016, which popularized location-based AR experiences (Suh & Prophet, 2018). Since then, AR applications for smartphones and tablets have become increasingly common.

The second focus technology are chatbots. Chatbots are conversational agents, which allow adaptive conversations on certain topics. In public administration, chatbots have high potential to achieve more transparent processes while providing 24/7 access to governmental data sources. Chatbots may be found in a variety of public processes (Abbas et al., 2023). However, chatbots integrated today in public administrations are mainly for simple and experimental interaction cases (Cortés-Cediel et al., 2023).

A combination of VR/AR and chatbots is currently scarce in public projects (Lnenicka et al., 2024). In regard to science-fiction and virtual digital utopias, the combination is foreseen to be powerful as intelligent technology becomes integrated into our daily lives (Dwivedi et al., 2022). Possible fields of application are virtual medical assistants or virtual AI systems, which may be positioned in the real or virtual world (Chadha et al., 2023). Promising fields are also educational or cultural settings where both technologies can enhance the common effect and provide vivid input to the learner (Hwang et al., 2024).

3. Methodology

3.1. Thematic Analysis

In order to highlight the potential of a VR/AR and chatbot combination in the public sector, we analyze a dataset of 104 VR/AR projects on possible application fields. As shown in Figure 1, 59% of the highlighted projects in the datasets originate from Germany and the broader DACH region. Germany is a country with a highly complex

bureaucracy that encounters many challenges in the introduction of innovative digital technologies (Sept, 2020). Further projects were located in the USA (18%), additional European countries (Sweden, Finland, Ireland, Netherlands and the UK) and Australasian countries (Indonesia and Australia). To understand the potential of VR/AR and chatbot combination, we initially started with an analysis of current barriers that were experienced in the projects.

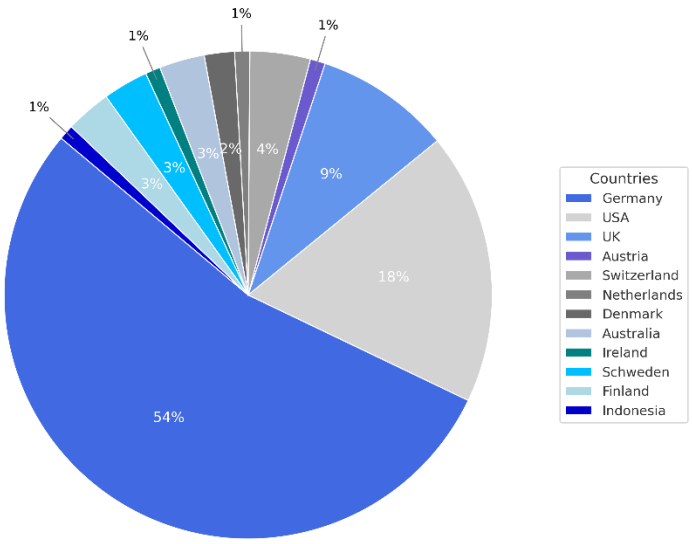


Fig 1. - VR/AR Project Sample

Barriers were observed based on project descriptions, reports, videos, and additional content about the projects. These were coded in a deductive thematic analysis (Boyatzis, 1998; Braun & Clarke, 2019), following the Steps presented in Figure 2. For the coding process, a category system of potential barriers was developed based on secondary literature on VR/AR integration in the public sector. Each category was defined and described with anchor examples and coding rules. The findings were consolidated and organized through the pre-defined category system. If findings were reoccurring, new subcodes on relevant topics were created on the basis of the defined categories. After conducting the deductive thematic analysis (Boyatzis, 1998; Naeem et al., 2023), we continued to explore potential application areas for chatbots within the projects and noted the potential of their integration in the given domain. We analyzed the potential of chatbots for public integration based on the proposed principles and fields of application presented by Cortes Cediél et al. (2023). We incorporated the proposed chatbot evaluation metric to highlight potential attributes that could be integrated into the list of projects.

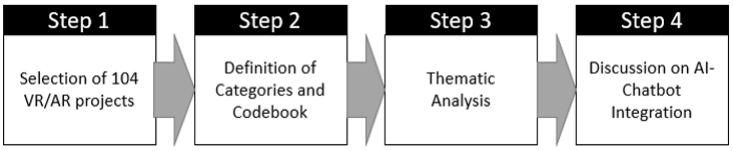


Fig 2. - Steps of the Thematic Analysis

To understand the current status of acceptance of VR/AR systems in public administrations, we rooted the analysis in theories of acceptance. The UTAUT model, as a modern and well-researched approach, involves the key aspects of performance expectancy, effort expectancy, social influence, and facilitating conditions, which lead to behavioral intention and use behavior. In regard to VR/AR adoption, users need to experience satisfaction based on their initial expectations of the system. Especially with immersive technologies like VR/AR, expectations may widely range. A totally immersive world may be expected, where the other one has no expectations (Xiong et al., 2024). Further, it needs to be mentioned that the UTAUT does not include an explanation of potential barriers that limit the acceptance of technology (Le Tan et al., 2024). Moreover, an individual's perspective is taken into account, while an organizational view is not prioritized (Ajibade, 2018). Barriers to the adoption of digital technologies stand in contrast to the adoption of a technology. In regard to VR/AR adoption in the public sector, well defined barriers are still missing to our knowledge (Vimal et al., 2023). Previous literature mentions the challenge to adopt VR/AR in the public sector (Lnenicka et al., 2024). The barriers in the public sector are versatile, which makes an evaluation of VR/AR technologies challenging. Nevertheless, to identify barriers regarding technology, the purpose and goal need to be taken into account. VR and AR are technologies that are well suited to educate vividly on different topics (Dwivedi et al., 2022). Le Tan et al. (2024) identified relevant barriers to VR/AR adoption in educational settings . They propose five central barriers from scientific literature: VR/AR adoption is affected by

infrastructure, technical issues, cost factors, complication, and human interaction. In this regard, VR/AR barriers in the public sector display similarities that warrant attention. VR/AR projects in the public sector demonstrate a strong focus on educational settings, with over 65% of the identified projects falling into this category. This includes public learning, but also education on public projects and cultural and historic settings, as for instance city tours and virtual art installations.

Infrastructure is highly relevant for the integration of innovative technologies (Dionisio et al., 2013; Lnenicka et al., 2024). Especially with the vision of an interconnected metaverse, infrastructure becomes a relevant indicator for VR/AR integration potential (Dwivedi et al., 2022). Public projects are already today integrated in internal services, support of urban planning, and e-participation (Ricoy-Casas, 2023). If a project manages to integrate existing data and information, the impact of this service increases in the eyes of the citizens (Frank et al., 2010). Existing public platforms, such as smartphones-apps and social networks, profit in the same way from an integration of VR/AR services. With regard to AI integration and the era of generative AI and technological advancements, infrastructure is a fundamental barrier to VR/AR systems and future adoption (Zuiderwijk et al., 2021).

Technical issues as barriers are a central problem for VR/AR adoption. These may result from technical limitations or immature implementations. Technical issues are the result of multiple factor problems and often strongly relate to the planning process and predicted goals for the system (Kumari & Polke, 2019). Regarding technical issues with VR/AR, it needs to be taken into account that already small flaws in the systems can highly affect the perception (Hsiao et al., 2024). In case of immature systems, users can experience technostress or cybersickness that affect the continuous use of a system (Souchet et al., 2023).

Avoiding unnecessary complexity is essential when quick results are valued (Lnenicka et al., 2024). As VR/AR projects often cope with unrealistic requirements, complication can arise without leading to observable value. Unnecessary complication may be the implementation of a VR system without a clear benefit in comparison to a 2D PC system (Stejskal et al., 2003). Also, complication can arise through nontechnical aspects in the project facilitation. Hence, inadequate communication of the service may lead to an awareness problem and ongoing complications with citizens.

Cost factors are relevant in the adoption process of a system. Innovative technologies can involve costs, which are not directly predictable (Naugolnova, 2024). Furthermore, the maintenance of these systems can create a quick overhead in comparison to the perceived reward. Some participants in public projects raised concerns about the impact of the technology and its complication (Teutenberg, 2025). Especially in learning settings, the results are not necessarily satisfactory. Further, the time cost factor should be considered while implementing these systems (Fegert et al., 2020).

The public sector needs to manage requirements from a variety of different users and stakeholders. Ease of use is not always guaranteed with public services (Chen & Aklikokou, 2020). Especially with technologies such as VR and AR, citizens need to be introduced on how to use and interact with a system. Usability can become a central barrier if not satisfactorily addressed (Kim et al., 2020). How effectively systems in public administrations address this topic is decisive for their further usage. Alongside usability, human interaction also becomes a relevant factor (Kim et al., 2020). As a technology that embodies users, VR is creating new normative rules and interaction patterns that influence how individuals perceive themselves and others within virtual environments.

3.2. AI-Chatbot Integration

The identified chatbot characteristics in the public sector by Cortés-Cediel et al. (2023) are used as a fundamental source for potential application fields. Cortés-Cediel et al. (2023) observed five principal purposes for chatbot integration: 1) searching for government information; 2) supporting access to government data; 3) providing public services; 4) improving citizen participation; and 5) facilitating communication between stakeholders. In regard to the identified barriers of VR/AR in the public sector, we outline how chatbots can be integrated with regard to these five principal purposes in public VR/AR applications. We propose solutions that could be implementable in the upcoming 3-10 years from the time of the given analysis due to technical advancements and innovation cycles in the public sector (Lnenicka et al., 2024; Stewart-Weeks & Kastelle, 2015). Data policies and individual country perspectives were not included, as the primary goal of the analysis is to highlight the potential of VR/AR and AI-chatbot integration in a divergent idea generation process without prematurely focusing on country-specific limitations.. We root the discussion on existing functionalities of chatbots and conversational agents and create an extensive perspective for the given problems in the public sector. Except for commercial services like ChatGPT, we analyzed multiple chatbot platforms for the public sector from private and governmental providers, including Botfriends, DialogBits, and the General Service Administration Chatbot. We analyzed these systems to extract a comprehensive picture of potential integration in VR/AR services.

4. Findings

The findings regarding barriers of current VR/ AR adoptions can be grouped into the five categories, namely infrastructure, technical issues, complication, cost factors, and human-interaction, as proposed by Le Tan et al. (2024). See Table 1 for a comprehensive overview.

Within the barrier of *infrastructure* three main problems could be identified from the sample set of VR/AR projects. Projects for firefighters or for police training, for instance, show promising applications to simulate critical situations in the job (e.g., project firefightervr). The project systems are mature and vividly present contents to the user. However, public administrations often set up cooperations with private IT-companies, which sell services to the public institutions. This can be problematic, as new content for the VR/AR systems is often not affordable or exceeds initial budget plans (Bonomi Savignon et al., 2024). A majority of the retrieved VR/AR projects did not actively proceed one year after release. Further, the education of administrative workers is a barrier, which limits the potential of VR/AR systems. IT experts are hard to recruit for the public sector (Haug et al., 2024). However, continuous maintenance of the VR/AR systems would be necessary to further develop and improve the contents. An additional challenge regarding infrastructure is the isolated setup of VR/AR services. Interfaces to existing infrastructure are rarely considered. So, projects that implement urban data, like the Ashbury Park Bike Lane Demonstration Project, are relying on a limited dataset. A continuous data-flow is nonexistent between external services and VR/AR systems. However, specifically projects aiming to boost efficiency require an accurate, precise, and current dataflow. The lack of real-time data decreases the quality of simulations and analyses. Thus, the continuous data updates are a highly relevant aspect for Digital Twin integration. For instance, the Hamburg port authority set up a promising project that integrates a continuous data stream from the port to the Digital Twin in the virtual environment, enabling real-time simulations (Hamburg Port Authority [Hg], 2025). This example indicates that an integration of urban data in VR and AR is already possible and that the incorporation into existing systems can be beneficial to allow data exchange. However, the majority of projects do not implement an API or interface to existing urban data sources. VR/AR infrastructure problems often root in design issues rather than implementation (Creed et al., 2024). Critical are limited standardizations, such as complicated devices or a limited scope of application. A variety of AR city tour apps were integrated in many different towns in Germany. The towns (e.g., Bergen-Belsen, Chemnitz, or Munich) developed their own system with individual functionalities. Furthermore, low-code tools, which allow the development of applications for the public, are not frequently applied (e.g., ARget). A common infrastructure of applications in general could condense the potential of the technologies and allow the exchange of knowledge and resources. For instance, 3D-models that are used in one project may also be applicable in an AR communication app in a different project. A shared technological infrastructure, including databases and APIs, sets the foundation (Creed et al., 2024). Barriers in project infrastructure sometimes were already rooted in the project design. For instance, the Ashbury Park Bike lane project, initially created to gather data on the usefulness of a new bike lane, lacked a control condition or site; thus, the infrastructural design flaw led to inconclusive results.

Tab. 1- VR/AR Integration Barriers in the Public Sector

Infrastructure	**Technical Issues**	**Complication**	**Cost Factors**	**Human Interaction**
1a) Difficulties finding schooled personnel	1b) Issues with system stability	1c) Unclear outlines of project necessities and value propositions	1d) Projects dependent on external funding	1e) Barriers of usability
2a) Introduction of isolated systems rather than incorporation into existing systems	2b) Necessities for additional equipment and sensors	2c) Insufficient communications to target audience	2d) High time-effort for setup and maintenance	2e) Demographic differences in interaction
3a) Infrastructural issues often rooted in the project design prior to implementation	3b) Difficulties with intuitive interaction and model quality	3c) Permanent relevance not ensured		3e) The dangers of over-gamification
	4b) Incomparability of data due to variations in quality			4e) Limiting negative effects
				5e) Difficulties with task alignment

A major *technical issue* in VR/AR projects is the stability of the systems. Especially in complex experimental settings with collaborative VR or with real-time rendering (e.g. Vision 5.G or FX Reality), systems tend to be still immature. Further, in some cases additional equipment is necessary, which can affect the motivation of the citizens and public target groups. Specifically simulators for medical or police training often involve heavy and complex tools, which reduces the scalability of these projects and requires additional testing (e.g., virtual extinguishing trainer). Moreover, latencies are still a major issue, which needs to be addressed (see project Telemedicine in the emergency services). Another factor often not sufficiently explored prior to implementation are barriers with quality and fidelity of the presented 3D-models. Depending on the field of usage, reduced quality can significantly impact the overall usefulness of the application (e.g. Pixplorer). Within the projects, complex 3D models were often taken as self-explanatory (e.g. HoloPLANNING). However, given that 3D models are the primary means of visualization in these systems, a clear definition and standardization of model requirements would enhance usability. In conclusion, the technical complexity of VR/AR projects varies widely, from high-end 5G-based implementations (e.g., Vision 5.G) to low-cost AR tools (e.g., ARget), making their technological maturity difficult to compare directly.

Based on the projects investigated, no direct conclusions could be drawn regarding costs or *financial stability*. However, many services appear to be highly dependent on external third-party funding (e.g., from the German Ministry of Education and Research).
Beyond financial stability, the time and effort required to set up and maintain these systems is considerable. Furthermore, due to the lack of reliable user data, it is important to emphasize that, at the time of this research, most VR/AR projects remain in an experimental phase and do not yet offer financially sustainable services capable of driving rapid transformation in the public sector IT landscape.

In the VR/AR-projects an overhead of *complications* are observable. VR and AR are complex technologies, which require well defined use-cases and a clear value-proposition (Kim & Hall, 2019; Pedersen, 2024). These technologies are often implemented in cases where a need for immersive visualization does not necessarily exist, or is not outlined sufficiently (e.g., Conflict Handling Ambulance Syd). Many public VR/AR projects are not sufficiently communicated to its audience and therefore endangered to not permanently be relevant (e.g. ARget). Furthermore, permanent relevance can be a barrier in project fields that are regularly subject to scientific advances (e.g. medical tr.AI.ning or OP der Zukunft, eng. OR of the future).

In relation to *human-computer interaction*, a few aspects may limit the interaction between citizens and administration. Primarily some services are described to have low perceived usability. For instance, in the project AR/VR.NRW figments, an open-source content creator tool, was developed to set up virtual environments for learning and teaching. In the project it was noticed that VR is not necessarily a better tool for communication of learning contents than a standard PC version: “With regard to self-assessed learning success, no significant advantage of the VR group over Desktop could be identified” (Müser et al., 2023).

A second point that administrations need to be aware of is the interaction with critical target groups. Some projects (e.g., SenopiVR) work with elderly, disabled, or dementia-affected people. Except for demographic states, the individual levels could also be considered. An application in historic settings could be addressed for different educational levels and personal preferences (e.g., Chemnitz.Zeitweise, eng. ChemnitzTimewise). Each target group needs special communication and treatment (Bruno & Muzzupappa, 2010). VR/AR often inherits gamification aspects that need to be aligned. Gamification can be an engaging factor; nevertheless, gamification can also reduce attention when not securely applied and adjusted to the educational level (Dicheva et al., 2015). Additionally, it needs to be taken into consideration that gamification can induce stressful and uncomfortable situations. Simulations in critical situations, such as police treatments, or training for firefighters should be limited to their target audience to not traumatize inexperienced users (e.g., projects Ambulance Syd and firefightervr). VR/AR applications in the public sector often have just one communication goal, which is communicated. Information is provided mainly to one target group. However, public processes, such as participatory initiatives, involve multiple target groups that play a significant role. A setup of multiple VR and AR views would address this problem and align knowledge states. Also, the experience in VR and AR is important to fulfill the potential of the applications. Especially avatars and interaction partners need to be aligned to the task. Here it is extremely important to mention that the right degree of abstraction and presentation is essential to create a satisfying presentation and relation (Commonwealth of Pennsylvania, 2025).

5. Discussion

From a long- and short-term perspective AI-chatbots can be relevant to improve current VR/AR-applications in multiple fields. Before possible integrations are presented, we would like to note that the proposed concepts are not filtered on cost-efficiency and maturity level. The proposed applications of chatbots address primary the identified barriers and highlight potential synergies.

Infrastructure Barriers: AI-chatbots may help in the upcoming years to reduce the dependency of private IT

providers with VR/AR services. AI-powered low-code environments could be useful to reduce the number of external providers through AI-services. Already today advanced conversational agents and chatbots are able to provide content based on a given prompt of a user. For instance, AI-driven 3D agents, which produce VR/AR models based on a given prompt like e.g. Shutterstock Generative-AI. In comparison with the public low-code platforms in the administrations (e.g. ARget or VRpigments), public integration could improve flexibility and generalizability. Dependency problems from external partners would not vanish, however the number of VR/AR IT-service providers could be reduced, as more functionalities could be implemented with the assistance of an AI chatbot. Also, the maintenance problems would fade away, as the chatbot could enable to generate new content without the need for external maintenance. AI-chatbots are often able to learn, which could help to improve VR/AR-services over time. The core functionalities would improve constantly without the need for updates after the end of potential funding. Apart from core functionalities, a chatbot could provide quick data analysis on top of the existing data-streams and visualizations (Alaaeldin et al., 2021). For instance, in digital twin projects, such as the Hamburg Port Digital Twin, a chatbot in the virtual environment could provide additional information on visualized data-streams and highlight critical points in the virtual environment. A chatbot would also allow new interaction techniques in the VR/AR-environments, as it may interact with the user by verbal communication. As typing is not a reliable option in VR/AR, voicebots could be an alternative (Hwang et al., 2024). A chatbot does not necessarily require integrated data operations. However, advanced chatbot systems provided by external vendors may include limited data analytics functionalities. For complex requests, an API driven chatbot could be an optimal solution. This type of solution only handles requests with a language NLU and forwards the contents to an external service provider (data-warehouse, BI-platform) (Adamopoulou & Moussiades, 2020).

Technical Stability: The quality of VR/AR projects is critical. AI-chatbots and agents could be used for optimization and quality control in VR/AR projects. A chatbot could serve as a guide during the implementation process, for instance within low-code applications (e.g., ARget). Public employees could then streamline development processes of future applications (Kumar et al., 2024). The chatbot could engage with the employee and give guidance either in a content management interface or integrated in the virtual environment as a virtual avatar. If problems occur in the development process, the chatbot could also work as an advanced developer console, which gives hints on development issues, or makes suggestions for given coding problems (Simão de Deus & Barbosa, 2024).

Cost-factors & Complications: As an additional functionality, chatbots do not resolve the financial challenges of current VR/AR projects. However, given the growing demand for chatbots in public websites and services, integrating VR/AR functionalities into chatbot systems could enhance the visibility, flexibility, and user guidance of existing applications

Human Computer Interaction: Chatbots can provide guidance in VR/AR-applications and allow to streamline interactions. Possible application fields are citizen participation, facilitation of communication between stakeholders, provision of public services and presentation of government data (Cortés-Cediel et al., 2023). Especially for different demographic groups, chatbots could provide assistance in VR/AR-applications. Based on this, flexible interaction techniques could be enabled through a chatbot that processes spoken information and transforms it into meaningful content. One possible application would be a chatbot acting as a virtual tour guide in interactive experiences, answering questions, providing guidance, or engaging in storytelling. Moreover, AI-chatbot collaboration represents a novel form of interaction that could enhance the liveliness and responsiveness of VR and AR environments. Particularly, AI-driven avatars used for onboarding processes (e.g. in firefighter training scenarios) could help personalize the experience (Luo et al., 2024). In this context, the perceived similarity of the chatbot may foster closer interaction between users and administrative systems.

Chatbots can serve as a powerful tool to address barriers encountered by current applications and to reshape the landscape of VR/AR service systems. In particular, chatbots help streamline existing applications and communicate their functionality in a more flexible and personalized manner. However, it remains debatable whether AI-driven chatbot integration and the incorporation of chatbot personality are essential, or whether the provision of information could be sufficiently handled by standard text interfaces or simple rule-based logic. With technological advancements such as the emergence of Generative AI, the introduction of intelligent, AI-driven chatbots in the public sector appears to be a matter of time. Nonetheless, considering current technological limitations, it may take several more years before the public sector reaches a level of maturity where both technologies, VR/AR and chatbots, can develop meaningful synergies. It is worth emphasizing that VR/AR and chatbot projects should ideally be designed in close alignment. These technologies complement each other through combining visual, auditory, and textual elements. For the VR/AR projects analyzed in this study, chatbot integration may pose a challenge, as the systems are often deeply embedded within their own ecosystems and databases. Establishing a reliable and unified network infrastructure is a crucial prerequisite for unlocking the full potential of a combined VR/AR and chatbot solution.

6. Conclusions

This study examined the current state of VR/AR applications in the public sector, with a particular focus on barriers, potential use cases, and technological synergies. Special attention was given to AI-powered chatbots as a complementary technology that may enhance usability, accessibility, and human–computer interaction. Against this backdrop, two central research questions were addressed: (1) What are the current barriers to VR/AR adoption in the public sector? and (2) How can AI-powered chatbots contribute to overcoming these barriers? A thematic analysis of 104 public sector VR/AR projects was conducted, highlighting four key challenge areas: infrastructure, technical limitations, system complexity, and human-centered design.

The analysis revealed several recurring challenges. Many systems are dependent on private IT providers, which reduces autonomy and increases long-term vulnerability. High maintenance requirements and a lack of standardization have led to a fragmented ecosystem of incompatible platforms and services. System stability, positioning accuracy, and hardware requirements remain problematic. Core components such as 3D models often fall short of application-specific demands in terms of quality and clarity. In addition, the absence of established design patterns hinders the scalability and usability of these systems. Financial sustainability poses another critical issue, as most projects rely on temporary external funding. In many cases, the complexity of the solutions outweighs their practical value, making their unique selling points difficult to identify or justify in comparison to conventional approaches.

In regard to chatbot applications, the study explored several promising use cases aligned with the barriers identified. Chatbots show potential in enhancing interaction with VR/AR systems by simplifying navigation, providing guidance, and personalizing experiences. However, their integration is more feasible in high-quality systems with substantial data communication. It remains questionable whether low-budget implementations would benefit equally. The analysis also suggests that AI chatbots could assume administrative roles in immersive environments, acting as tutors, assistants, or digital workforce elements. In particular, AI-driven avatars functioning as public companions present a compelling area for future exploration.

This study has certain limitations that should be acknowledged. Primarily, the analysis is based on a dataset of 104 VR/AR projects, which, while supported by secondary literature, cannot be considered representative. Thus, while the findings provide meaningful insights, they are to be understood as an initial foundation for further empirical and design-oriented research.

Looking ahead, the convergence of chatbot and VR/AR technologies opens up promising interdisciplinary fields. As chatbot functionalities become increasingly compatible with immersive systems, the boundaries between modalities—visual, auditory, and textual—begin to dissolve. This intersection calls for the development of new design patterns tailored to hybrid applications in the public sector. Exploring these frontiers may significantly shape the future of digital public services and user engagement.

Acknowledgement

- **Data/Software Access Statement**: Collected Data being available at request.
- **Contributor Statement**: Raphael Palombo: Conceptualization, Methodology, Data analysis, Writing, Final approval; Jan Westermann: Writing – Reviewing and Editing; Jette Friederike Pröschold: Writing – Reviewing and Editing
- **Use of AI**: During the preparation of this work, the author(s) used ChatGPT in order to correct spelling and grammar. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest

References

Abbas, N., Følstad, A., & Bjørkli, C. A. (2023). Chatbots as Part of Digital Government Service Provision – A User Perspective. In A. Følstad, T. Araujo, S. Papadopoulos, E. L.-C. Law, E. Luger, M. Goodwin, & P. B. Brandtzaeg (Eds.), *Lecture Notes in Computer Science. Chatbot Research and Design* (Vol. 13815, pp. 66–82). Springer International Publishing. https://doi.org/10.1007/978-3-031-25581-6_5

Adamopoulou, E., & Moussiades, L. (2020). An Overview of Chatbot Technology. In I. Maglogiannis, L. Iliadis, & E. Pimenidis (Eds.), IFIP Advances in Information and Communication Technology. Artificial Intelligence Applications and Innovations (Vol. 584, pp. 373–383). Springer International Publishing. https://doi.org/10.1007/978-3-030-49186-4_31

Ajibade, P. (2018). Technology Acceptance Model Limitations and Criticisms: Exploring the Practical Applications and Use in Technology-related Studies, Mixed-method, and Qualitative Researches. *Library Philosophy and Practice*.

Alaaeldin, R., Asfoura, E., Kassem, G., & Samir Abdel-Haq, M. (2021). Developing chatbot system to support decision making based on big data analytics. Journal of Management Information and Decision Sciences(Volume 24, Issue 2). https://search.proquest.com/openview/925d6c14f592df436da7293ca241e3cf/1?pq origsite=gscholar&cbl=38743

Androniceanu, A. (2023). The new trends of digital transformation and artificial intelligence in public administration. Administratie Si Management Public, 40, 147–155. https://doi.org/10.24818/amp/2023.40-09

Bonomi Savignon, A., Zecchinelli, R., Costumato, L., & Scalabrini, F. (2024). Automation in public sector jobs and services: A framework to analyze public digital transformation's impact in a data-constrained environment. *Transforming Government: People, Process and Policy*, *18*(1), 49–70. https://doi.org/10.1108/TG-04-2023-0044

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Sage Publications. http://www.loc.gov/catdir/enhancements/fy0656/97045405-d.html

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, *11*(4), 589–597. https://doi.org/10.1080/2159676X.2019.1628806

Bruno, F., & Muzzupappa, M. (2010). Product interface design: A participatory approach based on virtual reality. *International Journal of Human-Computer Studies*, *68*(5), 254–269. https://doi.org/10.1016/j.ijhcs.2009.12.004

Casheekar, A., Lahiri, A., Rath, K., Prabhakar, K. S., & Srinivasan, K. (2024). A contemporary review on chatbots, AI-powered virtual conversational agents, ChatGPT: Applications, open challenges and future research directions. *Computer Science Review*, *52*, 100632. https://doi.org/10.1016/j.cosrev.2024.100632

Cassani, R., Moinnereau, M.-A., Ivanescu, L., Rosanne, O., & Falk, T. H. (2020). Neural Interface Instrumented Virtual Reality Headsets: Toward Next-Generation Immersive Applications. *IEEE Systems, Man, and Cybernetics Magazine*, *6*(3), 20–28. https://doi.org/10.1109/msmc.2019.2953627

Chadha G.K., Punhani, R, Ritu, & Saini, S. (2023). 3 Merging of artificial intelligence (AI), artificial life (AL) and virtual reality (VR). In J. Hemanth, M. Bhatia, & I. de La Torre Diez (Eds.), Artificial Intelligence for Virtual Reality (pp. 27–44). De Gruyter. https://doi.org/10.1515/9783110713817-003

Chen, L., & Aklikokou, A. K. (2020). Determinants of E-government Adoption: Testing the Mediating Effects of Perceived Usefulness and Perceived Ease of Use. *International Journal of Public Administration*, *43*(10), 850–865. https://doi.org/10.1080/01900692.2019.1660989

Commonwealth of Pennsylvania. (2025, January 15). *Department of Corrections Introduces Virtual Reality Technology to Augment Progr | Department of Corrections | Commonwealth of Pennsylvania*. https://www.pa.gov/agencies/cor/about-us/newsroom/newsroom/department-of-corrections-introduces-virtual-reality-technology-to-augment-programming-for-incarcerated-parents-and-their-children.html

Cortés-Cediel, M. E., Segura-Tinoco, A., Cantador, I., & Rodríguez Bolívar, M. P. (2023). Trends and challenges of e-government chatbots: Advances in exploring open government data and citizen participation content. *Government Information Quarterly*, *40*(4), 101877.

Creed, C., Al-Kalbani, M., Theil, A., Sarcar, S., & Williams, I. (2024). Inclusive AR/VR: Accessibility barriers for immersive technologies. *Universal Access in the Information Society*, *23*(1), 59–73. https://doi.org/10.1007/s10209-023-00969-0

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in Education: A Systematic Mapping Study. *Journal of Educational Technology & Society*(Vol. 18, No. 3), pp. 75-88.

Dionisio, J. D. N., III, W. G. B., & Gilbert, R. (2013). 3D Virtual worlds and the metaverse. *ACM Computing Surveys*, *45*(3), 1–38. https://doi.org/10.1145/2480741.2480751

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D. P., Gustafsson, A., Hinsch, C., Jebabli, I., . . . Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, *66*, 102542. https://doi.org/10.1016/j.ijinfomgt.2022.102542

Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A., Galanos, V., Ilavarasan, P. V., Janssen, M., Jones, P., Kar, A. K., Kizgin, H., Kronemann, B., Lal, B., Lucini, B., . . . Williams, M. D. (2021). Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, *57*, 101994. https://doi.org/10.1016/j.ijinfomgt.2019.08.002

Fegert, J., Pfeiffer J., Peukert, C., Golubyeva, C., & Weinhardt, C. (2020). Combining e-Participation with Augmented and Virtual Reality: Insights from a Design Science Research Project.

Frank, K.Y., Chan, James Y.L. Thong, Viswanath Venkatesh, Susan A. Brown, Paul Jen-Hwa Hu, & and Kar Yan Tam (2010). Modeling Citizen Satisfaction with Mandatory Adoption of an E-Government Technology.

Hamburg Port Authority. (2025). *Digitalisierung im Hafen*. https://www.hamburg-port-authority.de/de/themenseiten/digitalisierung-im-hafen

Haug, N., Dan, S., & Mergel, I. (2024). Digitally-induced change in the public sector: A systematic review and research agenda. *Public Management Review*, *26*(7), 1963–1987. https://doi.org/10.1080/14719037.2023.2234917

Hsiao, S.-H., Wang, Y.-Y., & Lin, T. L. (2024). The impact of low-immersion virtual reality on product sales: Insights from the real estate industry. *Decision Support Systems*, *178*, 114131. https://doi.org/10.1016/j.dss.2023.114131

Hwang, Y., Lee, S., & Jeon, J. (2024). Integrating AI chatbots into the metaverse: Pre-service English teachers' design works and perceptions. *Education and Information Technologies.* Advance online publication. https://doi.org/10.1007/s10639-024-12924-4

Kim, M. J., & Hall, C. M. (2019). A hedonic motivation model in virtual reality tourism: Comparing visitors and non-visitors. *International Journal of Information Management*, *46*, 236–249. https://doi.org/10.1016/j.ijinfomgt.2018.11.016

Kim, Y. M., Rhiu, I., & Yun, M. H. (2020). A Systematic Review of a Virtual Reality System from the Perspective of User Experience. *International Journal of Human–Computer Interaction*, *36*(10), 893–910. https://doi.org/10.1080/10447318.2019.1699746

Kumar, Y., Manikandan, A., Li, J. J., & Morreale, P. (2024). Preliminary Results from Integrating Chatbots and Low Code AI in Computer Science Coursework. In 2024 IEEE Integrated STEM Education Conference (ISEC) (pp. 1–4). IEEE. https://doi.org/10.1109/ISEC61299.2024.10665039

Kumari, S., & Polke, N. (2019). Implementation Issues of Augmented Reality and Virtual Reality: A Survey. In J. Hemanth, X. Fernando, P. Lafata, & Z. Baig (Eds.), *Lecture Notes on Data Engineering and Communications Technologies. International Conference on Intelligent Data Communication Technologies and Internet of Things (ICICI) 2018* (Vol. 26, pp. 853–861). Springer International Publishing. https://doi.org/10.1007/978-3-030-03146-6_97

Le Tan, T., Thu Thi Nguyen, H., Chau Ngoc Khanh, N., Hien Thi Le, T., & Truong Hoang Vo, U. (2024). Researching Influences of Learner Experience on AR/VR Adoption - The Case of Vietnamese Universities. *Journal of Information Technology Education: Research*, *23*, 7. https://doi.org/10.28945/5264

Lnenicka, M., Rizun, N., Alexopoulos, C., & Janssen, M. (2024). Government in the metaverse: Requirements and suitability for providing digital public services. *Technological Forecasting and Social Change*, *203*, 123346. https://doi.org/10.1016/j.techfore.2024.123346

Luo, K., Cahalane, M., & and Mysore Seshadrinath, S. (2024). The Intersection of GenAI and Immersive Systems: Towards a Responsible Generative Metaverse. ACIS 2024 Proceedings.

Müser, S., Maiero, J., Fehling, C. D., Gilbert, D., Eroglu, S., Bachmann, D., Wiederspohn, S., & Meyer, J. (2023). Konzeption und Evaluation einer virtuellen Lernumgebung für die Hochschullehre. *MedienPädagogik: Zeitschrift Für Theorie Und Praxis Der Medienbildung*, *51*, 345–372. https://doi.org/10.21240/mpaed/51/2023.01.24.X

Naeem, M., Ozuem, W., Howell, K., & Ranfagni, S. (2023). A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research. *International Journal of Qualitative Methods*, *22*, Article 16094069231205789. https://doi.org/10.1177/16094069231205789

Naugolnova, I. A. (2024). VR/AR Technologies in Cost Management Throughout the Product Life Cycle Stages. In V. V. Mantulenko, J. Horák, & J. Kučera (Eds.), *Lecture Notes in Networks and Systems. Proceedings of the XI International Scientific Conference "Digital Transformation of the Economy: Challenges, Trends and New Opportunities" (ISCDTE 2024)* (Vol. 1063, pp. 24–29). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-65662-0_4

Pedersen, P. M. (Ed.). (2024). *Elgar Encyclopedias in Business and Management*. *Encyclopedia of Sport Management* (Second edition). Edward Elgar Publishing.

Renu, N. (2021). Applications of AR and VR technologies in healthcare marketing. *Journal of Marketing Management (JMM)*. https://www.researchgate.net/profile/nishant-renu-2/publication/357574895_applications_of_ar_and_vr_technologies_in_healthcare_marketing/links/61d4bcbcda5d105e551ce918/applications-of-ar-and-vr-technologies-in-healthcare-marketing.pdf?origin=journaldetail&_tp=eyjwywdlijoiam91cm5hberldgfpbcj9

Ricoy-Casas, R. M. (2023). The Metaverse as a New Space for Political Communication. In P. C. López-López, D. Barredo, Á. Torres-Toukoumidis, A. De-Santis, & Ó. Avilés (Eds.), *Smart Innovation, Systems and Technologies. Communication and Applied Technologies* (Vol. 318, pp. 325–334). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-6347-6_29

Sept, A. (2020). Thinking Together Digitalization and Social Innovation in Rural Areas: An Exploration of Rural Digitalization Projects in Germany. European Countryside, 12(2), 193–208. https://doi.org/10.2478/euco-2020-0011

Simão de Deus, W., & Barbosa, E. F. (2024). OER-Chat: An Open Chatbot to Support the Reuse of Open Educational Resources of Introductory Programming. https://doi.org/10.5281/ZENODO.8339188

Souchet, A. D., Lourdeaux, D., Pagani, A., & Rebenitsch, L. (2023). A narrative review of immersive virtual reality's ergonomics and risks at the workplace: cybersickness, visual fatigue, muscular fatigue, acute stress, and mental overload. *Virtual Reality*, *27*(1), 19–50. https://doi.org/10.1007/s10055-022-00672-0

Stejskal, T., Kethuda, K., & Pfeiffer, J. (2003). Knowledge All Around Me: Comparing the Effect of VR, Text and Desktop on Learning Outcomes. ECIS 2023 Proceedings.
Stewart-Weeks, M., & Kastelle, T. (2015). Innovation in the Public Sector. Australian Journal of Public Administration, 74(1), 63–72. https://doi.org/10.1111/1467-8500.12129
Suh, A., & Prophet, J. (2018). The state of immersive technology research: A literature analysis. *Computers in Human Behavior*, *86*, 77–90. https://doi.org/10.1016/j.chb.2018.04.019
Teutenberg A. (2025). *FNR-Verbundprojekt: Virtual Reality Forestry Training (VR-FT) in proWald*. https://kwf2020.kwf-online.de/artikel-zum-fnr-verbundprojekt-virtual-reality-forestry-training-vr-ft/
Vimal K.E.K., Sivakumar, K., Kandasamy, J., Vaibhav, V., & Mani, R. S. (2023). Barriers to the adoption of digital technologies in a functional circular economy network. Operations Management Research, 16(3), 1541 1561. https://doi.org/10.1007/s12063-023-00375-y
Xiong, C., Lam, L., Karimi, S., Xinyue, W., Tian, A., & Lei, S. (2024). Virtual Reality Adoption in Marketing: Unveiling Its Impact on Firm Value. PACIS 2024 Proceedings.
Yeh, T.-M., Pai, F.-Y., & Jeng, M.-Y. (2019). The Factors Affecting Older Adults' Intention toward Ongoing Participation in Virtual Reality Leisure Activities. *International Journal of Environmental Research and Public Health*, *16*(3). https://doi.org/10.3390/ijerph16030333
Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly*, *38*(3), 101577. https://doi.org/10.1016/j.giq.2021.101577

Multi-level Collaborative Governance Framework for Designing Accountable AI Systems for Emergency Management

Yu-Che Chen [a*], *Chun-Hua* Tsai [b], *Edouardo* Zendejas [c]

[a] School of Public Administration, College of Public Affairs and Community Service, University of Nebraska at Omaha, Omaha, Nebraska, U.S.A., ychen@unomaha.edu, ORCID 0000-0003-2830-5589.

[b] Information Systems and Quantitative Analysis, College of Information Systems and Technology, University of Nebraska at Omaha, Omaha, Nebraska, U.S.A., ORCID 0000-0001-9188-0362.

[c] School of Public Administration, College of Public Affairs and Community Service, University of Nebraska at Omaha, Omaha, Nebraska, U.S.A.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. This paper addresses a gap in the AI governance literature in understanding collaboration between national governments and tribal nations in governing AI systems for emergency management. This conceptual work develops and presents a governance design framework for accountable AI systems to fill the knowledge gap by drawing from the fields of public administration, information systems, indigenous studies, and emergency management. This framework situates the governance framework in a cross-sovereignty historical, legal, and policy contexts. It captures the multi-level features and embeddedness of governance structures, including the levels of collaborative governance structure, software system governance rules, and technical software system design. The focal governance dynamics involve the collaborative process in the bi-directional relationship between governance rules and technical design for accountability and the feedback loop. The framework highlights the importance of multi-level and process considerations in designing accountable AI systems. Productive future research avenues include empirical investigation and resulting refinement of the framework and analytical rigor employing institutional grammar.

Keywords. Collaborative governance, AI systems, governance design, tribal nations, socio-technical systems, AI chatbots
Research paper, DOI: https://doi.org/10.59490/dgo.2025.980

1. Introduction

The governance of artificial intelligence (AI) for public value creation is both a significant challenge and forward-looking opportunity for digital government. AI affords capabilities in finding patterns and making predictions by leveraging numeric, text, and image data to improve public policy and administration. However, the data-driven AI algorithm also tends to magnify and worsen the biases and errors existed in the data (Wirtz et al., 2020; Young et al., 2021). Such biases tend to disproportionately impact marginalized populations such as indigenous people that are not appropriately represented in the digital data sphere. The forward-looking opportunity lies in the design and implementation of a governance framework that proactively minimizes the harm and optimize public value creation.

The current literature on the governance of AI has provided governance options and frameworks (Chen et al., 2023; Wirtz et al., 2022; Young et al., 2019). Governance solutions span from within a particular governance agency, to national AI governance arrangement, and to a regional or global governance rules for responsible AI. EU AI Act passed in 2024 is an example of managing the risks of AI. Industry self-governance has been promoted by major international corporations as a governance option. The academic scholarship has provided governance frameworks that address the unique features of public administration (Chen et al., 2023; Gasco-Hernandez et al.,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2022; Ruijer, 2021; Wirtz et al., 2022; Young et al., 2019). One such framework is the four-layered and integrative AI governance framework, inclusive of risks, risk management, guidelines, and governance layers, that aims for risk management (Wirtz et al., 2022).

However, the knowledge gap of AI governance exists in several crucial areas as related to public value creation and salient issues facing our society. First, the governance of AI in cross-sovereignty context as related to marginalized tribal nations and indigenous communities is under-addressed. Second, there is a gap in fully addressing the complexity of the interactions between the social system and technical systems for effective governance of technologies such as AI. Lastly, the literature has opportunities to grow in governance of AI in addressing emergency management as a growing public service area.

This paper aims to provide a governance framework to address the three aforementioned areas of knowledge gap. This framework focuses the cross-sovereignty context of national government working with tribal nations while recognizing the legal and policy framework governing the design and implementation of AI systems. It takes an integrative and interdisciplinary approach to analyze the socio-technical system while recognizing the embeddedness of rules and processes at multiple levels. This paper focuses on the AI chatbots for emergency management to address the salient issues of EM in the wake of rising natural and manmade disasters. For public value creation, this paper selects accountability as an important public value recognized by both software and public administration scholars and encompassing other public values.

Section 2 provides the specifics on the cross-sovereignty context, accountability, AI systems, and emergency management to pinpoint the contribution of the proposed framework to the larger literature. Section 3 develops and describes the proposed multi-level collaborative cross-sovereignty governance framework grounded in the supporting literature and practice. This section constitutes the majority of the paper length. Section 4 provides a summary of the work and point to future research.

2. Context, Accountability, AI System Design, and Emergency Management

2.1 The Socio-Technical and Cross-Sovereignty Context

The broad socio-technical context includes biological and physical attributes, natural and man-made resources, data, technology, policy and legal frameworks, rules at the constitutional and collective action levels, political and power relationships, socioeconomic and cultural characteristics, and history of collaboration and conflicts (Chen & Lee, 2018; Emerson & Nabatchi, 2015a; Ostrom, 2010). Biological and physical attributes are essential for understanding the bio-physical context of public service challenges such as disaster recovery (Ostrom, 2010). The state of and need for data and technology are essential for digital governance across boundaries (Chen & Lee, 2018a). Data and technology elements relevant to the context are particularly salient for the development and implementation of information systems in tribal nations facing the challenge of limited internet accessibility and digital infrastructure (Intahchomphoo, 2018). Rules at the constitutional and collective action levels reflect the formal policy and legal requirements and the informal cultures and power relationships.

A cross-sovereignty context requires attending to both formal and informal aspects of collaboration. The history of conflicts and collaboration is another salient contextual element for collaborative governance. An important historical context is the harm U.S. federal government policies have inflicted on indigenous people, such as through the Indian Removal Act in 1830, which removed Indian tribes from their original lands, and the Dawes Act in 1887, which sent children in Indian tribes to boarding schools.

Such cross-sovereignty context increases the heterogeneity and complexity of governing and designing software systems. From the beginning, tribal nations have held land and their own form of governance, as determined in the Supreme Court cases of Cherokee Nation v. Georgia, 30 the U.S. 5 Pet. 1 (1831), and Worcester v. Georgia, 31 the U.S. 515 (1832) at 516. The complexity of governance grew after the passage of the Wheeler-Howard Act in 1934, also known as the Indian Reorganization Act. This Act created tribal governments that replicated the U.S. form of governance, complete with an executive branch, legislative branch, and judiciary. Today, this often translates to a tribal chairman, tribal councils, and court systems. This Act also created Constitutions written by the individual tribes, with their own laws, police, and set of procedures. Moreover, there is heterogeneity in the capacity, population, land area, and governance structure among tribes. There are 574 federally recognized Indian tribes 87 FR 4636 (United States Bureau of Indian Affairs, 2022). The Census Bureau's data on the American Indian and Alaska Native populations reveals the diversity of population sizes. Reservations can range from the 15-million-acre Navajo reservation in Arizona to the 1.32 acre Likely Rancheria of the Pit River Tribe in California (Tiller & Harris, 2015). Each reservation has its own government and governance structure and process that blend U.S. and tribal elements.

Explicit recognition and consideration of tribal sovereignty is essential for effective inter-governmental collaboration between the U.S. government and tribal nations (Quick, 2021). There is an urgency to address the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

challenges of climate change and environmental stewardship that do not comply with jurisdictional boundaries (Kettl, 2006). The experiences in inter-governmental collaboration involving tribal nations suggest the importance of recognizing and protecting boundaries rather than dissolving them (Quick & Feldman, 2014). Mutual consent among sovereign entities is necessary. Sovereignty necessitates proper tribal consultation to facilitate inter-governmental collaboration (Quick, 2021).

2.2 Accountability and Its Assessment

Accountability is a core concept of public administration (Koppell, 2005) and a significant public value to enable the advancement of other public values (Nabatchi, 2018). Some people in the computer science community also recognize the importance of holding software systems accountable for the core values held by our society such as privacy and security (Feigenbaum et al., 2011). On a basic level, accountability is about holding an organization or individual to be responsible for its actions (Lampson, 2005). Some actors (either organizations or individuals) have the right to hold other actors to a set of responsibility standards, judge the fulfilment of these standards, and to impose sanctions for not meeting these standards (Grant & Keohane, 2005, p. 29). Although contexts and conceptualizations of accountability differ, the organizing question is who is accountable to whom and for what.

This paper takes an inclusive approach to accountability for public policy and administration by defining it as the achievement of policy objectives. This paper extends policy objectives to intermediate ones, including the development of technical and governance capacities needed for achieving the final policy objectives. The process capabilities are critical conditions for achieving policy goals (Overman & Schillemans, 2022). A design of effective collaborative process across organizations and jurisdictions constitutes a process capability.

Moreover, this paper incorporates the varying assessments by key stakeholders representing different sovereign entities and the people impacted. Stakeholder bodies include, but not limited to, governmental agencies, professional associations, civil society organizations, client representation groups, and interest groups (Brummel, 2025). The perspective and focus of a particular group of stakeholders can impact the assessment of goal attainment. For instance, the U.S. federal government probably focuses on what is prescribed by federal laws and regulations for their collective interactions with tribal nations. Tribal nations tend to focus on their unique conditions and needs. The proposed framework's inclusive approach allows for multiple assessments of accountability depending on the stakeholder in question. Moreover, the involvement of a variety of stakeholders brings the benefits of multiple perspectives, including control, institutional, managerial, learning, and reputational (Brummel, 2025).

2.3 Interdisciplinary and Integrative Design

This paper aims to develop a preliminary framework of collaborative governance of information systems for public service across sovereign entities. This framework integrates insights from collaborative governance by Emerson and Nabatchi (2015a, 2015b), institutional analysis and development by Ostrom and colleagues (Ostrom, 2010; Ostrom et al., 1994), and digital governance by Chen and Lee (Chen & Lee, 2018). Our framework first recognizes sovereign nations and the U.S. governments as autonomous entities entering a collaborative arrangement. Such recognition serves as the political and institutional basis for collaboration (Emerson & Nabatchi, 2015a). The recognition of autonomy in decision-making aligns with the self-determination and sovereignty of tribal nations.

This framework also integrates insights from human-computer interaction (HCI) research with an emphasis on working with indigenous people. Successful intercultural HCI design goes beyond a typical design process by considering different mentalities, thought patterns, and problem-solving strategies unique to different cultures (Abdelnour-Nocera et al., 2013). It is important to acknowledge local epistemologies in HCI research and prioritize values such as harmony and humanness in community-based interactions. One main challenge facing HCI design involving indigenous people is that information dissimilarities may arise from a knowledge mismatch between indigenous participants and researchers (Parsons et al., 2016). Participatory design empowers indigenous members as co-participants to enhance the understanding and application of indigenous knowledge and practices. For example, storytelling and reflection are more appropriate ways of knowledge sharing with indigenous people (Ostashewski et al., 2020).

The development of this framework advances the knowledge about governance design by following the guidelines for applying design science in public administration (Meijer, 2024). The focus of this paper is on governance design. The considerations of methodological guidelines such as studying causal mechanisms, understanding the distinctive impacts of context and design intervention, and addressing the interactive effect of design and context. The proposed framework also shares the goal of moving from the specific cases to generic knowledge (Meijer, 2024) and adds the multi-level and dynamic nature of governance design and outcomes.

2.4 Emergency Management (EM) and EM Technologies

This study focuses on emergency management as a critical area of knowledge advancement in the face of more

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

frequent and larger scale climate-related disaster events such as wildfire, hurricane, flood, etc. An effective approach to emergency management requires a life-cycle approach, including phases of emergency management as defined by the U.S. Federal Emergency Management Agency include preparedness, mitigation, response, and recovery. Collaboration among organizations and individuals in the public, private, and nonprofit sectors is critical for leveraging people and resources needed to respond and recover from an emergency, as defined by FEMA as the whole community approach. Moreover, a cross-jurisdiction coordination and collaboration are equally important as those disasters impact multiple jurisdictions (Kettl, 2006).

Emergency management is even more critical because of the magnified vulnerability experienced by indigenous communities on tribal lands. The impact of climate change hits the indigenous communities particularly hard because of being pushed to move to the marginalized land by the colonizers (Flavelle & Goodluck, 2021). The lack of federal recognition needed for financial assistance for some indigenous tribes exacerbates the recovery challenge (Chavez, 2021). A vast majority of indigenous tribes has only limited financial and human resources for emergency management.

Technologies play an important role in effective emergency management. There are a variety of communication technologies such as social media, web-based EOC, mass notification software programs deployed to facilitate notification of an emergency and coordination of disaster responses (Chen et al., 2024). Technologies can also support decision-making at an emergency operation center by creating a common operating picture to coordinate organizations and individuals to facilitate timely and coordinated responses (Kapucu, 2006).

The recent developments of AI afford the opportunity to process incident-related information from a variety of sources and conduct real-time translation for community-members speaking different languages. Moreover, AI can facilitate the reporting of emergency situation or damage via chats. For instance, AI chatbot can serve as an emergency reporter for the tribal members (Tsai et al., 2023).

3. A Multi-level Collaborative Cross-sovereignty Governance framework for Software System Accountability for Emergency Management

3.1 Governance Design: An Institutional Approach

The governance framework adapts pertinent rules from institutional design (Ostrom, 2010; Ostrom et al., 1994) to model the governance structure of a sociotechnical system for software design. First, participant rules prescribe who can participate in various positions and decisions. For a software system regarding tribal affairs, a participant rule can require someone to be a tribal member to participate in the design. Second, position rules specify the positions that participants can take in the governance structure. At the system design governance level, one position can be policymakers, who decide whether to adopt a certain software system for the entire tribe. Another position is the software co-designer. The third type is authority rules, which prescribe a set of decisions attached to a position. For instance, a software developer has the authority to make technical decisions on the choice of the software development environment. The fourth type is information rules, which prescribe what information is available to each position and decision. For instance, an information rule can allow tribal leadership council members to have full access to the software system development history and system specifications for making the decision on tribe-wide adoption of the system. The payoff rules specify how benefits and costs are allocated to a participant in a specific position. For instance, a tribal member may be a software system user who can use the system for free. This framework utilizes these rules to model the governance structure.

The application of this framework will utilize typology and the specifics of rules to model the governance structure. The governance structure includes the specifics of each type of rules and their configuration. Rule configuration is important to understanding the governance structure and its impact on outcomes (Ostrom, 2010). Moreover, attention will be paid to the rules-in-use, which reflect practice better than the rules in the book. Rules-in-use structure the actual behavior of the participants taking on various positions and making decisions. Thus, some of the empirical work proposed by this project is understanding the rules-in-use.

3.2 Multi-level Governance Structure and Embeddedness for Emergency Management

The sociotechnical system of software system design has three levels within the legal and policy framework for cross-sovereignty relations as seen within the dotted box in Figure 1. The “collaborative governance structure” level includes the laws and policies that structure the interaction between FEMA and tribal nations for emergency management. Tribes typically go through the states where they have land to declare disasters and receive funds from FEMA. Post Hurricane Sandy in 2012, the Federal Government started the Pilot Program, wherein tribes could declare disasters and directly petition on the federal level for funding and help. This process requires a Tribal Chief Executive to declare a disaster after an event has occurred. At that time, the Tribe’s Emergency Plan should be activated (Robert T. Stafford Disaster Relief and Emergency Assistance Act, 1988). An Initial Damage Assessment should be conducted. The disaster event should be of such severity and magnitude that it is beyond the ability of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the tribal government to respond (Federal Emergency Management Agency, 2017). The Initial Damage Assessment requires teams to collect data, travel to the affected areas, and conduct appropriate research on the matter. From there, a Joint Preliminary Damage Assessment is completed by FEMA to substantiate the Initial Damage Assessment. Damages should amount to a minimum of $250,000.00. All this must be done within a 30-day period.

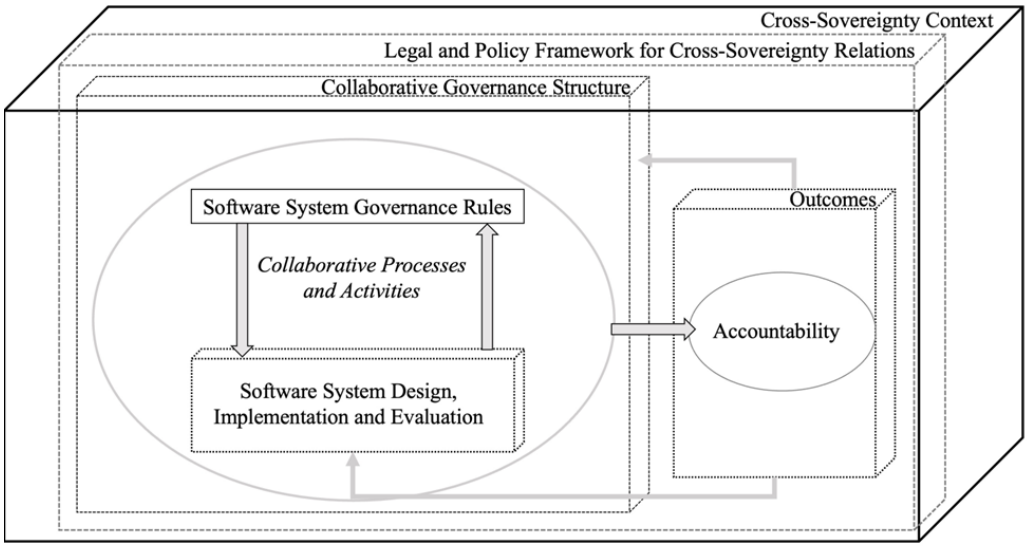


Fig. 1 - Multi-level Collaborative Design Framework for Cross-Sovereignty Software Accountability.

At the level of software system governance as illustrated as the top box inside the oval, there are rules prescribing the design and implementation of software systems across sovereign entities. Participant rules for participatory design can allow tribal members and the FEMA tribal liaison to participate as co-designers of the software system. Position rules prescribe various roles that participants can assume, such as tribal council members, software system designer, and software system users. Authority rules dictate what a position, such as a software system co-designer, can choose to do. For example, a software system co-designer may choose to decide on the features or express feature preferences. Information rules determine what information is available to various positions. For example, software system users may not have access to specific cost and revenue information about the system. The payoff rules specify how benefits and costs are allocated to a participant in a specific position. At this level, the payoff rules specify how the costs and benefits are distributed across users, designers, council leaders, and FEMA officers. Rule configuration and rules-in-use better reflect the reality of the governance structure at this level.

The third level is the technical design of software systems as illustrated as the bottom box inside the oval. The technical design operates within the rules governing participation, positions, authority, information, and payoffs at the system governance level. At this level, the decisions are more technical in nature. Such technical decisions include those on data, information architecture, server, telecommunication networks, and human-computer interface. Such technical design is likely to span across the design, implementation, and validation phases of a prototype.

These decisions at the level of technical software design are embedded in the software system governance level. Rules at the system governance level prescribe the roles, authority, and interactions between people assuming various positions. These rules are further embedded in the level of laws and policies that prescribe the parameters and boundaries within which the rules at the system governance level are legitimate. The base level of the sociotechnical system, such as laws and policies governing cross-sovereign relations, is the most difficult level to change. Such a change requires negotiation between sovereign entities and approval from their respective legislative bodies. The rules at the software system governance level are easier to change than those at the base level. The technical decisions made throughout a software system lifecycle are the easiest of the three levels to modify. Technical rationality is the main basis for justifying decisions. The relative difficulties of changing these levels have implications for the feasibility of recommendations targeting a specific level and for the dynamics of change connecting various levels.

3.3 Processes, Activities, and Dynamics of the Governance Framework

Several processes are essential for effective collaborative governance. These include building trust and shared understanding, cultivating institutions and the capacity for joint action, managing interdependence and motivation, and developing the technical capacity for collaboration (Chen & Lee, 2018; Emerson & Nabatchi, 2015a). Trust building is essential for addressing historical distrust between tribal nations and the U.S. government, which is a

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

barrier to collaboration (Quick, 2021). Furthermore, it is important to have a shared understanding of the goals of the collaboration and incentives for participation (Ansell & Gash, 2008). Joint actions between the U.S. government and tribal nations require guiding principles for collaboration and coordination, such as reciprocity and respect for sovereignty. Effectively managed interdependence provides the needed payoffs for motivating each participating organization to contribute to collaborative efforts. Tribal nations typically depend on the U.S. government's financial assistance in disaster recovery, especially for any damage to their infrastructure. Technological capacity is needed for cross-boundary coordination and collaboration, especially for a sociotechnical system spanning organizations (Chen et al., 2021; Chen & Lee, 2018). Such technical capacity can be a centralized information system used to organize and produce collaborative services.

Collaborative governance processes are used to achieve the intended outcomes. The outcomes for collaborative governance include productivity outcomes, such as effectiveness in achieving policy goals, and process outcomes, such as sustainability of the collaborative process (Emerson & Nabatchi, 2015b). Outcomes can be measured at the level of individual participating organizations or of the collaborative (Emerson & Nabatchi, 2015b; Provan & Milward, 2001). There can also be personal-level outcomes for individual participants. Moreover, these outcomes influence the adaptation of the system context and collaborative governance structures and processes (Emerson & Nabatchi, 2015a). An understanding of these influences over time provides insights into the feedback loops and evolution of the system.

A process framework for accountable AI-enabled systems involves the entire lifecycle of the service goal-setting, system development, service impact, and evaluation (Chen & Ahn, 2022). Participation of key stakeholders when implementing AI systems in the public sector is critical for achieving public values such as efficiency, effectiveness, and accountability. One governance solution is the participation of impacted groups, especially in the phase of goal-setting and evaluation of the impact of AI systems. Facilitative leadership for cross-boundary collaboration in aligning the goals and objectives of participating organizations is likely to be helpful for algorithmic accountability (Mikhaylov et al., 2018). Transparency is also an important element in achieving AI system accountability (Chen & Ahn, 2022). AI systems present new challenges related to transparency that are distinctive from other software systems. The machine learning of model development and refinement introduces opaqueness in system development. A solution to the opaqueness of AI systems that increases transparency is explainable AI that is considered an effective governance solution (Coglianese & Lehr, 2019; König & Wenzelburger, 2020). During the final phase of the lifecycle, it is important to have transparency on the specific impacts of AI systems on each stakeholder group. A process mechanism needs to be in place to ensure transparency from goal-setting to impact evaluation and thus achieve accountability (Chen & Ahn, 2022).

3.4 The Bi-Directional Structure and Processes of Accountable Cross-Sovereignty Smart Chatbot Design

This paper focuses on AI chatbots as a type of AI-enabled software system due to their relevance to a cross-sovereignty context involving tribal community members and their adaptability to a diversity of user capabilities and preferences. AI chatbots are AI-enabled systems that provide interactive, personalized assistance in accomplishing a particular task. The tasks can include finding relevant service information and submitting a service request. The conversational capability of smart chatbots fits the oral tradition of tribal communities, as the chatbots and these traditions use conversations to interact, learn, and organize. Smart chatbots with natural language processing capabilities also allow for voice inputs. Moreover, AI chatbots can adapt to user capabilities and preferences. The capability of both text and voice options on mobile phones supports a variety of user capabilities and preferences. Moreover, a smart chatbot can also personalize the information and support depending on the knowledge and needs of the users.

This section focuses on the bi-directional relationships between the software system governance level and the technical software design level, as illustrated within the oval in Figure 1. The software system governance level prescribes the goals, structure, and processes for the technical software level. The goals of an AI chatbot are to ensure public values such as efficiency, effectiveness, and equity (Chen & Ahn, 2022). These goals are also the basis for the performance metrics assessing process and productivity outcomes. The governance level also dictates the management of financial, human, and material resources for the AI system. The governance-level decisions impact the technical system design level by prescribing which organizations are eligible to participate, what positions are available, what authority is associated with each position, what information is available to what position, and the distribution of costs and benefits across organizational boundaries. A salient aspect of the governance level decision is determining the tribal office and U.S. government offices that are legitimate governmental participants in the cross-sovereignty collaboration.

The results of the decisions at the technical design level serve as important information feedback for the decisions made at the governance level. These technical decisions include how the design addresses use cases and user characteristics. These characteristics include efficacy in using technology, trust in technology, subject literacy, and system-specific familiarity and understanding. In addition, these decisions determine the data used, algorithm development, and the selection of a service platform. The performance of these technical decisions provides the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

needed information for decisions made at the governance level. The performance information can cover the frequency and duration of using AI systems and the extent and quality of the service rendered by the AI system. The information on the practice and behavior of the technical design can be useful for understanding the alignment between prescribed rules and actual behavior.

These bi-directional relationships between the two levels and their joint results become important information feedback for the base level of the sociotechnical system for software design, namely the relations between sovereign entities. The sovereign entities, in this case, the U.S. and tribal governments, can review these bi-directional relationships and collective outcomes. In so doing, they can decide which government or governmental office is a legitimate entity for formulating system governance rules to ensure accountability of the software system to its stakeholders.

Collaborative governance activities shape the bi-directional relationships at the system governance level and system technical design level and their collective impact. Leadership activity can foster shared understanding across sovereign entities and motivation for collaboration. Another main area of activity is cultivating the rules for promoting cross-sovereign collaboration at the system governance level and the technical design level. The development of technical capacity for joint action facilitates coordination among participants across sovereign entities. Collectively, these collaborative governance activities strengthen the bi-directional relationships by providing the conditions for better alignment of activities at both levels and increasing the joint impact of activities at both levels.

The bi-directional relationships and their collective outcome can be seen in the participatory design process aiming to achieve accountability of AI systems for tribal emergency management. Participatory design involves the design of participant rules at the system governance level. Participants should include representatives and users from different stakeholder groups, such as FEMA's tribal affairs office, tribal leadership, tribal emergency management, and tribal user community. The position rules can appoint tribal emergency managers as system co-designers. Moving from the governance level to the technical decision level, these governance level rules prescribe the roles and responsibilities for making decisions at the technical design level. The reverse direction of the relationship involves information feedback on the performance of the AI-enabled chatbot resulting from implementing these participatory design features. The performance information used by participants at the governance level can result in modifications of the AI chatbot governance design, such as the creation of a coordinating committee.

4. Conclusion and Future Application and Research

4.1 Summary and Concluding Remarks

This paper is a development of a governance framework for the study of software accountability in the context of cross-sovereignty collaboration. The specific public administration challenge to address is emergency management that has become increasingly salient in light of the growing frequency and damage of natural and manmade disasters. The focal software system is AI chatbot that leverages natural language processing as an artificial intelligence capability. Such AI chatbot can benefit from the advancement of large language models and computational capabilities. This governance framework draws from collaborative governance in the public administration literature and the human-computer interaction (HCI) in the information science one.

The main contribution of this paper is the articulation of the governance structure and process and their relationships to the accountability results. Such articulation provides the foundation for theoretical and analytical advancements in the accountability of AI systems. The focal contribution lies in the cross-sovereignty context and marginalized circumstances facing indigenous communities.

The governance structure has three levels within the legal and policy framework for cross-sovereignty relations. The collaborative governance structure provides the high-level rules on what action is permitted, incentivized, or prohibited across the entities and individuals that are involved in the cross-sovereignty relationships. Emergency management is the public policy and management issue of focus. The next two levels are on software systems with AI chatbot as the focused system in this paper. Software system governance rules dictate who can participate in the design, who should be accountable for the design, who can get what information, and the benefits and risks associated with decisions. At the more technical level is the software system design, implementation, and evaluation. At this level, technical decisions are made to optimize the goals set by the governance body of the software systems.

Moreover, the levels are embedded from those of software system design, to the governance of such design, to the collaborative governance structure. The technical software system design operates within the goals, parameters, and rules set at the governance design levels. The software system governance rules need to be in congruent with those of collaborative governance structure dictating the eligibility and appropriate behavior of various organizations and individuals participating in the software governance. Such cross-boundary collaborative

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

governance structure embeds itself to the legal and policy framework for cross-sovereignty relations.

The main dynamics between levels are the collaborative processes and activities that address the bi-directional relations between the technical decisions on software systems at the most detailed level and the on decisions on the governance rules for structuring the decision-making, depicted inside the big oval in Figure 1. The governance rules dictate who can set the goals and functionalities of the software systems and who should be accountable for system performance. The technical decisions and their system performance shape the risks and benefits to various stakeholder groups participating and, to a certain degree, the legitimacy of their relative decision-making power. Moreover, there are dynamics jointly determined by actions taken at these two levels to impact accountability. Accountability is primarily measured by goal attainment. Complications lie in the divergent expectations of accountability across various stakeholder groups such as the tribal nations and U.S. governments. As depicted in Figure 1, the perceived accountability as the outcomes will feed back into some possible adjustment of the collaborative governance structure and the collaborative processes and activities for the bi-directional relationships.

4.2 Future Development and Research

The proposed governance framework integrates insights from various bodies of literature across disciplines and prescribes a comprehensive set of structure and process for future development of the theory and practice for AI system accountability. The next logical step is rigorous empirical investigation into the validity and relevance of the levels, their embeddedness, bi-directional relationships, and linkages of collective impact of multi-level governance structure on accountability, and the dynamism in feedback. This study will follow methodological guidelines developed from design science to understand the independent and combined contribution of context and governance design to impact (Meijer, 2024) Such investigation provides opportunities for validation, modification, or refinement of these conceptual elements and their relationships as depicted in Figure 1. Such investigation needs to include extensive policy and document review to study both the rules in the book. Moreover, extensive field research and user input would fill the details needed for the rules in practice and how these rules affect the software system development behavior and the perceived accountability.

Future research on governance for accountable AI systems can benefit from obtaining inputs on the structure and process of this governance framework from a variety of stakeholders. For emergency management, these include stakeholders such as tribal leadership and members and emergency management managers and personnel in U.S. governments. Moreover, the use of analytical framework and tools afforded by institutional grammar (Frantz & Siddiki, 2021) would advance the analytical rigor of studying rules and their configuration for understanding the entities involved and their actions and impacts.

Acknowledgement

- **Funding or Grant:** The authors acknowledge the support of the U.S. National Science Foundation Grant Award Number 2317086.
- **Contributor Statement***: Yu-Che Chen: conceptualization, methodology, visualization, and writing – original draft, final review, and editing. Chun-Hua Tsai: conceptualization and writing – elements of original draft. Edouardo Zendejas: conceptualization.
- **Use of AI***: During the preparation of this work, the author(s) used Grammarly with AI capabilities in order to provide some editing suggestions. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Abdelnour-Nocera, J., Clemmensen, T., & Kurosu, M. (2013). Reframing HCI through local and indigenous perspectives. *International Journal of Human-Computer Interaction*, *29*(4), 201-204. https://doi.org/10.1080/10447318.2013.765759

Ansell, C., & Gash, A. (2008). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory*, *18*(4), 543-571.

Brummel, L. (2025). Stakeholder involvement as a form of accountability? Perspectives on the accountability function of stakeholder bodies in Dutch public agencies. *Public Policy and Administration*, *40*(1), 27-49. https://doi.org/10.1177/09520767231203283

Chavez, R. (2021, October 20). *Why some Indigenous tribes are being left behind in Louisiana's Ida recovery*. PBS News. https://www.pbs.org/newshour/nation/why-some-indigenous-tribes-are-being-left-behind-in-louisianas-ida-recovery

Chen, T., Gil-Garcia, J. R., Burke, G. B., Dey, A., & Werthmuller, D. (2024). Characterizing technology affordances,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

constraints, and coping strategies for information dissemination to the public: Insights from emergency messaging in US local governments. *Government Information Quarterly*, *41*(1), 101910. https://doi.org/10.1016/j.giq.2024.101910
Chen, Y.-C., & Ahn, M. (2022). Governing AI Systems for Public Values: Design Principles and a Process Framework. In J. B. Bullock, Y.-C. Chen, J. Himmelreich, V. M. Hudson, A. Korinek, M. M. Young, & B. Zhang (Eds.), *The Oxford Handbook of AI Governance. Oxford University Press*. https://doi.org/10.1093/oxfordhb/9780197579329.001.0001
Chen, Y.-C., Ahn, M. J., & Wang, Y.-F. (2023). Artificial Intelligence and Public Values: Value Impacts and Governance in the Public Sector. *Sustainability*, *15*(6), 1–22. https://doi.org/10.3390/su15064796
Chen, Y. C., Cheng, X., & Knepper, R. (2021, June). Performance of US scientific research cyberinfrastructure: Structural and relational factors for usage. In *Proceedings of the 22nd Annual International Conference on Digital Government Research* (pp. 424-436). https://doi.org/10.1145/3463677.3463722
Chen, Y.-C., & Lee, J. (2018a). Collaborative data networks for public service: Governance, management, and performance. *Public Management Review, 20*(5), Article 5. https://doi.org/10.1080/14719037.2017.1305691
Chen, Y.-C., & Lee, J. (2018b). Collaborative Data Networks for Public Service: Governance, Management, and Performance. *Public Management Review, 20*(5), 672–690.
Coglianese, C., & Lehr, D. (2019). Transparency and Algorithmic Governance. *Administrative Law Review*, *71*(1), 1-56. https://www.jstor.org/stable/27170531
Emerson, K., & Nabatchi, T. (2015). *Collaborative governance regimes*. Georgetown University Press.
Emerson, K., & Nabatchi, T. (2015). Evaluating the productivity of collaborative governance regimes: A performance matrix. *Public Performance & Management Review*, *38*(4), 717-747. https://doi.org/10.1080/15309576.2015.1031016
Feigenbaum, J., Jaggard, A. D., & Wright, R. N. (2011, September). Towards a formal model of accountability. In *Proceedings of the 2011 New Security Paradigms Workshop* (pp. 45-56). https://doi.org/10.1145/2073276.2073282
Flavelle, C., & Goodluck, K. (2021, June 27). Dispossessed, Again: Climate Change Hits Native Americans Especially Hard. *The New York Times*. https://www.nytimes.com/2021/06/27/climate/climate-Native-Americans.html
Frantz, C. K., & Siddiki, S. (2021). Institutional Grammar 2.0: A specification for encoding and analyzing institutional design. *Public Administration, 99*(2), 222-247. https://doi.org/10.1111/padm.12719
Gasco-Hernandez, M., Gil-Garcia, J. R., & Luna-Reyes, L. F. (2022). Unpacking the role of technology, leadership, governance and collaborative capacities in inter-agency collaborations. *Government Information Quarterly, 39*(3), 101710. https://doi.org/10.1016/j.giq.2022.101710
Grant, R. W., & Keohane, R. O. (2005). Accountability and abuses of power in world politics. *American Political Science Review*, *99*(1), 29-43. https://doi.org/10.1017/S0003055405051476
Intahchomphoo, C. (2018). Indigenous peoples, social media, and the digital divide: A systematic literature review. *American Indian Culture and Research Journal*, *42*(4), 85-111. https://doi.org/10.17953/aicrj.42.4.intahchomphoo
Kapucu, N. (2006). Interagency communication networks during emergencies: Boundary spanners in multiagency coordination. *The American review of public administration*, *36*(2), 207-225. https://doi.org/10.1177/0275074005280605
Kettl, D. F. (2006). Managing boundaries in American administration: The collaboration imperative. *Public Administration Review*, *66*(Supplement to Issue 6 (Special Symposium on Collaborative Public Management), 10-19.
König, P. D., & Wenzelburger, G. (2020). Opportunity for renewal or disruptive force? How artificial intelligence alters democratic politics. *Government Information Quarterly, 37*(3), 101489. https://doi.org/10.1016/j.giq.2020.101489
Koppell, J. G. (2005). Pathologies of Accountability: ICANN and the Challenge of "Multiple Accountabilities Disorder." *Public Administration Review, 65*(1), 94–108. https://doi.org/10.1111/j.1540-6210.2005.00434.x
Lampson, B. (2005, October). Accountability and freedom. In *Cambridge Computer Seminar, Cambridge, UK* (pp. 1-26).
Meijer, A. (2024). Design science in public administration: Producing both situational interventions and generic knowledge. *Perspectives on Public Management and Governance*, gvae012. https://doi.org/10.1093/ppmgov/gvae012
Mikhaylov, S. J., Esteve, M., & Campion, A. (2018). Artificial intelligence for the public sector: opportunities and challenges of cross-sector collaboration. *Philosophical transactions of the royal society a: mathematical, physical and engineering sciences*, *376*(2128), 20170357. https://doi.org/10.1098/rsta.2017.0357
Nabatchi, T. (2018). Public values frames in administration and governance. *Perspectives on public management and governance*, *1*(1), 59-72. https://doi.org/10.1093/ppmgov/gvx009
Ostashewski, M., Johnson, S., Marshall, G., & Paul, C. (2020). Fostering reconciliation through collaborative research in Unama'ki: engaging communities through indigenous methodologies and research-creation. *Yearbook for Traditional Music*, *52*, 23-40. https://doi.org/10.1017/ytm.2020.7

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Ostrom, E. (2010). Institutional Analysis and Development: Elements of the Framework in Historical Perspective. In C. Crothers (Ed.), *Historical Developments and Theoretical Approaches in Sociology: Vol. II* (pp. 261–288). EOLSS (Encyclopedia of Life Support Systems) Publishers, Co. Ltd.
Ostrom, E., Gardner, R., & Walker, J. (1994). *Rules, games, and common-pool resources*. University of Michigan press.
Overman, S., & Schillemans, T. (2022). Toward a public administration theory of felt accountability. *Public Administration Review*, *82*(1), 12-22. https://doi.org/10.1111/puar.13417
Parsons, M., Fisher, K., & Nalau, J. (2016). Alternative approaches to co-design: Insights from indigenous/academic research collaborations. *Current Opinion in Environmental Sustainability, 20*, 99–105. https://doi.org/10.1016/j.cosust.2016.07.001
Provan, K. G., & Milward, H. B. (2001). Do networks really work? A framework for evaluating public-sector organizational networks. *Public Administration Review*, *61*(4), 414-423. https://doi.org/10.1111/0033-3352.00045
Quick, K. (2021). Tribal sovereignty and the limits and potential of inter-governmental collaboration. In J. W. Meek (Ed.), *Handbook of Collaborative Public Management* (pp. 253–267). Edward Elgar Publishing.
Quick, K. S., & Feldman, M. S. (2014). Boundaries as Junctures: Collaborative Boundary Work for Building Efficient Resilience. *Journal of Public Administration Research and Theory, 24*(3), 673–695. https://doi.org/10.1093/jopart/mut085
Robert, T. (1988). *Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288 as amended)*.
Ruijer, E. (2021). Designing and implementing data collaboratives: A governance perspective. *Government Information Quarterly*, *38*(4), 101612. https://doi.org/10.1016/j.giq.2021.101612
Tiller, V. E. V., & Harris, L. (2015). *Tiller's Guide to Indian Country: Economic Profiles of American Indian Reservations, Third Edition*. Bow Arrow Publishing Company.
Tsai, C. H., Rayi, P., Kadire, S., Wang, Y. F., Krafka, S., Zendejas, E., & Chen, Y. C. (2023). Co-design disaster management chatbot with indigenous communities. In *20th International Conference on Information Systems for Crisis Response and Management (ISCRAM)* (Vol. 2023, p. 1).
United States Bureau of Indian Affairs. (2022, January 28). *Indian Entities Recognized by and Eligible To Receive Services From the United States Bureau of Indian Affairs. Notices* (87 FR 4636). Office of the Federal Register, National Archives and Records Administration; Federal Register. https://www.govinfo.gov/app/details/FR-2022-01-28/2022-01789
Wirtz, B. W., Weyerer, J. C., & Kehl, I. (2022). Governance of artificial intelligence: A risk and guideline-based integrative framework. *Government Information Quarterly, 39*(4), 101685. https://doi.org/10.1016/j.giq.2022.101685
Wirtz, B. W., Weyerer, J. C., & Sturm, B. J. (2020). The Dark Sides of Artificial Intelligence: An Integrated AI Governance Framework for Public Administration. *International Journal of Public Administration, 43*(9), 818–829. https://doi.org/10.1080/01900692.2020.1749851
Young, M. M., Bullock, J., & Jesse D. Lecy. (2019). Artificial Discretion as a Tool of Governance: A Framework for Understanding the Impact of Artificial Intelligence on Public Administration. *Perspectives on Public Management and Governance, 2*(4), 301–314. https://doi.org/10.1093/ppmgov/gvz014
Young, M. M., Himmelreich, J., Bullock, J. B., & Kim, K. C. (2019). Artificial intelligence and administrative evil. *Perspectives on Public Management and Governance*, *4*(3), 244-258. https://doi.org/10.1093/ppmgov/gvab006

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Rethinking AI Readiness: A Framework for LMICs with Argentina as Case Study

Lucia Mariana Galarreta Bolia[a]

[a]AI4Gov alumni, Politecnico de Madrid and Politecnico di Milano, Spain- Italy, https://orcid.org/0009-0004-0167-0257, lgalarretab@outlook.com.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 8 July 2025

Abstract. Standard indices and AI readiness criteria often do not adequately capture digital transformation's complex and context-specific dynamics in the public sector, especially in low and middle-income countries (LMICs). These tools typically provide decontextualized, static indicators that fail to consider historical processes and the evolution of local institutions. This paper examines Argentina's experience with AI adoption in the public sector using the Digital Government Ecosystem (DGE) framework —a context-sensitive tool that emphasizes the interaction of institutional, organizational, and governance factors. Drawing on empirical data, the study analyzes how AI initiatives have emerged, evolved, and been influenced by both national and subnational dynamics. It argues that understanding AI implementation as a situated and evolving process is essential for developing more meaningful assessments and strategies in LMIC contexts. The findings aim to contribute to more accurate, locally grounded approaches to analyzing and guiding AI integration in public administration.

Keywords. AI Readiness criteria, AI index, digital government, digital transformation, Artificial Intelligence Institutional Capacity, AI Governance, Argentina, Global South, Low- and Middle-Income Countries (LMICs).
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1069

1. Introduction

Like many Latin American countries, Argentina grapples with many challenges to ensure the full exercise of rights. These obstacles include poverty, low levels of education, poor connectivity in remote areas, technological backwardness, economic issues, and challenges to federal government organizations. The country's complex agenda involves addressing these 'fundamental problems' while striving for government technological improvement and digital innovation. This dual focus is crucial to prevent further widening of existing inequality.

While the UN E-Government Survey 2022 ranks Argentina at 41, indicating that the country has a very high level of e-government development, there are no significant examples of applying AI in public policies in Argentina. This could indicate that other variables may be needed to address this lag between AI adoption in the public sector and its relatively high performance on e-government indicators.

How does a country with a very high E-Government Development Index (EGDI) like Argentina have only so few AI initiatives in its public sector? What minimum conditions does Argentina need to implement AI solutions in public policies that respect rights and address the diverse problems of its population? More importantly, could existing frameworks and indexes provide categories to analyze the readiness levels to enable the implementation of AI to improve public service delivery in Latin America, or should other categories and frameworks be sought and developed?

While existing frameworks and indexes can provide categories for analyzing the readiness or conditions for AI implementation in the public sector, a more comprehensive understanding of the context and needs that hinder AI implementation is crucial. This emphasis on thorough research is necessary to develop practical recommendations and guidelines for the Argentinian public sector.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This research explores the existing frameworks and indexes and assesses their limitations. It also attempts to describe the conditions that influence how AI is adopted in the public sector in the complexity of the Argentinian case, based on data and policy analysis as of early 2024. Finally, it will propose a different approach to understanding how AI solutions are introduced into the public sector in Latin America, specifically in Argentina. Moreover, it is important to provide a more comprehensive perspective than those offered by some of the existing indexes.

2. State of the art and theoretical background

This section reviews existing indexes and AI readiness criteria, the main theoretical approaches, and the concepts used in this work. These will help frame a more situated analysis of AI implementation in Latin America and Argentina. It will explain how we understand the limitations of indexes as the only tool that provides information about national government conditions and readiness, mainly because they cannot grasp each context's challenges and opportunities. Federal or centralized governments are different, and for that, digital transformation is not adopted in the same way in each country. The adoption path of AI to low and middle-income countries (LMICs) differs from that of the wealthiest countries.

It also tries to address some crucial concepts to understand our case. Digitalization and digital transformation are required to analyze how AI is adopted in a country, and the importance of understanding the maturity of this digitalization process. One of the main objectives of this chapter is to define them and explain how they play a part in this analysis. It is also essential to understand why AI adoption in the public sector is related to the main objective of government, which, in my work, I frame as the provision of public value through different types of public policies and regulations.

2.1 The limitation of Indexes

There are many examples of public AI readiness indexes. Helen Tueni and Andrea Glorioso (2022)in their master's thesis, did an excellent job reviewing indexes and frameworks such as the OECD, the Government AI Readiness Index from Oxford Insights, and others. This builds on seminal work analyzing AI readiness in the public sector (Ubaldi, et al., 2019; Berryhill et al., 2019) that established foundational criteria for evaluating governmental preparedness for emerging technologies. Even though these have their differences in categories and approaches, the coincidences are focused on the following:

- Data and its availability, quality, and treatment.
- Public servant skills and technical capabilities around security and transparency.
- The existence of regulations and political decisions to modify cultural barriers propels changes and innovation in public services.
- Infrastructure and cybersecurity.

The Latin American Artificial Intelligence Index (ILIA) - developed by universities and governmental agencies from Chile, IADB, CAF, and UNESCO - represents a regional approach to measuring AI readiness. While it takes a more situated perspective and includes factors such as infrastructure maturity, data availability, and talent development, its categories largely mirror those of international indexes. Furthermore, as a general index rather than one specifically focused on the public sector, it provides limited insight into the particular challenges of government AI adoption.

All the indexes that analyze the readiness of the public sector have challenges in addressing the complexity of the problems that specific regions, such as Latin America and the Caribbean, would face in the walkthrough of AI development. These challenges extend beyond simple metrics to fundamental infrastructure issues. For instance, while indexes emphasize data availability and quality, they often overlook the fundamental challenges of digitalization and interoperability that many governments still face. Even when digitalization initiatives exist, as Novas's study (2019) of Argentina's Electronic Document Management platform shows, implementation often reveals significant operational challenges that indexes fail to capture.

The case of public servant capabilities also illustrates these limitations. Despite having over 137 post-secondary technology education programs in Argentina, only about 50% of public servants have postsecondary education, primarily in health and education rather than technology sectors (Maito, Garay, & Schachte, 2023). This example demonstrates how standard readiness metrics may miss the complex interplay between general education levels, specific technical skills, and actual public sector needs.

2.2 Digitalization

The previously analyzed indexes miss a crucial dimension in Latin America's AI path: the comprehensive

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

understanding and implementation of digitalization in the public sector. Adopting new technologies, such as AI, requires a deep understanding and a willingness to modify traditional and previous public sector activities and services.

In an exhaustive Inter-American Development Bank study, Estevez et al. (2024) propose an enlightening classification of government types based on their digital evolution. A "traditional government" delivers public services to citizens upon request, over the counter, and provided by a human public servant. A "digital government" advances this by delivering services through digital channels upon request, still provided by a human public servant. The most evolved form, an "automated government," delivers services proactively through digital channels, with algorithms replacing or complementing human public servants.

This classification aligns with Holmström's (2022) conceptualization of digital evolution in organizations. He identifies digitization - the process of converting analog to digital - as a preliminary stage that precedes digitalization, which involves using digital technologies and digitized data to establish new ways of working (Holmström, 2022, p. 330). Building on this foundation, he frames AI adoption as part of a broader digital transformation, defining AI readiness as "an organization's abilities to deploy and use AI in ways that add value to the organization. This represents "the profound transformation of organizational activities, boundaries, and goals to leverage the opportunities of digital technologies" (Holmström, 2022, p. 331).

Estevez et al. and Holmström's approaches provide valuable insights that standard readiness indexes often overlook. They emphasize that digital transformation is a progression of steps rather than a set of conditions, and both frameworks place value creation at the core of digital transformation efforts, including AI adoption. This progression is not just theoretical but represents a crucial roadmap for the public sector's future. Without successfully establishing traditional and digital government foundations, transitioning to an automated government, which relies on this accumulated history, structure, and capabilities, becomes problematic. This understanding underscores the urgency of addressing fundamental digital governance issues before governments can embrace AI's potential meaningfully.

2.3 Maturity of the Digital Environment

To understand how digital transformation unfolds in different contexts, Lorenzo (2016) introduces the concept of "maturity models" to indicate the incremental path organizations must take to increase digital maturity. The maturity refers to the formalization and optimization level of the process these organizations acquired (Lorenzo, 2016, p. 575) This concept is crucial for our work because it introduces the concept of time in a step-by-step development towards an ultimate ideal state of digital transformation, seeing it as a process, not as a moment, like indexes do. At the same time, maturity models focus on organizations as their core unit, which is a limitation for understanding an ecosystem's broader capabilities, as this work aims to do.

The historical development of digital government demonstrates the concept of maturity in this context. In high-income countries, some governments began collecting digital information and establishing institutional frameworks, infrastructure, technology, and human capacity as early as the 1950s. This process was driven by the need to enhance efficiency and manage information, alongside the introduction of computer technologies. This early adoption of information technology laid the groundwork for the development of electronic government and facilitated digital transformation in subsequent years (Margets, 2022). These initiatives are characterized by their long-term policies, which are less subject to changes in political administration. They are considered strategic, as they provide resources and infrastructure over time.

According to Estevez et al. (2024), one crucial condition for implementing new technologies in a digital governmental ecosystem is to do so with proven and mature ones, guaranteeing safety and respect for citizen rights. This principle emphasizes the importance of ensuring that digital systems and processes have reached an appropriate level of maturity before they are widely implemented, particularly in contexts where institutional capacities may be limited or resources are constrained.

The maturity criteria apply fundamentally to digital environments and their readiness for digital transformation. AI implementation becomes desirable when the digital ecosystem demonstrates sufficient maturity to guarantee safety and rights protection across different government levels. This maturity requires time, sustainability, political decisions, and resources—elements that are often scarce in developing regions. Therefore, the challenge goes beyond technical capabilities; it also involves prioritizing long-term policies, ensuring sustained resource allocation, and maintaining institutional consistency. These factors are essential for fostering robust digital ecosystems that can support the adoption of AI.

2.4 Public Value in Digital Transformation

One of the main objectives of a government is to create public value: "To produce public value with no (or minimal) waste of government resources such as time, effort, authority, and others" (Estevez, Janowski, & Roseth, 2024, p.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

9). This objective becomes particularly critical in the context of digital transformation as it involves three interconnected elements: political aspects (public value creation), operational capabilities, and strategic capabilities. These elements form the foundation for transformation towards digitalization and automation, where the potential to reduce waste and improve resource management offers significant efficiency gains that cannot be ignored or postponed. In the current technological landscape, the risk of failing to deliver public value increases when governments undermine the priority of addressing digital transformation and automation.

The pursuit of public value through digital transformation can follow multiple pathways, each with its own implications for government effectiveness. These pathways manifest in different dynamics:

- Scaling and maturing the entire digital governmental system—This is a comprehensive approach that seeks to enhance public value creation across all government functions and levels simultaneously.

- Fragmentary efforts in different domains and levels of government—This is a more targeted approach, where public value is enhanced in specific areas or services based on immediate needs or opportunities.

- One-shot implementations in specific contexts - Focused interventions addressing particular public policy problems, often in response to well-defined challenges or opportunities for innovation.

These pathways are not mutually exclusive but rather represent different strategies for enhancing public value through digital means. In the Latin American context, these multiple approaches often coexist, reflecting the region's complex reality of public administration. While traditional recommendations advocate for a centralized, whole-of-government strategy to provide coherence in data, technologies, and infrastructure (Estevez, Janowski, & Roseth, 2024, p. 78), the practical pursuit of public value often requires a more flexible approach. This results in the coexistence of bottom-up and top-down initiatives in public policy design, each contributing differently to public value creation through digital transformation.

2.5 Public policies, frameworks, and legislation

The regulatory landscape for AI presents significant challenges and variations globally. Currently, the EU is the only major player with comprehensive AI legislation. At the same time, the United States has taken a more flexible approach through an executive order that outlines regulatory directions. China, meanwhile, has established strict state control rules. Despite these different approaches, unified international AI governance remains a notable vacancy, creating uncertainty for countries developing their own regulatory frameworks. (Klein & Patrick, 2024)

In response to these regulatory challenges, some jurisdictions explore innovative governance approaches such as regulatory sandboxes. As analyzed by the Economic Commission for Latin America and the Caribbean (ECLAC) (Guio, 2024), these sandboxes offer a controlled environment to test new technologies and regulatory frameworks before full-scale implementation. They represent a balanced approach between innovation and regulation, allowing governments to understand and address potential risks while fostering technological advancement. However, in Latin America, the adoption of such innovative regulatory tools has been limited, with only Brazil, Colombia, and Bermuda implementing sandbox initiatives (Guio, 2024). This limited adoption reflects a broader challenge in implementing flexible regulatory frameworks that can support AI innovation while protecting public interests.

This regulatory context has particular implications for LMICs. Without global AI governance frameworks, these nations face significant barriers in accessing and benefiting from AI innovations in crucial areas like healthcare, education, and government efficiency. The lack of established international standards and governance mechanisms exacerbates existing technological gaps between LMICs and more prosperous countries, often leaving developing nations to work in isolation, cut off from markets, funding, and technological innovation opportunities.

The regulatory landscape thus extends beyond mere legal frameworks to encompass broader questions of technological access, innovation capacity, and international cooperation. As countries develop their AI policies and regulations, they must balance multiple considerations: promoting innovation, protecting public interests, ensuring ethical use of AI, and maintaining competitiveness in the global digital economy. For LMICs, this balance is particularly challenging given resource constraints and the need to catch up with rapid technological advancement while ensuring appropriate safeguards are in place.

2.6 Revisiting Key Concepts through the LMIC Lens: Towards an Integrative Framework

The previous sections have outlined several key dimensions that shape how digital transformation and AI adoption unfold in the public sector: readiness indexes, digitalization processes, digital maturity, public value creation, and regulatory frameworks. When these dimensions converge in LMIC contexts, they create a distinct landscape that demands careful consideration. Unlike high-income countries that underwent gradual digital evolution over

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

decades, LMICs face unique challenges in their digital transformation journey, requiring them to address basic digitalization needs while simultaneously pursuing advanced technological capabilities.

Traditional indexes and "readiness criteria" often prove insufficient in this highly contrasting context, offering merely listings of good practices rather than foundational guidelines for realistic AI implementations in the public sector. This limitation stems from their failure to account for core elements such as digitalization infrastructure, resource constraints, and the need for long-term policies and strategies on human resources and talent development.

The contrast between high-income and low- and middle-income countries is particularly stark in their digitalization pathways. While developed nations followed planned and gradual digitalization efforts, LMICs typically experience rapid and disorderly changes, leading to less structured and more complex digitalization processes. The UN E-Government Survey consistently highlights these disparities in digital infrastructure and capacity between developed and developing nations.

This situation is further complicated by the political dynamics in LMICs, where changes in administration often result in policy discontinuity or abandonment, jeopardizing previous achievements. The challenge of strengthening digital ecosystems becomes particularly acute when considering system scalability, which requires sustained resources, long-term projects, and institutional consistency across different governments. For instance, some systems may become inoperative when national governments fail to provide resources to provinces or municipalities, severely limiting possibilities for scaling and innovation. In federal countries like Argentina, this challenge is amplified by the high cost of political transactions, where party politics often dominate negotiation processes (Palumbo, 2019, p. 143).

The creation of public value, which should be the primary goal of any government, becomes especially critical in LMICs given their complexity and limited resources. Unfortunately, we often observe the implementation of "canned responses" that provide little real benefit while consuming precious resources. This creates a fundamental tension: how can these countries harness AI's benefits for public value creation while simultaneously building the comprehensive digital foundation that the literature suggests is necessary?

The global context further compounds these challenges. The absence of global AI governance particularly affects LMICs' ability to access and benefit from AI innovations in areas such as healthcare, education, and government efficiency. Without such governance, the gap between LMICs and more prosperous countries continues to widen, often leaving developing nations to work in isolation, cut off from markets, funding, and technological innovation opportunities.

However, regional initiatives offer some hope. Despite historical fluctuations in Latin American cooperation, AI has emerged as a unifying agenda, exemplified by the Santiago Declaration. This agreement establishes a workgroup for an Intergovernmental Artificial Intelligence Council for Latin America and the Caribbean, which represents a pivotal moment for the region. Despite varying national positions, including Argentina's, this initiative creates an opportunity to address shared regional challenges and ensure the Global South's perspectives are included in broader AI discussions.

Given these realities, Latin America and the Caribbean must develop frameworks that better reflect their circumstances and actual position in the AI adoption journey. These frameworks should account for the unique challenges and opportunities present in the Global South, moving beyond traditional assessment models to create more relevant and actionable guidance for digital transformation. This recognition forms the foundation for the analytical framework proposed in this work.

3. The Argentinian Case

In this section, we will analyze Argentina's adoption of AI in the public sector through the conceptual lens developed in the previous chapter. This analysis will allow us to identify Argentina's specific challenges and opportunities in implementing AI technologies within its complex institutional framework. First, we will examine the most significant AI initiatives implemented in recent years, evaluating not only their technical characteristics but also how they reflect the broader digital maturity of Argentina's public sector. After establishing this empirical foundation, we will assess the country's digital infrastructure, data governance practices, and institutional readiness to develop a comprehensive understanding of Argentina's digital ecosystem and its capacity for AI integration.

This analysis reflects the situation in Argentina as of early 2024. While specific digital government initiatives may evolve with changing administrations, the structural challenges and institutional arrangements tend to persist beyond political transitions. Readers should consider potential developments that may have occurred after the research period.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3.1 AI experiences in the Argentinian public sector

Despite the global acceleration of AI technologies and their increasing adoption in public administration worldwide, Argentina's public sector shows a relatively limited implementation of AI solutions. The existing initiatives can be categorized into several functional areas:

- Citizen-facing conversational AI

The national government's "Tina" chatbot is a virtual assistant that is available 24/7. It provides citizens with information on more than 200 procedures, programs, scholarships, subsidies, and consultations on health, inclusion, justice, transparency, and gender issues.

Similarly, Buenos Aires City implemented "Boti," an AI chatbot for citizen assistance. During the COVID-19 pandemic, this platform was enhanced with "IAtos," an AI tool that detected potential COVID infections by analyzing user cough audio samples.

- Judicial process automation

The "Prometea" system applies artificial intelligence techniques to prepare court opinions automatically. The development of PROMETEA began in 2017 by the Prosecutor's Office in the Autonomous City of Buenos Aires, Argentina. This tool increases efficiency: brought a reduction from 90 minutes to 1 minute (99%) for the resolution of a tender process, from 167 days to 38 days (77%) for processes of the requirement to trial, and from 190 days to 42 days (78%) for protection housing with citation of third parties, among others. (Estevez, Fillottrani, & Linares Lejarraga, 2020)

Like Prometea, there are other experiences in the provinces' justice systems. The provinces of La Pampa and Río Negro are using AI to improve the process and the times of the procedures.

The State Prosecutor of the province of Buenos Aires implemented Velox, a machine-learning model used to help lawyers prepare for the tax hearing issued by the State Prosecutor.

A few additional experiences can be mentioned (OECD and CAF, 2022). While the AI initiatives in Argentina demonstrate the potential of AI to enhance efficiency and service delivery, they often rely on relatively limited technologies. For example, chatbots like Tina and Boti primarily use rule-based systems or basic natural language processing, which can be helpful for citizen interaction. Although Prometea and Velox employ more advanced AI techniques, they focus on automating specific tasks within defined domains. These initiatives are isolated efforts rather than examples of widespread AI adoption within the public sector. This situation highlights the absence of a strategic, national-level plan for AI implementation in Argentina, leading to a fragmented landscape where AI initiatives are concentrated in specific areas without integration into the overall governmental structure.

This fragmentation suggests that, despite technical experimentation, AI adoption remains disconnected from systemic public sector transformation. Understanding this misalignment is critical for informing institutional reforms and capacity-building efforts. These patterns of AI adoption align with broader regional trends identified by Aguerre (2020), where AI implementations in Latin American public sectors tend to be isolated, technologically conservative, and concentrated in urban centers rather than integrated into comprehensive digital transformation strategies.

These experiences highlight a public sector that, despite making significant progress with concrete and replicable solutions, still struggles with strategic coordination. In Argentina, the use of AI in the public sector is mainly focused on improving administrative efficiency and automating processes. However, as we will present in 3.2, there is a lack of a clear governance framework to ensure sustainability, transparency, and social participation in AI development. This underscores the need to transition from isolated technological adoption to a comprehensive and deliberative public policy on AI.

To fully understand the limited scope of these AI initiatives, it is important to consider the scale of Argentina's public sector. Beyond the national administration, Argentina consists of 24 provincial governments, over 1,900 municipal governments, and distinct systems across the executive, judicial, and legislative branches. Given this complex and decentralized structure, the identified AI initiatives represent isolated cases within a much larger and more intricate governmental landscape. This institutional complexity suggests the need for a more nuanced framework to analyze digital readiness—one that accounts for the multilevel nature of governance and the evolutionary process of digital transformation, as will be proposed in Section 4.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3.2 The current Argentinian digital public sector context

The E-Government Survey 2022 ranks Argentina 41st, reflecting a high level of e-government development. However, this overall ranking obscures a more complex reality within Argentina's federal structure, where uneven digital adoption leads to significant variations across different levels of government. Below, we will outline some observations about the Argentine landscape.

Digital Administration System: Argentina's unique federal structure and multiple independent governmental levels present a complex digital landscape. Provinces and municipalities responsible for decentralized services like health, education, and taxes contribute to this complexity. This context underscores that a high level of digitalization at the national level does not fully capture the country's digital reality.

Argentina presents a heterogeneous implementation scenario in the foundational area of administrative document management. Of the twenty-three (23) provincial governments and one federal district, eight (8) provincial executive governments have developed their own digital administrative file systems, while sixteen (16) use the system provided by the national government (called Electronic Document Management or GDE in Spanish). This diversity creates significant interoperability challenges, stemming from both technological differences and varying implementation timelines. For example, while the national government began using the GDE system in 2015, five provinces only adopted it very recently, between 2023 and 2024. At the municipal level, digital adoption is even more limited, with only about 90 municipalities (out of more than 1,900) using GDE as of early 2024.

One technology that has achieved widespread adoption is the digital signature, which enables legally binding electronic authorization of documents, providing security, authenticity, and non-repudiation for digital transactions. Every province has implemented this technology, demonstrating that cross-government digital tools can succeed when they offer clear value and align with existing legal frameworks. Implementing transborder digital signature capabilities with Uruguay, Chile, and Brazil further illustrates the potential for regional digital integration when adequately coordinated.

This uneven landscape affects every element of the digital ecosystem, from data quality and availability to cultural change and digital literacy among public servants. Digital platforms represent just one dimension of AI readiness, which depends on data governance, infrastructure, human capabilities, and regulatory frameworks.

Data Governance: Even though the national government has an open data policy, the volume of datasets available could be higher. With around 1200 datasets, the datos.gob.ar portal provides data from the national government and technical assistance to provinces and municipalities if they are willing to promote a data governance policy. Currently, only 14 provinces and 80 municipalities have open data portals. The same methodology is used with interoperability and authentication platforms, where the national government puts them at the disposition of the provinces. However, this adoption is entirely voluntary and sometimes challenges the technology teams of each part. In fact, the national government is promoting compatibility with provincial platforms that use X-Road, but only two start the first tests. There is no doubt that the improvement in the coordination between agencies and governmental levels to make better use of data already existing is a necessity that breaks the silo logic of the data and starts to create a fertile data governance space where AI could thrive.

Infrastructure Development: In the case of infrastructure, as we said previously, even though the internet coverage is high, it reproduces the inequity of the service distribution across the country. Some locations and populations still need to be communicated, impacting the digitalization level of government services. Moreover, connectivity is mainly through mobile phone networks, which are only used in individual communication activities or are limited to recreational use. Therefore, we should highlight that provinces and municipalities have minimal capabilities to invest in infrastructure because their budgets are mostly compromised by the payroll of their administrations and other priorities. That is why the investment in digital infrastructure for the provinces and municipalities might come from the national government or internationally funded projects from different organizations. In LMIC, that is the rule.

At the national level, the landscape is better, and the national government has more infrastructure. Argentina has ARSAT, at least for the moment, a national company that provides telecommunication services to the central government and the provinces that can afford them. For example, ARSAT has a data center and cloud services and is one of the critical actors in extending the country's optical fiber network (Federal Fiber Optic Network, in Spanish REFEFO). Argentina's national government also has one of the top 500 supercomputers in the world.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

YEAR	2021	2022	2023
	DECEMBER	DECEMBER	SEPTEMBER
Total Km	**31.876**	**32.585**	**32.804**

Fig. 1 REFEFO Extension in km (2021-2023) Self-made figure from internal government documents.

Even though there are still many things to do, Argentina has achieved vast improvements at all its governmental levels related to digital governance and is in a privileged position in the region.

This work does not intend to investigate every case of every subnational government per se. Still, it is essential to describe this complexity to explain why AI tools remain isolated cases dispersed in different agencies along the country's territory. Hence, digitalization at all levels and across the country is a leading condition that governments should address to adopt automation tools such as AI. To enhance what is missing, the maturity of the national digital ecosystem should be analyzed as a whole, with all the governmental levels and stages.

Institutional readiness and human capacity: as mentioned, Argentina is a federal country with different government levels and various institutional designs, where updated and out-of-date technologies coexist. Access to a shared digital infrastructure will not be achieved in the short and medium term because of the absence of a strategic plan for digitalization at all governmental levels that includes a unified infrastructure and interoperable systems. The need for more economic resources is one of the main reasons. This is why data exchange, data governance, and interoperability become core challenges.

At all levels of government, it is still more challenging to have in-house technological expertise than in the private sector, and provincial and municipal governments find this even more difficult because of the existing gaps in resources, education, state capacities, etc. These differences operate between provinces and municipalities and between them and the national government. Where an agency, a ministry, a province, or any part of a government is lucky enough to have a couple of well-trained people in the technology team, empowered to innovate, an improvement is willing to rise. These isolated, short-term solutions show the absence of a national plan or strategy to incorporate AI tools into the public sector at all governmental levels.

Even if this is a problem that every nation has worldwide, in the case of LMIC, the consequences provoke an overreliance on digital and AI solutions made by private companies that have a profound ignorance of government processes, their activities, the rights that must be attended to in public matters, etc. This is crucial to understanding the dispersed experiences with AI solutions in the Argentinian public sector.

Today, with AI development, the risk is high and costly for the government to leave private companies entirely in charge of their AI projects. Even if they outsource the technological expertise, there are many components, such as legal expertise, internal processes, and borderline cases, that only civil servants can provide (Estevez, Janowski, & Roseth, 2024, p. 87). For example, in the case of the TINA chatbot, the UX team is in-house (government) even though the national government contracts with Meta (because of the use of WhatsApp) and with Botmaker to integrate data, API, etc., and deploy the chatbot. It is essential to highlight that even if some AI experiences are partly outsourced, most cases we introduce in the 3.1 part are entirely in-house experiences.

Latin America and the Caribbean are rich in linguistic diversity, with Spanish and Portuguese serving as the predominant national languages alongside many other dialects and languages of native and different ethnicities. This diversity is not a hindrance but a valuable asset that enriches our region. However, it does present a challenge in developing a regional or national technological sector that genuinely reflects the needs and interests of our diverse continent, as the industry predominantly uses English as a universal language. This characteristic underscores the disparities between the South and North and the private and public sectors. The reliance on the private sector for AI or other outsourced projects often leaves the public sector in the hands of companies that do not even program in the same language.

One of the critical criteria for readiness, as identified by indexes, is the acquisition of skills and technological competencies by civil servants. This is crucial, as it enables the government to be more efficient and effective without outsourcing technological development. In the global AI race and the battle for global power, the rapid adoption of new technologies is more feasible if the innovation and capabilities are tailored and hosted within the government (Margets, 2022). Beyond highlighting the risks of excessive outsourcing, it is essential to outline

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

strategies to foster in-house AI capacity. These include creating interdisciplinary teams within government units, establishing public sector AI labs, investing in upskilling programs for civil servants, and fostering partnerships with local universities and research centers. Such efforts build technical expertise and enhance institutional memory and autonomy in AI governance. However, achieving this is more challenging in LMIC because public servants need specific skills, and the technological industry is structured and tailored for the central and wealthiest nations.

In 2019, Argentina unveiled an AI National Plan, a significant step that, unfortunately, has not been fully implemented. Since then, we have seen some scattered governmental actions that could pave the way for creating an ecosystem conducive to AI solutions, but there is still much room for growth. Notable among these actions are a couple of regulations and incentives for the Argentinian case: the AI National Plan (2019), which is yet to be executed, and a Disposition with recommendations for using AI in the public sector (2023). The disposition, titled "Recommendation for a reliable Artificial Intelligence," marks the first regulatory act of the Argentine state in this field. It is based on the UNESCO "Recommendation on the Ethics of Artificial Intelligence," Asilomar AI Principles, and OECD AI Principles, among other principles and papers on the topic.

The absence of global AI governance and the limited regulation framework in Argentina make the condition regarding the existence of regulation, according to what indexes usually indicate, far more complex for LMIC to achieve. The geopolitical competition, the inexistence of a global AI governance, and the breaches in access to every element that enables AI expansion (such as digitalization, funding, technology, infrastructure, education and scientific knowledge, markets, etc.) made it way more difficult for these types of countries to create regulations that could bring security, guarantee rights and create a fertile ground to grow AI initiatives and are the dominant barriers to AI implementation in the public sector. However, it does not imply that AI could not emerge.

Formulating a national AI strategy is a pressing need that must be co-designed, at least with the provinces. A comprehensive national strategy should encompass the entire public sector, not just the national government. In this context, Argentina's various thematic federal councils serve as institutional spaces where all provincial and national governments can collaboratively design strategies to address the sector's needs and challenges. For instance, the Federal Council of the Public Service (in Spanish, Consejo Federal de la Función Pública – COFEFUP) has been a critical platform for the provinces and national government to forge agreements and public policies for 30 years.

Section 4 introduces the Digital Governmental Ecosystem (DGE) framework, a novel approach used in this study to analyze the dynamics of digital transformation (and ultimately AI adoption) within Argentina's public sector more comprehensively than indexes.

4. Different Approaches for Argentina and Latin America

To clarify how we can address Argentina's reality as part of a Latin American landscape, we cannot have precise analyses of the readiness for AI implementation in public service if we ignore the degree of evolution of the digital environment.

As we have seen, the ecosystem concept is more related to the whole digital environment, including the private sector, all kinds of organizations from the social sector, and governments. At the same time, the maturity concept is usually used at the organizational level, undermining the relevance of a holistic view of the government's digital situation at all levels in the federal organization.

Developing specific analytical criteria to analyze the Argentinian case more precisely and gain a deeper understanding of AI implementation in the public sector is imperative. These criteria, which should consider the government as an ecosystem, will incorporate indicators that can gauge the level of maturity and, consequently, the potential for AI adoption in the public sector. Next, we will explain and describe this concept and how it interacts.

4.1 Defining the Digital Governmental Ecosystem (DGE)

To analyze the Argentinian case and other LMICs more precisely, it is necessary to move beyond traditional frameworks and indexes. This work proposes the concept of the Digital Governmental Ecosystem (DGE) as a more comprehensive and nuanced approach to understanding digital transformation and AI adoption in the public sector.

The DGE framework draws upon concepts from various theoretical perspectives. The Digital Governmental Ecosystem (DGE), as Systems Theory establishes, is understood as a complex system composed of interconnected components. Changes in one component can trigger cascading effects throughout the entire system. This

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

theoretical approach highlights the interconnectedness and interdependence of elements within the public sector, aligning with established research in systems theory and political systems. Notable scholars in this field include Easton, Parsons, Almond, and Powell, among others. (López Montiel, 2008).

Of course, and as its name indicates, DGE is based on the Ecosystem as a Model. Crucially, the DGE framework adopts the concept of ecosystems from the natural sciences. The ecosystem, understood as the "set of organisms and their physical environment interacting in a place," provides a globally applicable and flexible model for understanding complex systems. Its applicability across temporal and spatial scales and adaptability to diverse situations make it helpful in analyzing the digital government's dynamic and evolving nature. Any location presenting these conditions could be considered an ecosystem, regardless of size or the brevity of interactions. (Armenteras, et al., 2016).

Lastly, DGE is based on the theoretical construct of Digital Governance. It incorporates principles of digital governance, emphasizing the need for effective leadership, coordination, and regulation to guide the development and evolution of the digital ecosystem. This perspective underscores the importance of governance mechanisms in shaping the adoption and impact of digital technologies in the public sector (Naser, 2021).

The Digital Governmental Ecosystem (DGE) is a comprehensive construct encompassing all the institutions and agencies within the public sector. This includes:

- **Governmental Structures:** The various powers of the state (executive, judicial, and legislative) and the different levels of government (national, provincial, and municipal).
- **Technological Infrastructure:** The systems, technologies, and data utilized by governmental entities.
- **Regulatory Framework:** The regulations that govern the operations of public sector institutions and agencies.
- **State Capacities:** The resources, skills, and capabilities that enable the delivery of public value.

4.2 DGE Maturity

The maturity level of the DGE is assessed based on two combined variables: **evolution and coverage.**

Evolution refers to the main activities undertaken by governmental entities, progressing from analog and traditional government to digitization, digitalization, and ultimately, digital transformation (Holmström, 2022), representing the highest level of the evolutionary process. For example, if the main activities are focused on digitization, the DGE has a low level of evolution.

Meanwhile, **coverage** indicates the extent to which different government levels and agencies have been impacted or need to be impacted by prior activities such as digitization and digitalization. Coverage can range from narrow and dispersed to broad. For example, we can find a highly digitalized national government in Argentina, but the provinces and municipalities are behind in this process. So, the DGE's coverage is narrow and could be placed in the dispersed or medium position.

The maturity of the DGE influences the adoption and implementation of digital technologies, including AI, in the public sector. A mature DGE provides a more favorable environment for successful AI adoption, while a less mature DGE may face challenges in effectively leveraging AI's potential.

4.3 How does all this work together

The element of coverage in a federal organizational government is crucial in the process of digital innovation and AI incorporation in the public sector because citizens' primary services and data (and their lives) are located and generated in their closest governmental levels, even though some tools and solutions are deployed at the national level and then transferred to provinces and local governments.

If the evolution of the DGE is low and in a small number of agencies and government levels, public value will not be achieved to its full potential. The relationship between both elements will show us how mature the DGE is. By maturity, as we previously indicated, we identify how this relation is and how it materializes in government actions with all the elements that public value requires: efficiency, effectiveness, and capability to resolve people's problems. A thriving DGE that brings public value leads to a more comprehensive implementation of AI in the public sector.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

When the DGE has a low or middle level of maturity, digital transformation activities such as AI adoption are expected to be dispersed, with sustainability, scalability, and interoperability deficiencies. Mostly, no part of a strategy. It is more likely to be none or a few pieces of legislation.

4.4 The Argentinian DGE

Until 2023, Argentina seemed to be on the road to increasing its DGE maturity, even with back-and-forth. Considering the information in Chapter 3 and our new framework, we can quickly locate Argentina at a middle level of maturity, with some elements highlighting the tendency to increase it.

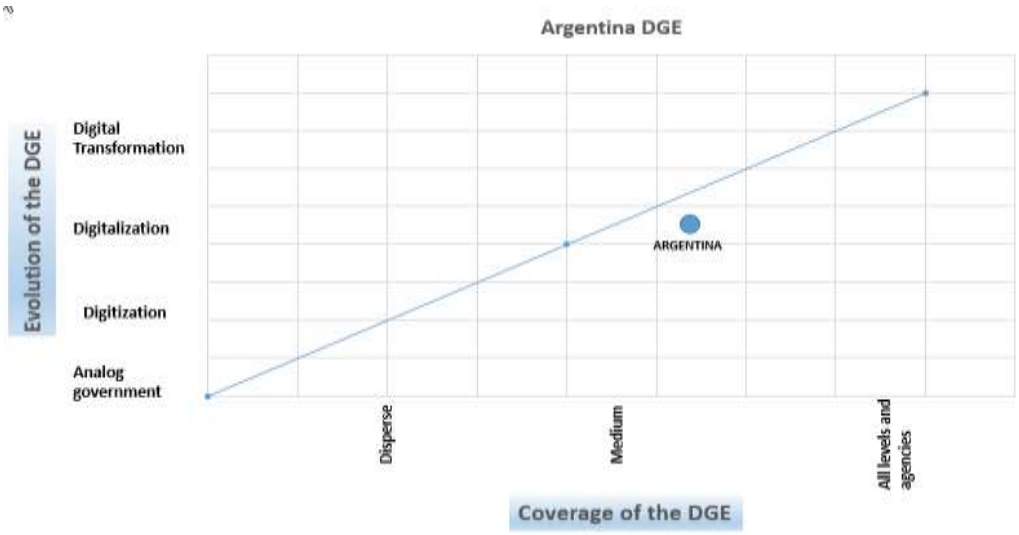


Fig. 2 Argentina DGE maturity location. Source: Author's elaboration

As Figure 2 shows, Argentina mainly covers all the middle maturity conditions. However, we can identify the tendency to cover all the government levels because the national government and all the provinces are already in the evolution stage of digitalization, even though many municipalities and some agencies at all levels are behind. We can also identify that the infrastructure and connectivity with ARSAT as a provider of cloud services and the REFEFO are closer to the conditions of a highly mature DGE. Moreover, even though AI initiatives in Argentina are dispersed, this shows a tendency to evolve into a digital transformation stage if the state's capacities and resources in AI tools could be strengthened over time.

Nevertheless, the actual situation enlightens that this level of DGE maturity brings only the possibility of AI implementation in some silos or situations that are more related to the disparity and gaps between agencies and governments: those who have some state capacities (recourses, skills, infrastructure, coordination between intra and extra state, etc.) could deploy an AI solution to a public problem.

Returning to our question about how LMIC can obtain the benefits of AI adoption to increase public value when we still need to go ahead with digitalization, the answer is given by the national experiences, as we did with Argentina. Even though the ideal condition shows that digitalization comes first before AI, other elements enable AI in the public sector to emerge in this case, and they all provide elements to the maturity of the DGE.

The process is simultaneous and unique for each case and evolves according to the decision-making. Every country's process differs and could take different approaches. Some could strengthen every level of government first and then focus on evolving the DGE. As we already indicated, these processes in Latin America are disorderly.

This framework guarantees a more realistic and individualized approach for every national case. It provides a dynamic view of the strengthening process of the DGEs where the "readiness criteria" are not the center of the analysis. We can avoid the need to force or dismiss a case if it does not apply to an AI readiness index. Digital transformation and automation are fundamental parts of AI's emergence in the public sector, but not determinants of its existence. Other elements are very distinctive to each process. Reediness criteria tend to make some elements invisible or overestimate some aspects, depending on how or who analyzes a national case.

Conclusions

This work tried to address the Argentinian public sector's current situation concerning AI implementation against a Latin American backdrop. The analysis includes the elements and processes that structured the implementation

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of AI as one of the stages of the digitalization of government and its transformation to automation. As the indexes indicate, Argentina requires consistent development of its infrastructure, frameworks, regulations, and a well-trained public servant body. However, we must extend our analysis beyond the existence or absence of these requirements to explain how AI is being implemented in Argentina, since these tools cannot grasp contextual factors involved in digitalization as a prerequisite for a comprehensive inclusion of AI across government.

It is necessary to dive into the DGE, analyze it as a whole, and take it as a living creature that grows and expands in disorder, in different directions, and with different velocities. By doing so, we can approach a possible explanation of why Argentina has a dispersed and small amount of AI experiences in the public sector. We can also try to seek solutions related to the structural needs of the DGE instead of focusing on resources and time on isolated efforts, like a reskilling program for public servants without knowing what they need, or a strategy or regulation that does not consider the current situation of the provinces and local governments. In the end, this kind of action only increases the internal gaps between provinces or municipalities with more resources and between them and the national government, and, of course, increases the inefficiency in government.

The maturity of the DGE is a concept that brings the idea of process, growth, and movement. The variables used in this work, such as evolution and coverage, bring to light that in one DGE, there coexist different realities, such as municipalities without relevant internet access and provinces with a ministry that still uses paper system files with a national government that provides digital ID or a city the integrated chat-GPT to the city chatbot. With this in sight, it is possible to design better public policies customized to each reality and co-design without leaving anyone behind. It also allows leveraging the existing AI solutions and digital transformation momentum that some agencies, governments, and stakeholders are conducting to benefit the whole DGE.

Therefore, we can provide some insights related to various topics of this work. Here are some limitations and future research ideas.

- Indexes are an excellent start to introduce some realities and comparatives between countries, but they are insufficient to explain the profound reasons and singularities of a digital transformation process. Readiness criteria would overestimate or put aside elements or experiences that are relevant or interesting for each case.

- AI implementations can emerge even though the path to digital transformation has not been completely achieved. This is a sign of a certain level of maturity of a DGE and must be seen as a characteristic and process, not as a lack of something.

- LMICs should simultaneously address catching up to digital transformation; meanwhile, they should try not to be left behind and minimize the loss of public value in delivering public policies.

- The LMIC regulation should address specific problems and particular characteristics; try to resolve each DGE's issues and not emulate foreign experiences.

- Resources of all kinds (state capabilities, infrastructure, etc.) remain the main agenda for the LMIC. In federal countries, this must be addressed at all governmental levels, in a coordinated way.

While this study provides valuable insights into the Argentinian public sector's current situation concerning AI implementation, several limitations should be acknowledged. First, the focus on a single case study limits the generalizability of the findings to other LMICs. Future research should consider conducting comparative studies to analyze AI adoption in the public sector across multiple regional countries.

Second, the availability and quality of data on AI adoption in the Argentinian public sector posed challenges to conducting a more comprehensive analysis. Future research could explore alternative data sources or develop new data collection and analysis methodologies.

Third, the Digital Governmental Ecosystem (DGE) framework, while offering a novel approach to understanding AI adoption in the public sector, requires further validation in different contexts. Future research should continue to develop and refine this framework to enhance its applicability and generalizability.

Finally, this study focused primarily on AI adoption in the public sector. Future research should broaden its scope to explore other important aspects of digital transformation, such as citizen participation and digital inclusion, to provide a more holistic understanding of the phenomenon.

These limitations highlight potential avenues for future research that can build upon this study's findings and contribute to a more comprehensive understanding of AI adoption in the public sector in LMIC.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

Aguerre, C. (.-M. (2020). Artificial Intelligence in Latin America and the Caribbean: Ethics, Governance and Policies. Universidad de San Andrés. Retrieved from https://proyectoguia.lat/wp-content/uploads/2020/10/compilado-espanol-compressed.pdf

Aguerre, C., & Frati, G. B. (2021). Prologo "IA, Justicia y Políticas de Transformacipon Digital en el ámbito público Latinoamericano. In Compilado, Preparación del sector judicial para la Inteligencia Artifical en América Latína. Buenos Aires: Centro de Estudios en Tecnología y Sociedad (CETyS) de la Universidad de San Andrés.

Armenteras, D., González, T. M., V., L. K., L. F., Rodríguez, N., & Bonilla, M. A. (2016). Revisión del concepto de ecosistema como "unidad de la naturaleza" 80 años después de su formulación [Review of the concept of ecosystem as "unit of nature" 80 years after its formulation]. Ecosistemas, 25, 83-89. doi:https://doi.org/10.7818/ECOS.2016.25-1.12

Berryhill, J., Heang, K. K., Clogher, R., & McBride, K. (2019). Hello, World: Artificial intelligence and its use in the public sector (Vols. OECD Working Papers on Public Governance, No. 36). Paris: OECD.

Estevez, E., Fillottrani, P., & Linares Lejarraga, S. (2020). PROMETEA: Transformando la administración de justicia con herramientas de inteligencia artificial. Washington, D.C.: Inter-American Development Bank. doi:http://dx.doi.org/10.18235/0002378

Estevez, E., Janowski, T., & Roseth, B. (2024). When Does Automation in Government Thrive or Flounder? Washington, D.C.: Inter-American Development Bank. doi:http://dx.doi.org/10.18235/0005530

Guio, A. (2024). Regulatory sandboxes in developing economies. An innovative governance approach (Vol. Project Documents(LC/TS.2024/59)). Santiago de Chile: Economic Commission for Latin America and the Caribbean (ECLAC.

Holmström, J. (2022). From AI to digital transformation: The AI readiness framework. Business Horizons, 65(3), 329-339. doi:https://doi.org/10.1016/j.bushor.2021.03.006.

Klein, E., & Patrick, S. (2024, March). Envisioning a Global Regime Complex to Govern Artificial Intelligence. 1-47. Retrieved from https://carnegieendowment.org/research/2024/03/envisioning-a-global-regime-complex-to-govern-artificial-intelligence?lang=en

López Montiel, Á. G. (2008). Las teorías de sistemas en el estudio de la cultura política [Systems theories in the study of political culture]. Política y cultura, 29, 165-187. Retrieved from https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-77422008

Lorenzo, O. (2016, December). Digital Maturity Models: What Are They and What Can We Learn From Them? Vol. LXXI - N.º 219, 17. Retrieved from https://www.researchgate.net/publication/313798566_Modelos_de_Madurez_Digital_en_que_consisten_y_que_podemos_aprender_de_ellos

Maito, M., Garay, I., & Schachte, L. (2023). Otra mirada del empleo público en la Argentina. Un análisis sobre la base de la EPH de alcance urbano. Notas breves (No. 6).

Margets, H. (2022). Rethinking AI for Good Governance. Volume 151(Issue 2), 360-371. doi:https://doi.org/10.1162/daed_a_01922

Naser, A. (2021). Gobernanza digital e interoperabilidad gubernamental: una guía para su implementación [Digital governance and government interoperability: A guide for its implementation]. Economic Commission for Latin America and the Caribbean (ECLAC). Obtenido de https://hdl.handle.net/11362/47018

Novas, M. (2019). Gestión Documental Electrónica en la Administración Pública 2015-2019. CASOTECA: Colección de Casos de Programas de Modernización, 70-88.

OECD and CAF. (2022). Caribbean, The Strategic and Responsible Use of Artificial Intelligence in the Public Sector of Latin America and the (Vol. OECD Public Governance Reviews). Paris: OECD Publishing. doi:https://doi.org/10.1787/1f334543-en

Palumbo, P. (2019). Gestión y Apertura de Datos Públicos en la Argentina. CASOTECA: Colección de Casos de

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Programas de Modernización Dirección, 130-150.

Tueni, H., & Glorioso, A. (2022). Artificial Intelligence (AI) organisational readiness assessment for public institutions. (M. i. Services, Ed.) Master in Artificial Inteligence for Public Services, 25.

Ubaldi, B., Fevre, E. M., Petrucci, E., Marchionni, P., Biancalana, C., Hiltunen, N., . . . Yang, C. (2019). State of the art in the use of emerging technologies in the public sector (Vol. OECD Working Papers on Public Governance No. 31). Paris: OECD.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The wallet demarcation problem: developing a taxonomy for classifying digital wallets

Bert Lukkien [a*], Mark de Reuver [a], Nitesh Bharosa [a]

[a] Faculty of Technology, Policy, and Management, Delft University of Technology, Delft, the Netherlands, J.A.Lukkien@tudelft.nl, 0009-0005-0540-8771.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. Digital wallets are emerging as new tools that provide citizens with control over their personal data while allowing innovation in service delivery. Wallets promise various functionalities, from authentication, authorisation, and signing, to storage and generating qualified electronic attestations. Given the potential, policymakers and service providers face significant challenges in selecting, developing, implementing, and regulating digital wallets due to the lack of clarity about their characteristics. This paper focuses on this lack of clarity. Through a socio-technical systems theory lens, we developed a comprehensive taxonomy for classifying digital wallets. Our empirical analysis reveals a taxonomy of 47 characteristics in 14 dimensions. The contribution of this taxonomy is two-fold. Firstly, it can help develop a more precise theory on specific types of wallets. Secondly, actors in the field can use the taxonomy for more granular communication on wallet development and adoption challenges, standardisation efforts, and policy development.

Keywords. wallet, digital identity, public value, privacy, taxonomy, responsible data sharing, eIDAS, Data Governance Act, policy instruments, personal data space, personal data.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1039

1. Introduction

Interactions in society are more digital than ever. In some countries, people order their groceries from the supermarket online; apply for a building permit via the municipality's app and book a trip via the travel agency's website. When interacting with (semi)public agencies, we also expect public values to be protected. In many cases, efficiency and ease of use have been the dominant values in the design of digital systems. Considering security scandals and privacy regulations, values such as privacy, choice, security, and trustworthiness have become increasingly important. One of the ways to promote privacy, choice, security, and trustworthiness in the digital exchange of personal data is the introduction of digital wallets. However, a digital wallet is an ambiguous concept. Research has revealed multiple types of wallets with various functionalities and objectives (Degen & Teubner, 2024).

The European Union is also introducing a digital wallet, the 'European Digital Identity Wallets (EUDI Wallet).' This wallet should offer private users and businesses a universal, trustworthy, and secure way to identify themselves when accessing public and private services across borders. Examples of how the EUDI wallet can be used include opening a bank account, proving one's age, renewing medical prescriptions, renting a car, or displaying their flight tickets."[1] EU Member states have been given the legal obligation to provide all citizens with a digital wallet upon request[2]. These can be provided by the Member State, on behalf of the Member State, by a private party, or by a private party with recognition from the Member State[3].

[1] https://digital-strategy.ec.europa.eu/en/news/commission-adopts-technical-standards-cross-border-european-digital-identity-wallets
[2] eIDAS Article 5a(1)
[3] eIDAS Article 5a(2)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

However, despite the legal framework available, it is still unclear what that digital wallet under eIDAS will look like. This new legislation does not aim for uniform implementation but leaves EU Member States and wallet providers with relative freedom of choice. It describes a set of minimum requirements about functionality, interoperability, security, and respect for privacy, as formulated in the General Data Protection Regulation (GDPR)[4]. Therefore, we can expect a wide variety of implementations across member states, each with its own focus and user context. Requirements such as protocols and interfaces are also specified in the European Digital Identity Wallet Architecture and Reference Framework (ARF)[5] and in five implementation acts[6].

As discussed in previous work, public and private service providers are struggling with the development and implementation of digital wallets in general and the EUDI wallet in particular (Lukkien et al., 2023). An explanation can be found in the complex environment in which wallets must operate. According to the ARF, wallets must be implemented in a multi-actor ecosystem with various trust services, including authentication, electronic signing, and data exchange. These functionalities need to be orchestrated for end-to-end service delivery (Bharosa, 2022).

This leads to a demarcation problem: how can we distinguish the different manifestations of digital wallets and their components from each other in multi-actor ecosystems? The use of vague or ambiguous terms or concepts that are not contextualised with each other is one of the causes of this lack of clarity, which can lead to operational and conceptual problems (Podsakoff, MacKenzie & Podsakoff, 2016). Moreover, the multi-actor ecosystem embedding wallets exacerbates the publicness puzzle problem (Bozeman & Bretschneider, 1994).

The objective of this paper is to contribute to solving this demarcation problem by providing both scholars and policy makers with a scientifically grounded and empirically tested taxonomy for studying wallets. Our premise is that we need a socio-technical lens for the wallet demarcation problem. According to socio-technical theory, socio-technical systems are generically defined as systems that include social (people) and technical elements (Polojärvi, 2022). Socio-technological systems also require an institutional structure that coordinates the positions, relations, and behavior of the parties that own and operate the system (Koppenjan & Groenewegen, 2005). Accordingly, the research question we answer in this article is as follows: *Which social technical design dimensions constitute a taxonomy for digital wallets found in practice?*

The contribution of this paper is two-fold. First, this is the first paper to take the socio-technical lens on digital wallets. Based on a literature review of taxonomies and wallets, we conclude that taxonomies of digital wallets that contribute to the socio-technical design are lacking, in particular for institutional design dimension. Our study contributes to the existing body of knowledge by introducing a taxonomy for digital wallets that covers this. Second, we provide practitioners and scholars with a comprehensive overview of the socio-technical design dimensions of digital wallets. This overview helps address the problem of lack of clarity in the delimitation of digital wallets. On the one hand, it facilitates scholars in their research on conceptual clarity and, on the other hand, it supports practitioners such as policymakers in choosing existing or designing new policy instruments that helps to put together the publicness puzzle (Bozeman & Bretschneider, 1994).

The remainder of this article is structured as follows. Section 2 presents the research background, zooming in on the complexity of wallets. Next section 3 presents the taxonomy development approach applied in this study. Section 4 discusses the resulting taxonomy. Section 5 concludes this paper with suggestions for further research and policy making.

2. Background: The wallet as an evolving concept

The concept of a wallet is ambiguous and is characterised by a myriad of descriptors such as 'identity', 'digital', and 'data' wallets. Synonyms for the term wallet include e-Wallet, mobile wallet, virtual wallet, online wallet, cyber wallet, electronic wallet, digital payment wallet, cryptocurrency wallet, digital identity wallet, or blockchain wallet. In this chapter, we will examine the digital wallet as a concept that has evolved over time, with technological and functional advancements occurring over several decades.

The concept “wallet” emerged in the academic literature in the late 1970s and early 1980s, initially referring to electronic financial methods by banks to enhance efficiency. Berton (1983) emphasised digital storage over cheques and cash, and Even et al. (1984) introduced electronic wallets for managing funds. This era set the stage for smart cards, progressing payment and ID digitisation. Clifford (1986) identified smart card applications beyond finance, using decentralised data storage, while Frank (1988) noted secure access and data storage. In the 1990s, wallets became decentralised, bolstered by merging PDAs[7] and smartphones with apps. The World Wide Web increased service demand, challenging old authentication. Winslett et al. (1997) argued that traditional

[4] http://data.europa.eu/eli/reg/2016/679/oj.

[5] https://github.com/eu-digital-identity-wallet/eudi-doc-architecture-and-reference-framework/blob/v1.4.0/docs/arf.md

[6] https://digital-strategy.ec.europa.eu/en/news/commission-adopts-technical-standards-cross-border-european-digital-identity-wallets

[7] https://en.wikipedia.org/wiki/Personal_digital_assistant

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

authentication was inadequate for authorisation. Thus, wallets expanded beyond finances to include digital IDs and licenses, marking a shift to digital personal data, credentials, and entitlements.

In recent academic literature, a *digital wallet* has been defined in many ways. A prevalent definition posits that a digital wallet is an electronic application accessible via smartphones or other electronic devices, facilitating rapid and secure electronic commerce transactions (Podgorelec et al., 2022a). Digital wallets are recognised as a type of electronic payment instrument that can be operated on multiple electronic platforms, including computers, laptops, and mobile phones (Shah & Rathod, 2022). These wallets offer convenience and usability in routine activities and transactions, with perceived utility being a key factor influencing users' adoption intentions.
Another perspective accentuates wallets in the digital identity sphere, empowering users with authoritative control over their identity data (Nugroho et al., 2022). Such wallets are engineered to give users governance over their digital identities, incorporating functionalities to manage and authenticate identity and other personal data (Liswanty et al., 2023a). The 'European Digital Identity Wallet' is defined as 'an electronic identification means which allows the user to securely store, manage and validate person identification data and electronic attestations of attributes to provide them to relying parties and other users of European Digital Identity Wallets, and to sign using qualified electronic signatures or to seal using qualified electronic seals' (Article 3(42) eIDAS 2024).

The ambiguity surrounding the concept of a wallet is further illustrated when zooming in on how control over personal data can be exercised. Personal Information Management Systems (Janssen & Singh, 2022b), Personal Data Stores (Kim et al., 2025a; Min & Son, 2022), and Personal Data Spaces (Lehtiniemi, 2017a) all share this objective and hence may also be regarded as manifestations of the concept of digital wallets. These developments align with the escalating datafication of society, driven by advancements in the Internet of Things (IoT) and data analysis technologies (Mejias & Couldry, 2019). The consequences of such progress include the rapid expansion of personal data and the diminishing distinction between identity and personal data, on the one hand, and non-personal data, on the other (Purtova, 2018). To allow users to exercise control over their personal information, they need exclusive online environments from which data access and sharing can be steered[8]. Illustrative examples of these advancements include IoT wallets (Lomazina et al., 2021a; Soli´c et al., 2020) and Human Digital Twins (Chen et al., 2024; Lin et al., 2024; Miller & Spatz, 2022; Zibuschka et al., 2020).

How might one navigate these wallets from a policy perspective, and under what circumstances does it apply? Determining what is encompassed and the aspects that require design consideration is crucial. A taxonomy helps to identify the 'essences in the research territory and their relationships' (Iivari J., 2007 p. 46). They are particularly crucial for both practitioners and scholars, as without a classification framework, they find it challenging to "generalise, communicate, and apply research conclusions" (Glass & Vessey, 1995 p.65). If we look at the taxonomies available in academic literature, we found (January 2025) in Scopus with the query "wallet" AND "taxonomy"[9] (in the relevant context) 38 results. A taxonomy from a policy perspective is currently absent. In the next chapter, we will explain the development of this taxonomy.

3. Research Approach: Taxonomy development process

In pursuit of the research objective, we employed the established taxonomy development methodology of Nickerson et al. (2013). This is a tested method for taxonomy development (Pawlowski & Scholta, 2023). It facilitates the integration of conceptual-to-empirical (C2E) and empirical-to-conceptual (E2C) iterations to ensure a thorough and comprehensive investigation. The approach consists of the following steps:

[8] E.g. the DGA (preamble 30) gives substance to the principle of *'bringing the algorithm to the data'* as a privacy-preserving measure when it is stated that, 'in certain situations, it could be desirable to collate actual data within a personal data space so that processing can happen within that space without personal data being transmitted to third parties in order to maximise the protection of personal data and privacy.'

[9] (ALL (taxonomy) AND ALL (wallet)) AND (LIMIT-TO (EXACTKEYWORD , "Taxonomies") OR LIMIT-TO (EXACTKEYWORD , "Taxonomy")) AND (LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "BUSI"))

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

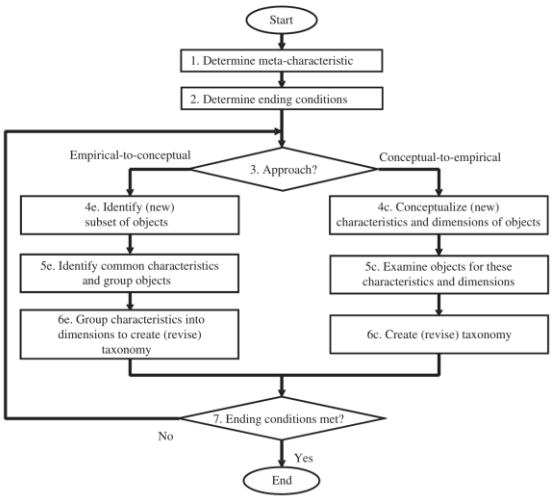


Fig. 1 The taxonomy development method (Nickerson et al., 2013)

We started by defining the purpose and expected use: differentiate digital wallets according to their characteristics for users, like practitioners, policy makers and scholars seeking to classify digital wallets. The second step was to define the objective ending conditions: The taxonomy consists of dimensions, each with mutually exclusive and collectively exhaustive characteristics. As subjective ending conditions, we followed Nickerson's recommendation: the taxonomy must be concise, robust, comprehensive, extensible, and explanatory (p. 344).

The initial iteration of the E2C encompassed a comprehensive examination of the design specifications relevant to the EUDI wallet. This examination was informed by European legislation, namely eIDAS 2.0, GDPR[10], and DGA[11], as well as Dutch legislation, ARF (which includes acknowledged standards such as the Verifiable Credentials Data Model v1.1), and Large Scale Pilots[12]. Seen through a socio-technical lens, we have concluded from this analysis that digital wallets contain the aspects of actors, capabilities, data, and infrastructure (including devices). We have delineated the following dimensions: 1- Identity model, 2- Guaranteed data, 3- Wallet provider, 4- Trust services, 6- Supervision, 7- Jurisdiction (territoriality), 8- Jurisdiction (organisation) and 9- Capabilities.

The objective of the second iteration was to perform an E2C analysis of a comprehensive set of existing digital wallets, utilising the dimensions established in the first iteration. The set compilation was informed by the description provided in Table 1 and three previous assessments by independent third-party entities. These entities were SIVI (88) [13], MyData (35) [14], and DUE (101) [15], amounting to a total of 224 digital wallets. These objects were analysed based on actors, capabilities, data, and infrastructure themes. The analysis was based on publicly accessible descriptions of the wallets, complemented by qualitative insights from interviews conducted during the initial inventories. The results of this iteration were a list of 13 characteristics on the dimension capabilities and adding the dimension transaction initiative, sector, and jurisdiction (organisation type). In addition, the characteristics of the first iteration have been supplemented.

The source material utilised in the second iteration offered significant insight into capabilities, though it provided limited information regarding the technology employed. For instance, cryptocurrency wallets facilitate crypto transactions. The understanding of the foundational technology, blockchain, has been extracted from alternative sources. Therefore, the third iteration (C2E) comprised an analysis of the academic literature based on Table 1, and in this iteration, the Applicability and Data exchange initiative dimensions were added.

[10] Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (OJ L 119, 4.5.2016, p. 1, ELI: http://data.europa.eu/eli/reg/2016/679/oj).

[11] Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (ELI: http://data.europa.eu/eli/reg/2022/868/oj)

[12] https://ec.europa.eu/digital-building-blocks/sites/display/EUDIGITALIDENTITYWALLET/What+are+the+Large+Scale+Pilot+Projects/

[13] PDM-Monitor-Hoofdtekst-1-augustus-2021.pdf

[14] Understanding-Mydata-Operators-pages.pdf

[15] Top 101 Digital Wallet Companies - Due

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 Literature Taxonomy and Wallet

Query	Literature selected on relevance
'taxonomy' AND 'wallet'(including e-wallet, electronic payment wallet, cryptocurrency wallet, identity wallet, IoT wallet)	(Amard et al., 2024; Degen & Teubner, 2024; Kersic et al., 2023a; Lama, 2022; Larsen et al., 2023; Liswanty et al., 2023; Lomazina et al., 2021b; Naik & Jenkins, 2020; Olsen et al., 2011; Podgorelec et al., 2022b; Sahmim et al., 2019; Sampath et al., 2022; Shah & Rathod, 2022; Stodt et al., 2024; Teng & Khong, 2021)

In the fourth iteration (C2E), we build on the technical insights of iteration 3. In this iteration, we used a selection of academic literature based on table 2, and in this iteration, the Platform dimension was added.

Tab. 2 Literature platform and infrastructure

Query	Literature selected on relevance
'taxonomy' AND 'digital platform', 'taxonomy' AND 'digital infrastructure' 'taxonomy' AND 'blockchain'	(Blaschke et al., 2019; da Silva Neto & Chiarini, 2023; Heurix et al., 2015; Rizk et al., 2018)
'digital platform', 'digital infrastructure', 'blockchain', 'digital ecosystem'	(Addo, 2022; Berndsen & Wandhöfer, 2020; Cammaerts & Mansell, 2020; de Reuver et al., 2020; Goertler et al., 2023; Hein et al., 2020; Lips, 2023; McIntyre et al., 2021; Ozalp et al., 2022; Rohn et al., 2021; Steffen et al., 2023; Susha et al., 2023)

The **fifth iteration** (C2E) focused on emerging concepts such as data spaces (e.g., eHealth data spaces[16]) and data intermediaries as described in the DGA[17]. Although these developments are still in progress, their inclusion allowed the identification of forward-looking characteristics and trends. The results of this iteration were adding the dimensions Data Intermediation.

Tab. 3 Literature data space and data intermediary

Query	Literature selected on relevance
Data Space	(Hägglund et al., 2024; Kim et al., 2025b; Lehtiniemi, 2017b; Marcus et al., 2022; Raab et al., 2023; Stellmach et al., 2022)
Data intermediary	(Bühler et al., 2023; de Rosnay & Stalder, 2020; Janssen et al., 2020; Janssen & Singh, 2022a, 2022c; Julia Hilberg, 2023; Micheli et al., 2023)

Digital wallets are, by their nature, only accessible to the user of the wallet. To analyse the implemented and working digital wallets and test our results so far, we chose the digital wallets that are accessible to the researcher. In the **sixth iteration** (E2C) we chose wallets provided by banks (ABN AMRO App using Apple Pay[18] and Triodos Mobiel Bankieren app[19],) and in the **final iteration** we chose wallets provided by the Belgium government (Itsme[20]) and Dutch government (Mijnoverheid.nl[21], and Mijn verzekeringsbericht[22]). These digital wallets were analysed to capture minute details of their functionalities, interfaces, and underlying architecture. No new dimensions or characteristics have emerged.

At each iteration, the characteristics and dimensions were validated, modified, or extended according to the findings of the data sets. This iterative process continued until the end objective conditions were met. The first version of the taxonomy yielded 83 characteristics in 20 dimensions. As subjective ending conditions, we followed Nickerson's recommendation: the taxonomy must be concise, robust, comprehensive, extensible, and explanatory (p. 344). Because we did not find 83 characteristics in 20 dimensions concise, we dropped the dimensions with characteristics related to functionalities as derived from the empirical analysis. We have renamed this dimension to one dimension functionality. The final list consists of 47 characteristics in 14 dimensions. These results are explained in more detail in the next section.

16 https://health.ec.europa.eu/ehealth-digital-health-and-care/european-health-data-space_en

17 Compare DGA article 10.

18 https://www.abnamro.nl/nl/prive/internet-en-mobiel/abn-amro-app/index.html

19 https://www.triodos.nl/mobiel-bankieren

20 https://www.vlaanderen.be/uw-overheid/werking-en-structuur-van-de-vlaamse-overheid/hoe-werkt-de-vlaamse-overheid/informatie-en-communicatie/aanmelden/aanmelden-via-itsme

21 https://mijn.overheid.nl/?r=1

22 https://www.uwv.nl/nl/arbeidsverleden-loongegevens/verzekeringsbericht

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4. Result: Proposed taxonomy of digital wallets

In this section, we introduce the proposed taxonomy for digital wallets. This taxonomy comprises 47 characteristics spread over 14 dimensions. Each dimension embodies an aspect or perspective of the digital wallet phenomenon. A characteristic delineates the potential values, derived from the analysis of the objects, that a dimension may assume concerning a digital wallet.

Dimension	Characteristics						
1-Identity model	1.1-centralised	1.2-decentralised	1.3-Federated	1.4-Self-sovereign			
2-Guaranteed data	2.1-non-EAA	2.2-EAA	2.3-QEAA	2.4-PuB-EAA			
3-Wallet provider	3.1-Member State	3.2-mandated organisation	3.3-recognised organisation	3.4-not recognised organisation			
4-Trust services	4.1-qualified	4.2-not qualified					
5-Data Intermediation	5.1-neutral DISP	5.2-Not-neutral DISP					
6-Supervision	6.1-present	6.2-not present					
7-Jurisdiction (territoriality)	7.1-only national territory	7.2-inside EU territory	7.3-outside EU territory				
8-Jurisdiction (organisation)	8.1-public	8.2-private	8.3-hybrid				
9- Funding model	9.1-public	9.2-privat	9.3-hybrid				
10-Applicability	10.1-open	10.2-brand open	10.3-bank-open	10.4-closed	10.5-semi-closed		
11-Functionality	11.1-high functionality	11.2-low functionality					
12-Data type	12.1-Regular personal	12.2-Special categories personal	12.3-Criminal records	12.4-Credential	12.5-Pseudo-nymized	12.6-Non-personal	12.7-Anonymous
13-Data exchange initiative	13.1-on initiative wallet user	13.2-on request relying party	13.3-at the initiative of the source				
14- Platform	14.1-Centralised	14.2-Decentralised	14.3-Distributed				

Fig. 2 Proposed taxonomy of digital wallets

In the subsequent sections of this chapter, the taxonomy will initially be presented, followed by an elucidation of each dimension alongside its corresponding characteristics. The numbering within the taxonomy aligns with that in the explanatory notes.

1- Identity Model

An identity model refers to how personal identity data are managed and shared. The similarity is that they all aim to manage and use them to provide access to services or systems. They distinguish themselves in the aspects managed by the issuer, user control level, privacy protection, single point of failure, trust by relying party, interoperability, and technology. An overview is explained in Annex 1. This taxonomy distinguishes the dimension Identity model between **centralised, decentralised, federated, and self-sovereign identity**.

2- Guaranteed data

An attribute can be defined as information that describes a certain quality, right, or permission of an identified subject (natural or legal person) or object. For a relying party that wants to rely on the accuracy of the data, guarantees concerning at least the following elements are central: (1) the accuracy of the identified subject and (2) the accuracy of the value of the attribute, and (3) the accuracy of the relationship between the identified subject and the attribute, and (4) the identity of the issuer. Electronic Attestation of Attributes (EAA) refers to the process of electronically verifying and confirming attributes of a subject. If an EAA is provided by a Qualified Trust Service Provider (QTSPs), it is called a Qualified Electronic Attestation of Attributes[23]. EAA issued by or on behalf of a public body responsible for an authentic source. A PuB-EAA is an EAA that is legally trusted by default[24]. For this taxonomy, we distinguish between **non-EAA, EAA, QEAA,** and **PuB-EAA**.

3- Wallet provider

A digital wallet provider facilitates the provision of a digital wallet to the end user. A provider can be a public or a private organisation whose location can, in principle, be worldwide. A provider can be part of a group (e.g. Google, Apple) or an independent organisation that provides its services to others. To increase trust in these parties, the eIDAS (2024) novel certification framework by the Member States to recognise providers (Article 5c).

[23] https://github.com/eu-digital-identity-wallet/eudi-doc-architecture-and-reference- framework/blob/v1.4.0/docs/arf.md (section 3.5)

[24] https://github.com/eu-digital-identity-wallet/eudi-doc-architecture-and-reference- framework/blob/v1.4.0/docs/arf.md (section 3.6)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Consequently, until recognition is granted, all digital wallet providers are classified as 'not recognised.' Upon implementation, three variants of EUDI Wallet Providers emerge: those instituted by Member States, those mandated by Member States, or those recognised by Member States, all of which provide the EUDI Wallet for end users[25]. For this taxonomy, we distinguish the dimension Wallet provider between **Member State, mandated organisation, recognised organisation**, and **not recognised organisation**.

4- Trust services

This dimension focuses on a trust service provider's level of trustworthiness. A trust service is defined as 'an electronic service normally provided for remuneration that consists of (a) the creation, verification, and validation of electronic signatures, electronic seals, or electronic time stamps, electronic registered delivery services and certificates related to those services, or (b) the creation, verification, and validation of certificates for website authentication; or (c) the preservation of electronic signatures, seals, or certificates related to those services' (eIDAS 2024 article 3(16).). Article 3 (17) defines a 'qualified trust service' as a trust service that meets the applicable requirements set out in the eIDAS Regulation. For this taxonomy, we distinguish between a **qualified trust service provider** and a **non-qualified trust service provider**.

5- Data Intermediation Services Provider

The emergence of the concept of inclusive data governance[26] stems from broader discussions of data ethics and human rights within academic literature and international organisations, among others. It aims to promote equitable, ethical, and participatory data management, considering various stakeholders' needs, rights, and perspectives. Data Intermediation services aim to give substance to this concept, whereby it should be noted that 'at the current time the landscape is still dynamic, and governance practices have not yet crystallised' (Centre et al., 2023). The DGA, article 2(11) defines 'data intermediation service' as 'a service which aims to establish commercial relationships for data sharing between an undetermined number of data subjects and data holders on the one hand and data users on the other, through technical, legal, or other means, including to exercise the rights of data subjects in relation to personal data'. Data Intermediation Services Providers include data cooperatives, data trusts, data unions, data marketplaces, and data sharing pools (Centre et al., 2023). The DMS draws up rules in Article 12, among other things, to safeguard the neutral position of that provider. For example, these rules provide restrictions on use, clarity about fees, etc. For this taxonomy, we distinguish between a **neutral DISP** (complying with the set DGA rules) and a **non-neutral DISP** (not complying with the set DGA rules).

6- Supervision

The deployment of independent and mandated agents is frequently employed to promote cooperation and trust among participants within an ecosystem[27]. These agents are entrusted with the responsibility of facilitating the integration of other participants into a trust-based system. Their duties include evaluating compliance with established regulations and, when required, enforcing adherence to these standards (encompassing admission, recognition, and enforcement processes). The existence of such supervisory entities ensures the effective operation of the ecosystem. For this taxonomy, we distinguish, therefore, between a **mandated supervisor present** and **no mandated supervisor present**.

7- Jurisdiction (territoriality)

A fundamental legal principle dictates that cooperating entities adhere to agreements, and such adherence can be enforced in the event of noncompliance. The commitment to the agreements made is paramount to this principle (*pacta sunt servanda:* "agreements must be kept")[28]. According to (Ryngaert (2008), jurisdiction is understood as individuals or entities' obligation to adhere to state regulations. Within international law, jurisdiction denotes the authority and capacity of a state to enact legislation, implement enforcement measures, and administer justice within a specified territory or concerning specific individuals or entities. Various principles of international and domestic law define a state's jurisdiction.

The primary foundational principle is the principle of territoriality, in which a state possesses jurisdiction over events, actions, or individuals within its territory (Ryngaert, 2008). Jurisdiction is further established through international treaties, as exemplified by the European Union. Given the simultaneity of these jurisdictional forms (territorial and treaty-based), an entity may encounter national and European regulations. Therefore, this taxonomy distinguishes between a digital wallet ecosystem that operates **only in national territory, inside EU territory**, and **outside EU territory.**

8- Jurisdiction (organisation type)

Digital wallets are made available by both public and private organisations. These organisations are distinguished by their purpose, ownership structure, and financing methods. Public organisations primarily prioritise the public interest, whereas the commercial interests of their owners drive private organisations. Such distinctions also

[25] https://github.com/eu-digital-identity-wallet/eudi-doc-architecture-and-reference- framework/blob/v1.4.0/docs/arf.md (section 3.2)

[26] https://www.unescap.org/events/inclusive-data-charter-making-everyone-count

[27] E.g. https://www.occ.gov/news-issuances/bulletins/2013/bulletin-2013-33.html and https://www.regulations.gov/agencies

[28] https://www.britannica.com/topic/pacta-sunt-servanda

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

impact the regulatory framework to which these entities are subject. Public law governs the relationships between government agencies and citizens and addresses the internal organisation of the government, intending to safeguard public interest and maintain public order. On the contrary, private law refers to the legal relationships between private entities.

The EUDI wallet represents a digital ecosystem that can be implemented jointly by public and private entities. Public entities within this framework are subject to public law, whereas private entities comply with private law. This regulatory discrepancy is evident, for example, in the guidelines concerning the procurement of services from third parties, as delineated by European competition law. Furthermore, both public and private organisations are engaging in innovative hybrid organisational forms by collectively owning an entity dedicated to providing digital wallets for use by citizens and businesses. For this taxonomy, we distinguish between **public, private**, and **hybrid** organisations involved in the wallet ecosystem.

9- Funding model

Introducing a digital wallet requires significant investment in development and operation. Governments will finance this from taxes, while for private actors in the digital ecosystem, this will often be an investment that must be compensated for to achieve an acceptable return on investment (ROI). This funding model relates to the business model for digital wallets and covers investments in development and operation on the one hand and monetisation of value transfer. Public business models are aimed at creating value for society, are publicly funded, and are aimed at cost reduction rather than profit maximisation. On the other hand, private business models are aimed at creating financial profit for shareholders or owners, have private financing, and are competitively driven by innovation, cost reduction, or customer loyalty. Hybrid models in which public and private parties work together combine characteristics of both domains. For this taxonomy, we distinguish the dimension funding model between **public**, **private**, and **hybrid**.

10- Applicability wallet

An organisation often provides digital wallets as an extension of their business processes to facilitate personalised transactions with the wallet user. For the retail sector and related payments, Levitin (2018) differentiates digital wallets into "open", "brand-open," "bank-open," "closed", and "semi-closed", concerning payments and acceptance. These differ in varying degrees of freedom of use for wallet users, vendor adoption, and interoperability between wallets. A similar distinction can also be found in other sectors where digital wallets are used. Because these wallets are also often provided as an extension of business processes, they will be more likely to support the personal data set, user interface, business rules, and functions required for that specific business process.

Examples of industries with sector-specific digital wallets include: Finance (ING Mobiel Bankieren App[29]), Health (SelfPass[30]), Real Estate (Zorgeloos Vastgoed[31], Property Wallet[32]), Education (Eduwallet[33]), Media (Datakluis[34]), Government (Digid[35]), Rental (Qii[36]), Telecom (Finacle[37]), Energy (EnergieID[38]), Agrifood (Agri-Wallet[39]) and Travel/Tourism (GrabPay[40]). These sector-specific digital wallets exist alongside more generically applicable ones, such as the EUDI wallet, which will offer identification, authentication, and a limited set of (verified) personal data. We follow the characteristics set by Levitin (2018) and generalise them to other digital wallets in the explanatory descriptions.

Tab. 5 Applicability wallet

10	System	Explanation	Example
1	Open	Can be used for managing personal data at a wide range of actors and often supports multiple capabilities like signing, sealing, sharing, storage, and so on. This wallet is also free of any brand or industry restrictions.	EUDI wallet
2	Brand-open	Developed and managed by a specific brand, but offers the ability to share data with other companies, often integrated into the brand's ecosystem but not limited to use within that ecosystem.	MyQii app
3	Bank-Open	Integrated with the user's bank account, it can be used to make payments from a variety of actors, like an open wallet, and often also	ING app

[29] https://www.ing.nl/particulier/digitaal-bankieren/app/downloaden-en-activeren

[30] https://www.selfresearch.org/

[31] https://www.zorgeloosvastgoed.nl/

[32] https://www.propertywallet.pk/

[33] https://npuls.nl/wp-content/uploads/2024/09/Wegen-naar-wendbaar-sessie-eduwallet.pdf

[34] https://www.datakluis.nl/

[35] https://www.digid.nl/

[36] https://www.qii.nl/

[37] https://www.finacle.com/

[38] https://www.energyid.eu/en/

[39] https://agri-wallet.com/

[40] https://www.grab.com/sg/consumer/finance/pay/

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

		supports bank transfers and other banking services.	
4	Closed	Can only be used with a specific actor or group of actors that are part of the same ecosystem and has no interoperability with other digital wallets or networks outside of its own system.	MijnOverheid.nl
5	Semi-closed	Can be used with multiple actors, but only within a specific network or group of contracted actors, but has limited interoperability with other systems.	Vidua Vastgoed

For this taxonomy, we distinguish the dimension **applicability** between **open, brand-open, bank-open, closed, and semi-closed** digital wallets.

11- Functionality wallet

The results of the digital wallet analysis showed a set of functionalities that can be part of a digital wallet. The first group relates to Identification and Authentication Management (management of identification, authentication, authorisation, representation, and consent). The second group relates to Customer Relation Management (management of preference, loyalty, and contact). The third group relates to Transactions (order service, execution transactions, payment service, and monetise data). Finally, the fourth group relates to additional services (digital diary for diabetes, personal finance management, lifestyle management, Know Your Customer check, billing, and payment request).

Digital wallets can support one or more of these functionalities depending on the intended use. This distinguishes between low-functionality digital wallets (limited to a few functionalities) and high-functionality digital wallets (supporting multiple functionalities). DigID (limited to identification, authentication, and representation) is an example of a low-functionality digital wallet. Examples of high-functionality digital wallets can be found in the Asia-Pacific region. WeChat Pay[41] and Alipay[42] (China), GrabPay[43] (Singapore), and Kakao Pay[44] (South Korea) combine various functionalities such as payment, order service, and execute transactions into multi-functional digital wallets. For this taxonomy, we distinguish the dimension functionality wallet between **high-functionality** and **low-functionality** digital wallets.

12- Data Type

Within the data type dimension, we distinguish between different forms of (personal) data. The starting point here is the European context, in which this distinction has been elaborated in the GDPR. For this taxonomy, we distinguish for the dimension data type between:

Tab. 6 Data Type

12	Data Type	Meaning:
1	Regular personal data	Any information relating to an identifiable or identified natural person. (Article 4(1) GDPR)
2	Special categories Personal Data	personal data concerning a person's racial or ethnic origin, political opinions, religious or philosophical beliefs, trade union membership, health, sex life or sexual orientation, genetic data, and biometric data.
3	Criminal record data	are data relating to criminal convictions and offences or to security measures related to them.
4	Credentials	personal data as a digital proof of qualities, training, or experience that make you suitable for doing something[45]
5	Pseudonymised Data	Identifying data with a certain algorithm is replaced by encrypted data (the pseudonym) so that someone's identity can be concealed. Because a link can be established between pseudonymised data and identifying data, pseudonymised data is full personal data. (defined in Article 4(5) GDPR)
6	Non-personal data	Any data that is not personal data.
7	Anonymous Data	Non-personal data, as these data cannot be traced back to an identified or identifiable natural person.

13- Data Exchange Initiative

The dimension data exchange initiative refers to the entity that is undertaking the initiative to insert, access, or extract data from the wallet. A transaction may necessitate this within the framework of an agreement or in adherence to a legal obligation. Furthermore, data exchanges are increasingly occurring autonomously, without

[41] https://pay.weixin.qq.com/index.php/public/wechatpay_en/

[42] https://www.adyen.com/nl_NL/betaalmethoden/alipay

[43] https://www.grab.com/sg/consumer/finance/pay/

[44] https://www.kakaocorp.com/page/service/service/KakaoPay?lang=en

[45] https://www.oxfordlearnersdictionaries.com/definition/english/credentials

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the necessity for direct human intervention. This phenomenon results from the growing datafication (encompassing personal data generated by sensors (IoT)), the deployment of algorithms that autonomously ascertain with whom and when data exchange transpires, and contactless data exchange (embracing Near Field Communication (NFC), Radio Frequency Identification (RFID), Bluetooth, Wi-Fi Direct, and Ultra-Wideband (UWB)). These systems are not identified as independent actors yet, but rather as technological instruments employed on behalf of a human actor. For this taxonomy, we distinguish for the dimension data exchange initiative between:

Tab. 7 Data Exchange Initiative

13	Initiative	Meaning:	Example
1	on initiative wallet user	The wallet user obtains data from an external source or provides/presents data to a relying party.	The user needs the last income data.
2	on request of the relying party	The relying party obtains data from the digital wallet, direct from the internal storage, or indirectly from the external source with the consent of the wallet user.	The user buys a house and provides data to the broker.
3	at the initiative of the source;	The source (human actor or systems) can provide data to the digital wallet	Automatically send when there is an update in the source.

14- Platform

A digital platform plays a central role in data exchange between actors. For this taxonomy, we distinguish for the dimension platform between centralised, decentralised, and distributed. Table 10 provides an overview.

Tab.10 Platform

Platform	is characterised by:
Centralised	All data and control are managed by a single entity or authority, leading to a dependency on a central system for operations and decision-making (Kersic et al., 2023b). They often have a single point of failure, making them vulnerable to security breaches and downtime if the central entity is compromised.
Decentralised	They distribute data and control across multiple nodes or entities, reducing the need for a single central authority for management and decision-making. They emphasise self-custodial and self-sovereign management of digital identities, enabling users to control their identifiers and related data without centralised entities (Kersic et al., 2023b).
Distributed	They involve a network of interconnected nodes that work together to achieve a common goal, sharing data, and processing tasks across multiple nodes in a peer-to-peer fashion (Sahmim, 2019). No single point of control or failure exists as the network operates collectively, improving resilience and scalability (Sahmim et al., 2019).

5. Conclusions and future research

This paper addresses the lack of clarity in the demarcation of digital wallets by developing a taxonomy for digital wallets. The demarcation problem amplifies the struggle of private and public service providers in their journey to develop and implement digital wallets. The research question we answered in this paper is: Which social-technical design dimensions constitute a taxonomy for digital wallets found in practice?

We first took the socio-technical lens on digital wallets to answer this question. We applied the methodological theory of Nickerson et al. (2013) to develop a taxonomy for digital wallets. This is a tested method for providing practitioners and researchers with a comprehensive overview of digital wallets' social and technical design dimensions.

The taxonomy developed in this study contains 14 dimensions and 47 variables that characterise a wallet. Our study contributes to the existing body of knowledge by introducing a taxonomy for digital wallets that covers the socio-technical design dimensions. Additionally, it facilitates scholars in their research on conceptual clarity, and, on the other hand, it supports practitioners such as policymakers in choosing existing or designing new policy instruments that support the launch of wallets.

Given the social impact of these wallets, more research is encouraged. We identify three main research directions. First, the proposed taxonomy can be further validated and developed by applying it to other empirical cases across the globe. Second, applying the taxonomy could help identify governance challenges for digital wallets. Studies looking into the governance of wallets are lacking, mainly focusing on safeguarding public values. What policy instruments and regulatory tools can effectively address specific challenges? Finally, we applied the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

methodological theory of Nickerson to develop a taxonomy for digital wallets. We have combined this methodology with socio-technical design theory for a taxonomy-driven digital wallet design approach. We encourage the further development of the theory of taxonomy-driven policy instrument design.

References

Addo, A. (2022). Orchestrating a digital platform ecosystem to address societal challenges: A robust action perspective. Journal of Information Technology, 37(4), 359–386. https://doi.org/10.1177/02683962221088333

Amard, A., Hartwich, E., Lu, E. H., Hoess, A., Lu, A. H., Rieger, A., Roth, T., Fridgen, G., & Lu, G. F. (2024). Designing Digital Identity Infrastructure: A Taxonomy of Strategic Governance Choices. https://hdl.handle.net/10125/106646

Berndsen, R., & Wandhöfer, R. (2020). To Centralize or Decentralize: What is the Question? An Application to Digital Payments. In IFIP Advances in Information and Communication Technology (Vol. 555, pp. 105–118). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/978-3-030-64246-4_9

Berton, L. G. (1983). Putting Intelligence In Your Wallet.

Bharosa, N. (2022). The rise of GovTech: Trojan horse or blessing in disguise? A research agenda. https://doi.org/10.1016/j.giq.2022.101692

Blaschke, M., Haki, K., Aier, S., & Winter, R. (2019). Taxonomy of Digital Platforms: A Platform Architecture Perspective. https://aisel-aisnet-org.tudelft.idm.oclc.org/wi2019/track06/papers/3/

Bozeman, B., & Bretschneider, S. (1994). The 'Publicness Puzzle' in Organization Theory: A Test of Alternative Explanations of Differences between Public and Private Organizations The 'Publicness Puzzle' in Organization Theory: A Test of Alternative Explanations of Differences between Public and Private Organizations*. Public Administration Research and Theory: J-PART, 4(2), 197–223.

Bühler, M. M., Calzada, I., Cane, I., Jelinek, T., Kapoor, A., Mannan, M., Mehta, S., Micheli, M., Mookerje, V., Nübel, K., Pentland, A., Scholz, T., Siddarth, D., Tait, J., Vaitla, B., & Zhu, J. (2023). Data Cooperatives as Catalysts for Collaboration, Data Sharing, and the (Trans)Formation of the Digital Commons. https://doi.org/10.20944/preprints202304.0130.v1

Cammaerts, B., & Mansell, R. (2020). Digital Platform Policy and Regulation: Toward a Radical Democratic Turn. In International Journal of Communication (Vol. 14). http://ijoc.org.

Centre, E. C. J. R., Micheli, M., Farrell, E., Carballa-Smichowski, B., Posada-Sánchez, M., Signorelli, S., & Vespe, M. (2023). Mapping the landscape of data intermediaries – Emerging models for more inclusive data governance. Publications Office of the European Union. https://doi.org/doi/10.2760/261724

Chen, J., Yi, C., Du, H., Niyato, D., Kang, J., Cai, J., & Shen, X. (2024). A Revolution of Personalized Healthcare: Enabling Human Digital Twin with Mobile AIGC. IEEE Network. https://doi.org/10.1109/MNET.2024.3366560

Clifford, B. (1986). Smart Card. Electronics , 59(37), 55–58.

da Silva Neto, V. J., & Chiarini, T. (2023). The Platformization of Science: Towards a Scientific Digital Platform Taxonomy. Minerva, 61(1), 1–29. https://doi.org/10.1007/s11024-022-09477-6

de Reuver, M., van Wynsberghe, A., Janssen, M., & van de Poel, I. (2020). Digital platforms and responsible innovation: expanding value sensitive design to overcome ontological uncertainty. Ethics and Information Technology, 22(3), 257–267. https://doi.org/10.1007/s10676-020-09537-z

de Rosnay, M. D., & Stalder, F. (2020). Digital commons. Internet Policy Review, 9(4), 1–22. https://doi.org/10.14763/2020.4.1530

Degen, K., & Teubner, T. (2024). Wallet wars or digital public infrastructure? Orchestrating a digital identity data ecosystem from a government perspective. Electronic Markets, 34(1). https://doi.org/10.1007/s12525-024-00731-1

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Even, S., Goldreich, O., & Yacobi, Y. (1984). Electronic Wallet. In D. Chaum (Ed.), Advances in Cryptology: Proceedings of Crypto 83 (pp. 383–386). Springer US. https://doi.org/10.1007/978-1-4684-4730-9_28

Frank, A. U. (1988). Requirements for a Database Management System for a GIS.

Glass, R. L., & Vessey, I. (1995). Contemporary application-domain taxonomies. IEEE Software, 12(4), 63–76. https://doi.org/10.1109/52.391837

Goertler, T., Papert, M., Schmidt, M., & Fischer, I. (2023). Designing Digital Platform Ecosystems: A Synthetization of Relevant Design Topics for Ecosystems from a Literature Review Digital Business Models View project DESIGNING DIGITAL PLATFORM ECOSYSTEMS A SYNTHETIZATION OF RELEVANT DESIGN TOPICS FOR ECOSYSTEMS FROM A LITERATURE REVIEW. https://www.researchgate.net/publication/371576799

Hägglund, M., Kharko, A., Bärkås, A., Blease, C., Cajander, Å., DesRoches, C., Fagerlund, A. J., Hagström, J., Huvila, I., Hörhammer, I., Kane, B., Klein, G. O., Kristiansen, E., Moll, J., Muli, I., Rexhepi, H., Riggare, S., Ross, P., Scandurra, I., … Johansen, M. A. (2024). A Nordic Perspective on Patient Online Record Access and the European Health Data Space. Journal of Medical Internet Research, 26(1). https://doi.org/10.2196/49084

Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., & Krcmar, H. (2020). Digital platform ecosystems. Electronic Markets, 30(1), 87–98. https://doi.org/10.1007/s12525-019-00377-4

Heurix, J., Zimmermann, P., Neubauer, T., & Fenz, S. (2015). A taxonomy for privacy enhancing technologies. Computers and Security, 53, 1–17. https://doi.org/10.1016/j.cose.2015.05.002

Iivari J. (2007). A Paradigmatic Analysis of Information Systems As a Design Science. Scandinavian Journal of Information Systems, 2007, 19(2):39-64, 19(2), 39–64.

Janssen, H., Cobbe, J., Norval, C., & Singh, J. (2020). Decentralized data processing: personal data stores and the GDPR. https://www.hubofallthings.com

Janssen, H., & Singh, J. (2022a). Data intermediary. Internet Policy Review, 11(1), 1–9. https://doi.org/10.14763/2022.1.1644

Janssen, H., & Singh, J. (2022b). Personal Information Management Systems. Internet Policy Review, 11(2). https://doi.org/10.14763/2022.2.1659

Janssen, H., & Singh, J. (2022c). Personal Information Management Systems. Internet Policy Review, 11(2). https://doi.org/10.14763/2022.2.1659

Julia Hilberg, S. (2023). Impulse Paper, October 2023 Reflections on the DGA and Data Intermediaries Key messages. www.internationaldataspaces.org//1

Kersic, V., Vidovic, U., Vrecko, A., Domajnko, M., & Turkanovic, M. (2023a). Orchestrating Digital Wallets for On- and Off-Chain Decentralized Identity Management. IEEE Access, 11, 78135–78151. https://doi.org/10.1109/ACCESS.2023.3299047

Kersic, V., Vidovic, U., Vrecko, A., Domajnko, M., & Turkanovic, M. (2023b). Orchestrating Digital Wallets for On- and Off-Chain Decentralized Identity Management. IEEE Access, 11, 78135–78151. https://doi.org/10.1109/ACCESS.2023.3299047

Kim, T. M., Ko, T., Hwang, B. W., Paek, H. G., & Lee, W. Y. (2025a). Self-sovereign management scheme of personal health record with personal data store and decentralized identifier. Computational and Structural Biotechnology Journal, 28, 16–28. https://doi.org/10.1016/j.csbj.2024.11.036

Kim, T. M., Ko, T., Hwang, B. W., Paek, H. G., & Lee, W. Y. (2025b). Self-sovereign management scheme of personal health record with personal data store and decentralized identifier. Computational and Structural Biotechnology Journal, 28, 16–28. https://doi.org/10.1016/j.csbj.2024.11.036

Lama, D. (2022). Role of Distributed Ledger Technology for the EU Digital Identity Wallet.

Larsen, B., El Kassem, N., Giannetsos, T., Krontiris, I., Vasileiadis, S., & Chen, L. (2023). Achieving Higher Level of Assurance in Privacy Preserving Identity Wallets. Proceedings - 2023 IEEE 22nd International Conference on Trust, Security and Privacy in Computing and Communications,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

TrustCom/BigDataSE/CSE/EUC/ISCI 2023, 1049–1059. https://doi.org/10.1109/TrustCom60117.2023.00146

Lehtiniemi, T. (2017a). Personal Data Spaces: An Intervention in Surveillance Capitalism? Surveillance & Society, 15(5), 626–639. http://library.queensu.ca/ojs/index.php/surveillance-and-society/index|

Lehtiniemi, T. (2017b). Personal Data Spaces: An Intervention in Surveillance Capitalism? Surveillance & Society, 15(5), 626–639. http://library.queensu.ca/ojs/index.php/surveillance-and-society/index|

Lin, Y., Chen, L., Ali, A., Nugent, C., Cleland, I., Li, R., Ding, J., & Ning, H. (2024). Human digital twin: a survey. In Journal of Cloud Computing (Vol. 13, Issue 1). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1186/s13677-024-00691-z

Lips, S. (2023). A Multifaceted Assessment Framework for Electronic Identity Schemes.

Liswanty, I., Muda, I., & Kesuma, S. A. (2023). Systematic Literature Review Intention to Use E-Wallet. International Journal of Social Service and Research, 3(3), 650–655. https://doi.org/10.46799/ijssr.v3i3.300

Lomazina, T. A., Surovtsova, T. G., & Ivanov, D. A. (2021a). Development of a Cryptocurrency IoT wallet with Automatic Authentication. Proceedings of the 2021 IEEE International Conference 'Quality Management, Transport and Information Security, Information Technologies', T and QM and IS 2021, 318–323. https://doi.org/10.1109/ITQMIS53292.2021.9642727

Lomazina, T. A., Surovtsova, T. G., & Ivanov, D. A. (2021b). Development of a Cryptocurrency IoT wallet with Automatic Authentication. Proceedings of the 2021 IEEE International Conference 'Quality Management, Transport and Information Security, Information Technologies', T and QM and IS 2021, 318–323. https://doi.org/10.1109/ITQMIS53292.2021.9642727

Lukkien, B., De Reuver, M., & Bharosa, N. (2023). Barriers for developing and launching digital identity wallets. https://doi.org/10.1145/3598469

Marcus, J. S., Martens, B., Carugati, C., Bucher, A., & Godlovitch, I. (2022). The European Health Data Space Subtitle (optional) Policy Department for Economic, Scientific and Quality of Life Policies Directorate-General for Internal Policies.

Martin, J. (1983). Managing the data-base environment. USA: Prentice Hall.

McIntyre, D. P., Srinivasan, A., & Chintakananda, A. (2021). The persistence of platforms: The role of network, platform, and complementor attributes. Long Range Planning, 54(5). https://doi.org/10.1016/j.lrp.2020.101987

Mejias, U. A., & Couldry, N. (2019). Datafication. Internet Policy Review, 8(4). https://doi.org/10.14763/2019.4.1428

Micheli, M., Farrell, E., Carballa-Smichowski, B., Posada-Sánchez, M., Signorelli, S., & Vespe, M. (2023). JRC SCIENCE FOR POLICY REPORT Mapping the landscape of data intermediaries Emerging models for more inclusive data governance. https://doi.org/10.2760/8943

Miller, M. E., & Spatz, E. (2022). A unified view of a human digital twin. Human-Intelligent Systems Integration, 4(1–2), 23–33. https://doi.org/10.1007/s42454-022-00041-x

Min, S. H., & Son, K. H. (2022). MyData Personal Data Store Model(PDS) to Enhance Information Security for Guarantee the Self-determination rights. KSII Transactions on Internet and Information Systems, 16(2), 587–608. https://doi.org/10.3837/tiis.2022.02.012

Naik, N., & Jenkins, P. (2020). Self-Sovereign Identity Specifications: Govern Your Identity through Your Digital Wallet using Blockchain Technology. Proceedings - 2020 8th IEEE International Conference on Mobile Cloud Computing, Services, and Engineering, MobileCloud 2020, 90–95. https://doi.org/10.1109/MobileCloud48802.2020.00021

Nickerson, R. C., Varshney, U., & Muntermann, J. (2013). A method for taxonomy development and its application in information systems. European Journal of Information Systems, 22(3), 336–359. https://doi.org/10.1057/ejis.2012.26

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Nugroho, T. C., Pubra, E. H., & Helwani, R. M. K. (2022). Analisis Pengalaman Penggunaan Dompet Digital (Studi Kasus : Shopeepay). IJAcc, 3(1), 26–31. https://doi.org/10.33050/jakbi.v3i1.2155

Olsen, M., Hedman, J., & Vatrapu, R. (2011). E-wallet properties. Proceedings - 2011 10th International Conference on Mobile Business, ICMB 2011, 158–165. https://doi.org/10.1109/ICMB.2011.48

Ozalp, H., Ozcan, P., Dinckol, D., Zachariadis, M., & Gawer, A. (2022). "Digital Colonization" of Highly Regulated Industries: An Analysis of Big Tech Platforms' Entry into Health Care and Education. California Management Review, 64(4), 78–107. https://doi.org/10.1177/00081256221094307

Pawlowski, C., & Scholta, H. (2023). A taxonomy for proactive public services. Government Information Quarterly, 40(1). https://doi.org/10.1016/j.giq.2022.101780

Podgorelec, B., Alber, L., & Zefferer, T. (2022a). What is a (Digital) Identity Wallet? A Systematic Literature Review. Proceedings - 2022 IEEE 46th Annual Computers, Software, and Applications Conference, COMPSAC 2022, 809–818. https://doi.org/10.1109/COMPSAC54236.2022.00131

Podgorelec, B., Alber, L., & Zefferer, T. (2022b). What is a (Digital) Identity Wallet? A Systematic Literature Review. Proceedings - 2022 IEEE 46th Annual Computers, Software, and Applications Conference, COMPSAC 2022, 809–818. https://doi.org/10.1109/COMPSAC54236.2022.00131

Raab, R., Küderle, A., Zakreuskaya, A., Stern, A. D., Klucken, J., Kaissis, G., Rueckert, D., Boll, S., Eils, R., Wagener, H., & Eskofier, B. M. (2023). Federated electronic health records for the European Health Data Space. In The Lancet Digital Health (Vol. 5, Issue 11, pp. e840–e847). Elsevier Ltd. https://doi.org/10.1016/S2589-7500(23)00156-5

Rizk, A., Bergvall-Kåreborn, B., & Elragal, A. (2018). Towards a Taxonomy of Data-driven Digital Services. http://hdl.handle.net/10125/50022

Rohn, D., Bican, P. M., Brem, A., Kraus, S., & Clauss, T. (2021). Digital platform-based business models – An exploration of critical success factors. Journal of Engineering and Technology Management - JET-M, 60. https://doi.org/10.1016/j.jengtecman.2021.101625

Ryngaert, C. (2008). The Territoriality Principle. In Jurisdiction in International Law (pp. 42–84). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199544714.003.0003

Sahmim, S., Gharsellaoui, H., & Bouamama, S. (2019). Edge computing: Smart identity wallet based architecture and user centric. Procedia Computer Science, 159, 1246–1257. https://doi.org/10.1016/j.procs.2019.09.294

Sampath, S., Sanjay, M., Ahmed, N., Bhagavath, A., & Nanjesh, B. R. (2022). Decentralized Digital Identity Wallet using Principles of Self-Sovereign Identity Applied to Blockchain. 7th IEEE International Conference on Recent Advances and Innovations in Engineering, ICRAIE 2022 - Proceedings, 337–341. https://doi.org/10.1109/ICRAIE56454.2022.10054286

Shah, S., & Rathod, K. (2022). A Study On Consumer Perception On E-Wallet In Ahmedabad. International Journal of Management, Public Policy and Research, 1(2), 56–60. https://doi.org/10.55829/ijmpr.v1i2.47

Soli´c, P. S., Loji´c, A., Kapetanovi´ckapetanovi´c, L., Tomislavˇ, T., Tomislavžupanovi´c, T., Kovačevi´c, I. K., Perkovi´c, T. P., & Popovski, P. (2020). IoT Wallet: Machine Learning-based Sensor Portfolio Application. https://www.thethingsnetwork.org/

Steffen, B., Möller, F., & Stachon, M. (2023). Success Factors of Digital Platform Design. ITM Web of Conferences, 51, 05001. https://doi.org/10.1051/itmconf/20235105001

Stellmach, C., Muzoora, M. R., & Thun, S. (2022). Digitalization of Health Data: Interoperability of the Proposed European Health Data Space. Studies in Health Technology and Informatics, 298, 132–136. https://doi.org/10.3233/SHTI220922

Stodt, F., Reich, C., & Stodt, F. (2024). Digital Wallets and Identity Management: Pioneering Advances for Cloud Service Evolution. In International Journal on Advances in Software (Vol. 17). http://www.iariajournals.org/software/2024,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Susha, I., van den Broek, T., van Veenstra, A. F., & Linåker, J. (2023). An ecosystem perspective on developing data collaboratives for addressing societal issues: The role of conveners. Government Information Quarterly, 40(1). https://doi.org/10.1016/j.giq.2022.101763

Teng, S., & Khong, K. W. (2021). Examining actual consumer usage of E-wallet: A case study of big data analytics. Computers in Human Behavior, 121. https://doi.org/10.1016/j.chb.2021.106778

Winslett M., Ching N., Jones V., & Slepchin I. (1997). Using digital credentials on the World Wide Web. Journal of Computer Security, 5(3), 255–267.

Zibuschka, J., Ruff, C., Horch, A., & Roßnagel, H. (2020). A Human Digital Twin as Building Block of Open Identity Management for the Internet of Things.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Unleashing Public Sector Innovation: Exploring the Impact of Big Data Analytics and Value-Driven Capabilities on Digital Governance

Sulemana Bankuoru Egala [a*], *Abdul-Hamid Sokun Alhassan*[a], John Asibuo Boakye[a]

[a] Faculty of Information and Communication Technology, Department of Informatics, SD Dombo University of Business and Integrated Development Studies, Wa, Ghana. sbegala@ubids.edu.gh*; ORCID; 0000-0002-1070-5480

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Big data analytics (BDA) is fast revolutionizing circular economy being driven by the avalanche of data. In public governance, harnessing the value-driven opportunities of BDA has been challenging studied to improve resource allocation, decision-making, and openness and accountability but, with little attention in existing literature. Through the lens of the task technology fit theory, this study examines how big data analytics and value-driven capabilities improve public sector digital governance innovation and performance. The study leveraged PLS-SEM and collected data from 310 staff of public sectors institutions in Ghana. The study found that, task complexities, value-driven capabilities, data quality, organizational support and analytical literacy have significant impact on public sector innovation. this relationship is not however moderated by digital governance maturity. Moreover, public sector innovation was found to influence digital governance performance. The study underscores how data-driven innovations could be leveraged to improve service delivery and citizen participation in digital governance. This study outlines best practices for public sector organizations to effectively utilize big data, enhancing decision-making and governance, and fostering trust and performance in the digital era.

Keywords. Public sector innovation, big data, analytics, digital governance, task technology fit
Research paper, DOI: https://doi.org/10.59490/dgo.2025.976

1. Introduction

Big data analytics (BDA) and artificial intelligence (AI) have emerged as transformative tools in reshaping public governance, enabling governments to analyze large, diverse datasets, uncover actionable insights, and optimize public service delivery. These technologies have the potential to address pressing societal challenges, enhance transparency, and foster citizen-centric governance models (Cingolani, McBride, & Hammerschmid, 2022; Curry et al., 2021). Initiatives like the European Data Space exemplify this promise by creating unified frameworks for data sharing and analysis, with an estimated economic contribution of €2.5 trillion annually by 2030, including benefits for public administration (European Commission, 2022). Similarly, in Kenya, integrating AI into healthcare has improved resource allocation and reduced maternal mortality rates by 15% over five years, showcasing the measurable impact of BDA on governance and service delivery (Agolla, 2015).

At its core, BDA involves collecting, processing, and analyzing vast datasets to identify patterns, correlations, and actionable insights (Mach-Król & Hadasik, 2021). In public governance, this enables predictive analytics for urban planning, disaster response optimization, and enhanced citizen engagement (Urs, Nisioi, & Roja, 2023). However, the successful implementation of BDA requires more than technical integration. It demands alignment with organizational and contextual factors, including value-driven capabilities, data quality, and analytics literacy—all essential for ensuring that technology adoption aligns with ethical, transparent, and citizen-centric principles. For instance, the Netherlands successfully combined participatory governance models with BDA, increasing public trust in municipal services by 25% over three years (Mariani & Mortati, 2024). Furthermore, organizational support and task complexities play a pivotal role in determining whether BDA tools are effectively utilized to address governance challenges.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Despite its potential, the public sector in most developing economies faces several challenges in adopting BDA effectively. Fragmented data infrastructures, insufficient technical expertise, and concerns over data privacy are significant barriers (Gupta et al., 2023; Egala & Afful-Dadzie, 2022). For example, over 60% of public sector organizations in the EU identify interoperability issues as a major obstacle to achieving data-driven innovation (European Commission, 2022). This is even dire in most developing economies where the issues go beyond interoperability to low literacy on BDA (Shah, 2019). This raises ethical concerns, including algorithmic bias and risks of mass surveillance, further complicate the adoption of BDA, threatening public trust and accountability. In contrast, the private sector has demonstrated considerable success in leveraging BDA to drive innovation and efficiency, leaving public institutions at risk of falling behind due to bureaucratic inertia and insufficient digital governance maturity (Dorasamy, 2021).

Existing research highlights the transformative potential of BDA in enhancing public governance. Gupta et al. (2023) for instance, emphasizes its role in promoting sustainability, while Palumbo et al. (2023) examine how open innovation frameworks can modernize public services. Urs et al. (2023) underscore the importance of leadership in fostering digital transformation, and Bwalya (2018) explores the role of e-government initiatives in developing economies. However, these studies often focus on isolated technical frameworks or case studies, leaving significant gaps in understanding the interplay between BDA and key variables such as task complexities, data quality, organizational support, and analytics literacy. Additionally, the moderating role of digital governance maturity, a critical factor influencing the success of technology adoption remains underexplored.

To address these gaps, this study synthesizes big data analytics with value-driven capabilities to investigate how they enhance public sector innovation by fostering efficiency, improving decision-making, and aligning governance with societal values. The research explores the mechanisms through which BDA drives innovation, emphasizing the importance of task complexities, data quality, and organizational support in enabling meaningful outcomes. Additionally, it examines how digital governance maturity moderates these relationships, enhancing public sector innovation and governance performance.

The objectives of this study are twofold: (1) to investigate how big data analytics capabilities influence public sector innovation and (2) to analyze the impact of value-driven capabilities, data quality, and organizational support on ethical and effective governance. By addressing these objectives, this research aims to bridge critical gaps in theory and practice, providing actionable recommendations for policymakers and practitioners. The study seeks to propose a holistic framework that integrates these elements to foster transparency, efficiency, and citizen-centric solutions. Ultimately, the convergence of big data analytics and value-driven governance represents a transformative opportunity for the public sector to achieve sustainable innovation. However, addressing systemic challenges, such as fragmented infrastructure, data privacy concerns, and insufficient digital governance maturity, remains critical. By advancing the understanding of these interactions, this study contributes to the ongoing discourse on digital transformation, offering a roadmap for fostering equitable and impactful public sector innovation particularly in developing economies.

2. Conceptual foundation and hypothesis formulation

2.1 Task technology fit theory

The Task-Technology Fit Theory (TTFT) provides a theoretical foundation for evaluating the alignment between technology, task requirements, and user capabilities. According to TTFT, the effectiveness of a technology depends on how well it supports the specific tasks it is intended to enhance (Goodhue & Thompson, 1995). The theory posits that when a technology is appropriately tailored to address the complexities, interdependencies, and requirements of tasks, it leads to improved performance outcomes (Abelsen et al., 2021). A strong task-technology fit ensures that the capabilities of the technology align with organizational goals and individual competencies, resulting in enhanced innovation and efficiency (Isaac et al., 2019).

In the context of public governance, the integration of big data analytics capabilities and value-driven frameworks has the potential to transform decision-making processes, enhance transparency, and foster citizen-centric governance. TTFT provides a robust framework to analyze the interplay between task complexities, data quality, organizational support, and analytics literacy in influencing the adoption and effectiveness of big data analytics (BDA) technologies (Abelsen et al., 2021). Furthermore, the maturity of digital governance systems acts as a moderating factor, influencing how these variables contribute to public sector innovation and digital governance performance.

This study leverages TTFT to explore how public sector organizations can harness BDA tools to meet complex governance challenges while ensuring alignment with ethical and societal values. The theory guides the investigation of how task characteristics, organizational factors, and technological readiness interact to drive innovation and improve governance outcomes. By integrating TTFT into the analysis, this research emphasizes the importance of aligning technical capabilities with organizational and societal priorities for achieving sustainable innovation.

2.2 Big data analytics task complexities effect on public sector innovation

Big data analytics, characterized by the 5Vs (volume, variety, velocity, veracity, and value), presents unique analytical challenges due to its scale, diversity, and dynamic nature (Sreenivasan, 2017). Task complexity examines the regulatory, stakeholder and technical challenges confounding big data. These inherent complexities can act as catalyst for innovation, particularly in the public sector, where data-driven insights can transform service delivery, policymaking, and citizen engagement. For instance, when governance tasks involve high complexity, such as managing large, heterogeneous datasets, navigating regulatory constraints, or addressing multi-stakeholder demands, traditional methods may prove inadequate, creating a misfit that necessitates innovative solutions (Abelsen et al., 2021). Gupta et al. (2023) contends that, BDA capabilities help bridge this gap by enabling advanced data processing, predictive insights, and real-time decision-making, thus improving task-technology alignment. However, excessive complexity without sufficient organizational support or analytics literacy can hinder innovation. Effectively managing and analyzing these complexities is crucial for implementing transformative initiatives such as smart city solutions, advanced healthcare systems, and adaptive environmental policies (Kuru,2020). Existing studies underscore the importance of data-driven decision-making in enhancing transparency and accountability within public administration (Alexopoulos & Janssen, 2020; Bibri, 2020). The ability to leverage BDA effectively is significantly influenced by task complexities coupled with low digital infrastructure, data governance frameworks, and skilled personnel. This influence of BDA complexities is supported by research emphasizing organizational context and digital transformation as key enablers of public sector innovation (Gil-Garcia et al., 2020). Studies also highlight the importance of digital governance frameworks for effective data utilization and public sector innovation (Janssen et al., 2020; Chhetri et al., 2021). Following these discussions, we hypothesize that:

H1: Big data analytics task complexities will significantly influence public sector innovation.

2.2 Big data analytics capabilities effect on public sector innovation

BDA capabilities, encompassing the technical infrastructure, analytical skills, and organizational processes necessary to effectively handle complex datasets, are crucial drivers of innovation, particularly within the public sector (Janssen et al., 2020). It measures the technical capabilities and assesses the predictive decision-making capabilities of big data. These capabilities enable organizations to understand citizen needs, identify emerging trends, and develop solutions to complex challenges. Existing research highlights the imperative of robust data governance and management practices in cultivating innovation and agility within public sector organizations (Janssen et al., 2020). Moreover, a data-driven culture and effective leadership are essential for harnessing the potential of BDA to drive organizational transformation and innovation in the public sector (Arshad et al., 2024). However, the ability of public sector organizations to effectively leverage BDA capabilities is significantly influenced by their existing digital infrastructure, data governance frameworks, and overall digital maturity (Waqar & Paracha, 2024). Organizations with more mature digital governance structures, characterized by robust data management practices, skilled personnel, and clear data strategies, are better positioned to harness the full potential of BDA for innovation. This moderating role of digital maturity is supported by research emphasizing the importance of organizational context and digital transformation in public sector innovation (Ndou, 2020). Extant research further underscores the significance of robust data governance frameworks in facilitating responsible AI implementation within the public sector, a critical component of contemporary digital governance (Leslie et al., 2021). Following these discussions, we hypothesize that:

H2: Big data analytics capabilities will significantly influence public sector innovation;

H2a: Digital governance maturity will moderate between big data capabilities and public sector innovation.

2.3 Effect of value-driven capabilities on public sector innovation

Value-driven capabilities in BDA represent the organizational capacity to ethically and transparently align technological applications with societal priorities, ensuring data-driven initiatives benefit citizens and communities (Mittelstadt et al., 2016). This ethical and societal alignment is crucial for translating raw data into public value and driving meaningful public sector innovation. Specifically, BDA value-driven capabilities influence public sector innovation by enabling organizations to derive actionable insights, align analytical efforts with strategic goals, and measure outcomes. Existing research underscores the significance of responsible data use and ethical considerations in optimizing the benefits of data-driven initiatives for citizens (Hagendorff, 2020). Moreover, robust data governance frameworks and effective management practices are essential for unlocking the value of data in the public sector (Brous & Janssen, 2020). By integrating stakeholder engagement and focusing on outcomes that align with societal goals, public sector organizations can leverage these value-driven capabilities to drive sustainable innovation and better serve their communities. Following these discussions, we hypothesize that:

H3: Big data analytic value-driven capabilities will significantly influence public sector innovation.

2.4 Effect of big data quality on public sector innovation

Data quality, encompassing dimensions like accuracy, completeness, consistency, and timeliness, is foundational

for effective data utilization and informed public sector decision-making (Egala & Afful-Dadzie, 2022). Thus, measuring the intrinsic and assessing the contextual accuracy, consistency, security and relevance of the public data. In the context of big data, these core dimensions are amplified, necessitating considerations of believability, interpretability, and accessibility (Batini et al., 2016). High-quality big data is pivotal for driving public sector innovation by providing reliable and actionable insights that inform policy decisions, resource allocation, and service delivery. Conversely, poor data quality undermines these efforts, leading to flawed insights and ineffective policies. Existing research underscores the critical role of data quality in various facets of public sector operations. Robust data quality management frameworks are essential for effective data utilization and innovation in public organizations, particularly in open government data initiatives, where high-quality data is paramount for fostering citizen trust (Kalampokis et al., 2020). The increasing reliance on real-time data in public services, such as smart city applications, further highlights the imperative of timely and accurate data for effective service delivery (Bibri, 2020). Moreover, extant studies emphasize the importance of effective data management practices, including rigorous data quality control, for informing data-driven decision-making and public service delivery (Janssen et al., 2020; Zuiderveen Borgesius et al., 2020). Following these discussions, we hypothesize that:

H4: Big data quality will significantly influence public sector innovation

2.5 Effect of organizational support on public sector innovation

Organizational support, encompassing leadership advocacy, resource allocation (financial, technological, and human), and a collaborative culture, is fundamental for public sector innovation, especially given complex societal challenges (Amabile & Pratt, 2016). This supportive environment fosters experimentation, risk-taking, and knowledge sharing, all of which are crucial for driving innovation within public organizations. While pioneering research investigated the general relationship between organizational support and various organizational outcomes, including innovation (Anderson et al., 2014), recent studies have narrowed their focus to examine the specific roles of leadership and organizational culture in cultivating digital innovation within public sector organizations (Nadkarni & Prügl, 2021; Kraus et al., 2022). Notably, the efficacy of organizational support in driving digital innovation is substantially augmented by the maturity of digital governance frameworks. Mature digital governance, characterized by strategic alignment, robust data management, and active citizen engagement, provides the necessary framework for effectively channelling organizational resources toward innovation (Udoh, 2024). The maturity of digital governance frameworks facilitates alignment with public needs, enhances transparency, and cultivates a data-driven culture, thereby ensuring that organizational support yields meaningful outcomes. This moderating role of digital governance maturity is corroborated by extant research, which underscores the significance of organizational context and digital transformation in driving public sector innovation (Ndou, 2020). Furthermore, existing studies highlight the importance of developing digital skills and capabilities within public sector organizations to facilitate successful digital transformation and innovation (Janssen et al., 2020). Following these discussions, we hypothesize that:

H5: Organizational support will significantly influence public sector innovations

H5a: Digital governance maturity will moderate between organizational support and public sector innovation

2.6 Effect of analytics literacy on public sector innovation

Analytics literacy, entails the ability to effectively interpret, analyze, and communicate data insights using analytical tools, is increasingly crucial for data-driven decision-making and innovation (Chen et al., 2012). Analytics literacy empowers individuals to transform raw data into actionable knowledge. Analytics literacy is a critical driver of public sector innovation, enabling data-informed solutions. While earlier work provided valuable perspectives (Magakwe, 2025.; Mpofu & Chasokela,2025), existing research emphasizes the specific skills and competencies required for effective data utilization and digital transformation within the public sector. For example, Janssen et al. (2020) highlight the importance of data literacy and skills development for public sector employees. Zuiderveen Borgesius et al. (2020) added that, effective data governance frameworks are essential for realizing the benefits of analytics literacy and data-driven innovation. The relationship between analytics literacy and innovation is significantly influenced by digital governance maturity. Mature digital governance, with robust infrastructure, strategic policies, effective leadership, and seamless data integration, amplifies the impact of analytics literacy by providing necessary support systems. This moderating role is supported by existing research emphasizing the importance of organizational context and digital transformation in public sector innovation (Mergel et al., 2019). Leslie et al. (2021) also found the role of data governance in supporting responsible AI implementation and data-driven decision-making within public sector organizations, further underscoring the importance of this moderating factor. Hence, we hypothesize that:

H6: Analytics literacy will significantly influence public sector innovation

H6a: Digital governance maturity will moderate between analytics literacy and public sector innovation

2.7 Public sector innovation on Digital governance performance

Public sector innovation, defined as the development and implementation of new or significantly improved processes, services, policies, organizational structures, or technologies aimed at enhancing public value and addressing societal challenges (Osborne & Brown, 2011). In this study, public sector innovation is operationalized by measuring frequency and impact of new digital initiatives in governance. Public sector innovation is crucial for improved public sector performance and effective governance. This innovation can range from incremental improvements to radical transformations, all aimed at enhancing public value. Public sector innovation plays a pivotal role in shaping digital governance performance by leveraging transformative approaches and technologies to achieve efficiency, transparency, and responsiveness, ultimately improving citizen services and engagement. Extant research underscores the pivotal role of digital transformation in driving public sector innovation and enhancing governance outcomes. Recent studies, for instance, demonstrate the transformative impact of digital technologies and data-driven approaches on public service delivery and governance (Janssen et al., 2020). Moreover, open government data initiatives, a key manifestation of public sector innovation, are recognized for their profound influence on enhancing transparency, accountability, and citizen engagement, which are fundamental tenets of effective digital governance (Zuiderveen Borgesius et al., 2020). Notably, recent research highlights the imperative of robust data governance frameworks for facilitating public sector innovation and effective digital governance (Janssen et al., 2020; Alexopoulos & Janssen, 2020). Thus, the study hypothesizes that:

H7: Public sector innovation will significantly influence digital governance performance.

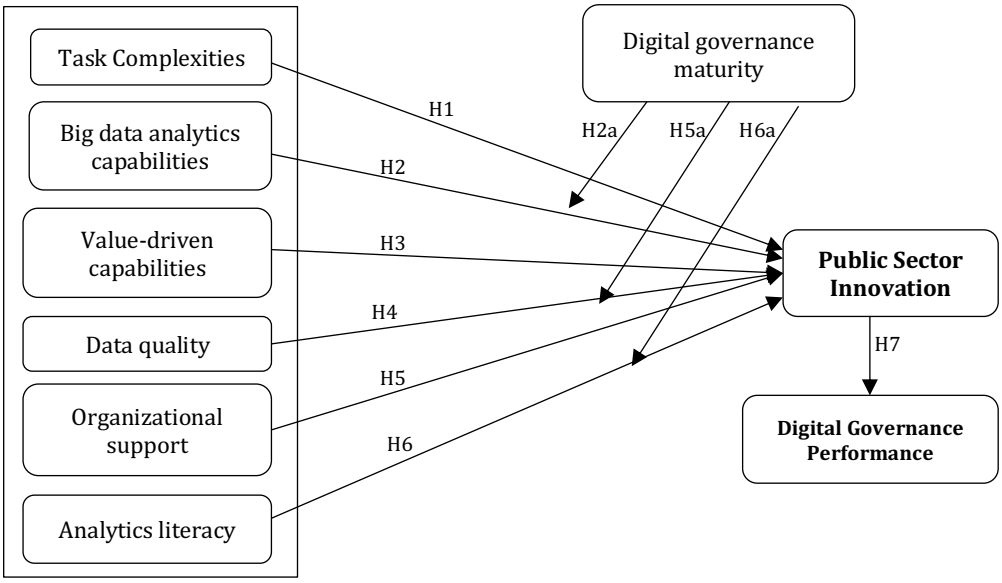


Fig. 1: Conceptual Model of the Research

3. Research Methodology

To adequately measure the determinant of BDA capabilities among public institutions in Ghana, this study employs a quantitative methodology. A questionnaire was developed based on an extensive literature review guided by the conceptual framework in Fig. 1. The first part of the questionnaire gathered demographic information, while the second section posed a series of questions on the determinants of BDA, based on a five-point Likert scale between 1-5 (1=Strongly Disagree - 5=Strongly Agree). To ensure question validity, a pre-test was conducted with sixty (60) respondents, and all questions received favourable results. After the pre-test, participants were purposively sampled using a non-probability sampling approach to ensure that the right respondents were selected from various public institutions in Ghana (Pace, 2021). Participants were selected based on their primary responsibility being data-driven and their appreciable knowledge of data mining. Again, respondents must be innovative-oriented and hold strong opinion about digital transformation. This selection criterion ensured consistency in the responses, justifying the use of purposive sampling aimed at getting results from proactive adopters. Ghana over the past decades have initiated a number of digital initiatives including the open Ghana initiative, national big data initiative, right to information act, and digital acceleration project. Other public sector innovation tools such as e-government system, Ghana digital address systems, e-procurement systems among others, are geared towards streamlining government data collection, processing, sharing and support decision-making across different public sector ministries, agencies and departments. The questionnaire was designed using Google Forms, an online survey tool, and was distributed to participants through a snowballing method between March and October 2024. A total of 310 valid responses were received for analysis.

The Statistical Package for Social Sciences (SPSS) and SmartPLS software were used for the descriptive and partial-

least quare structural modeling (PLS-SEM) analysis respectively. Recent studies have shown that Partial Least Squares Structural Equation Modeling (PLS-SEM) enhances construct variance and endogeneity compared to covariant-based SEM (Egala et al., 2022; Hair et al., 2019). Furthermore, PLS-SEM has been proven to be effective for its predictive relevance capabilities in the model.

The research adhered to all ethical standards, such as confidentiality, informed consent, and disclosing the study's implications to the respondents before answering to the questionnaire. The objective of the study was made clear, and the respondent's private information was kept private. This was done to ensure that all ethical protocols are ensured.

4. Results

4.1 Key findings

As presented in Tab. 1, the respondents comprised 56.5% males and 43.5% females. Majority, 53.9% of the respondents were aged 25 to 40. Relative to the respondent's educational qualification, majority (36.4%), diploma holders followed by bachelor's degree (33.9%) and (28.7%) master's holders. Participants were drawn from departments including Administration (31,6%), budget and planning (25.5%), statistics and IT (20.3%) and finance (19.7%).

Table 1: Demographic Variables of Respondents

Category	Variables	Frequency (N=310)	Percentage (%)
Gender	Male	175	56.5
	Female	135	43.5
Age	18-24	48	15.5
	25-40	167	53.9
	41-60	95	30.6
level of education	Diploma	130	36.4
	Bachelor	105	33.9
	Masters	72	28.7
	Doctorate	3	1.00
Department	Budget and planning	79	25.5
	Procurement	9	2.9
	Administration	98	31.6
	Finance	61	19.7
	Statistics and IT	63	20.3

4.2 Measurement model assessment

As per Hair et al. (2019), it is recommended to have indicator loadings of 0.708 or higher to ensure item reliability. Based on this criterion, variables BC2, OS1 and AL1 were excluded as they did not meet the minimum acceptable threshold. After removing these variables, the data was re-run and the factor loadings resulting from the PLS algorithm are presented in Table 2 and corresponding Fig. 2.

Tab. 2 Construct reliability and factor loadings

Construct/Indicator	Cronbach's Alpha	Composite Reliability	Ave. var. extr. (AVE)	Factor Loadings
PI: *Public Sector innovation*	0.882	0.914	0.679	
PI1: Our organization frequently introduces new digital governance initiatives.				0.809
PI2: We continuously explore innovative ways to improve public service delivery.				0.840
PI3: Our agency encourages experimentation with new digital solutions.				0.812
PI4: We adopt emerging technologies to enhance governance processes.				0.849
PI5: Our organization rewards employees for innovative ideas in digital governance.				0.810
OS*: Organizational Support*	0.856	0.902	0.697	
OS1: Top management actively supports the adoption of BDA.				0.831
OS2: Our agency allocates sufficient resources for digital governance innovation.				0.831
OS3: Employees receive training to enhance digital governance competencies.				0.836

OS4: There is a clear strategy for integrating BDA into governance.				0.839
***AL:** Analytics literacy*	0.839	0.892	0.675	
AL2: Employees in our organization understand how to interpret Big Data insights.				0.842
AL3: Decision-makers use data analytics to guide governance strategies.				0.928
AL4: Our agency has skilled personnel to manage BDA tools.				0.810
***DQ:** Data quality*	0.824	0.876	0.587	
DQ1: The data used in our governance processes are accurate and reliable.				0.748
DQ2: Our agency ensures timely updates of datasets for decision-making.				0.772
DQ3: We have mechanisms to verify the consistency of governance data.				0.757
DQ4: Data privacy and security measures are strictly enforced.				0.767
DQ5: Our Big Data sources are relevant to public sector needs.				0.780
***DP:** Digital governance performance*	0.866	0.903	0.651	
DP1: Digital governance tools improve service delivery efficiency.				0.806
DP2: Citizens are more satisfied with our digital public services.				0.846
DP3: Our agency reduces operational costs through digital governance.				0.805
DP4: Decision-making processes are faster due to data-driven insights.				0.826
DP5: Transparency and accountability in governance have increased.				0.745
***VC:** Value- driven capabilities*	0.819	0.873	0.579	
VC1: Our organization prioritizes citizen-centric values in digital governance.				0.759
VC2: Ethical considerations guide our use of BD in public services.				0.798
VC3: We align digital governance strategies with societal needs.				0.745
VC4: Stakeholder feedback is incorporated into governance innovations.				0.718
VC5: Our agency balances efficiency with equity in digital service delivery.				0.779
***BC:** Big Data Analytics capabilities*	0.767	0.848	0.584	
BC1: Our organization has the infrastructure to process large datasets.				0.792
BC3: We use predictive analytics to improve governance decisions.				0.700
BC4: Real-time data analytics enhance our responsiveness to public needs.				0.819
BC5: Advanced analytics tools (AI, machine learning) are leveraged in governance.				0.738
***TC:** Task Complexities*	0.825	0.876	0.586	
TC1: The governance challenges we face require sophisticated data analysis.				0.706
TC2: Multiple stakeholders increase the complexity of decision-making.				0.778
TC3: Regulatory constraints complicate digital governance implementation.				0.816
TC4: Rapid technological changes demand continuous adaptation.				0.805
TC5: Data integration from diverse sources is a challenge for our agency.				0.714

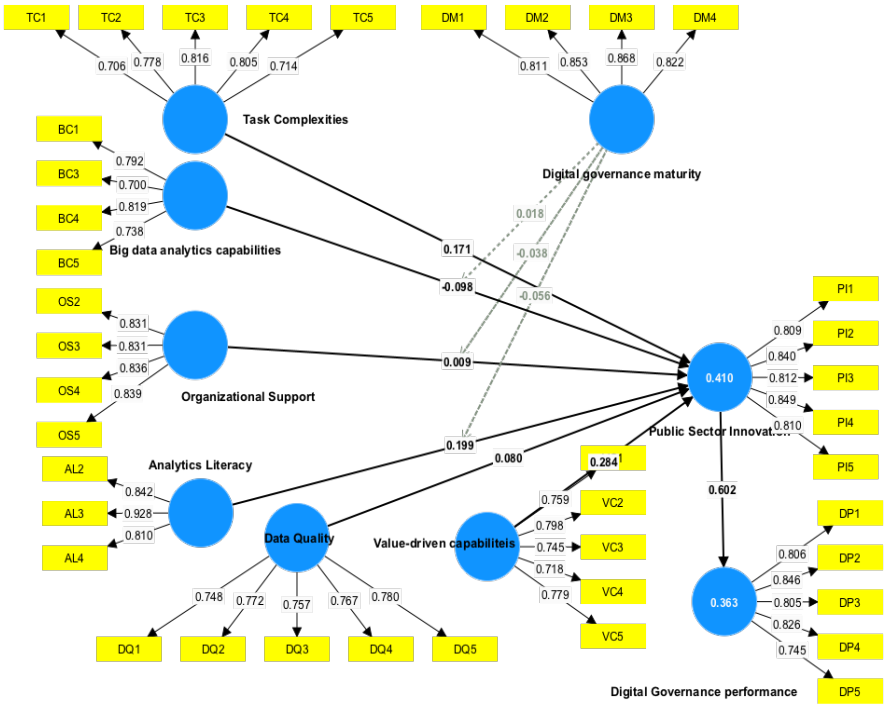


Fig. 2: Factor loadings

To ascertain the reliability of the constructs, Hair et al. (2019) recommend that composite reliability (CR) values between 0.60 and 0.70 are acceptable, 0.70 and 0.90 are good and values exceeding 0.95 are problematic since they cause a decline in the reliability of the model (Henseler et al., 2009). As shown in Tab. 2 all CR values were within the threshold indicating good reliability among constructs. The Average Variance Extracted (AVE) was also used to measure the convergent validity (CV) across all the items specific measured construct. CV is the degree to which separate items reflecting a concept converge or meet when compared to items measuring a distinct construct (Hair et al., 2019). The AVE's cut-off value is 0.50, which indicates that 50% of the construct's explanation of item variability is acceptable for CV (Hair et al., 2019). The AVE values derived for this study were above the 0.50 threshold indicating a satisfactory convergent validity.

Relative to the discriminant validity, the study adopts the Heterotrait-Monotrait ratio (HTMT) criterion given the weaknesses in the Fornell-Larcker criterion (Henseler et al., 2015), for its ineffectiveness in accounting for the uniqueness between the indicators. Tab. 3 presents the HTMT values between constructs which was within the acceptable range. The study adopts Henseler et al. (2015) recommended 0.85 threshold which suggest that, construct with this threshold are conceptually distinct.

Tab. 3 Discriminant validity with Heterotrait-Monotrait Ratio (HTMT)

Construct	1	2	3	4	5	6	7
BDA Capabilities							
Organizational support	0.479						
Analytics Literacy	0.281	0.15					
Data quality	0.576	0.753	0.098				
Digital governance performance	0.690	0.357	0.180	0.459			
Value- driven capabilities	0.606	0.589	0.096	0.829	0.591		
Big data analytics capabilities	0.486	0.497	0.192	0.762	0.340	0.812	
Task complexities	0.495	0.450	0.180	0.646	0.284	0.677	0.931

4.3 Structural model assessment

The next step was to access the inner structure of the model to determine the presence of collinearity with the predictor variables. When two or more formative indicators with the same values are inserted in the same block of indicators, collinearity occurs (Sarstedt et al., 2020). High degrees of collinearity impact on the formative indicator's statistical significance and weight estimate. It is thus, recommended that, the variance inflation factor (VIF) is kept low not above 5 (Hair et al., 2012). In this study, no collinearity problem existed since all VIF values.

The study finally tested the relationship among constructs using the PLS-SEM bootstrapping algorithm. This study

used the *t-statistic* values to measure the effect of the independent and mediating variables on the dependent variable relying on the recommended 1.65 threshold based on the 95% confidence interval (Hair et al., 2019). From the Ta. 4, six hypotheses (*H1, H3, H4, H5, H6 and H7*) out of the seven were supported.

Tab. 4 PLS-SEM Path Coefficients and hypotheses

	Hypothesis Relationship	**Std Beta**	**Std Error**	**T_Stat.**	**Interpretation**
H1	Task complexities -> Public sector innovation	0.205	0.126	1.693**	Supported
H2	Big data analytics capabilities -> Public sector innovation	-0.042	0.101	0.557	Not supported
H3	Value-driven capabilities -> Public sector innovation	0.28	0.083	3.415**	Supported
H4	Data quality -> Public sector innovation	0.123	0.07	1.732**	Supported
H5	Organizational support -> Public sector innovation	0.125	0.07	1.721**	Supported
H6	Analytics literacy -> Public sector innovation	0.214	0.046	4.664**	Supported
H7	Public sector innovation -> Digital governance performance	0.607	0.064	9.393**	Supported
Variables		*Coefficient of determination (R^2)*			*Adjusted R^2*
Public sector innovation		0.382			0.369
Digital governance performance		0.367			0.365

*Note: t denotes two-tailed statistics at **05 significant level*

To demonstrate the predictive capability of the model, an assessment of the structural model's path coefficient significance was performed to determine the goodness of fit (GOF) (Jung & Park, 2018). The commonly used criterion for this purpose is the determination coefficient (R^2), which gauges the exploratory power of the model (Hair et al., 2019). The range of R^2 values is from 0 to 1, with higher values indicating a greater level of explanatory power. R^2 values of 0.25, 0.50, and 0.75 are typically considered to be weak, moderate, and substantial, respectively (Hair et al., 2019). As shown in Table 3, the R^2 values were above 0.30, indicating a substantial model fit.

4.4 Moderation analysis

A moderation analysis was conducted to determine the moderating effect of digital governance maturity on the connection between the big data analytics capability, organizational support and analytics literacy, and public sector innovation. This was to find out how digital governance maturity affect the attainment public sector innovation. Using the t-value of 1.65 (Hair et al., 2019) as the benchmark, the result is shown in Tab. 5.

Tab. 5. Moderating Analysis result

Relationship	**Original Sample (O)**	**t- values**	**P Values**
IT*CO -> BDA	-0.048	0.595	0.552
IT*DS -> BDA	-0.08	1.135	0.257
IT*TI -> BDA	0.036	0.435	0.663

5. Discussion and implications

The results revealed that task complexity, value-driven capabilities, data quality, organizational support, and analytics literacy are the key factors influencing public sector innovations within the Ghanaian public sector. This finding aligns with prior research, including studies by (Egala & Afful-Dadzie, 2022; Yusif, 2017), which highlight the growing recognition of BDA capabilities as pivotal in enhancing decision-making, improving operational efficiency, and optimizing service delivery in public sector organizations.

The study identified that public sector innovation is significantly influenced by task complexity, value-driven capabilities, data quality, organizational support, and analytics literacy, validating hypotheses H1, H3, H4, H5 and H6. Instructively, H7 was also supported validating the proposition that, while the later antecedents lead to innovations in the public sector, it has a significant impact the performance of digital governance. These findings align with prior research by Joshi et al. (2021) and Didas (2023), which similarly highlighted these factors as key determinants of BDA adoption. Furthermore, Waqar and Paracha (2024) submit that BDA serve as a crucial enabler, offering public sector organizations the ability to strategically leverage data resources to enhance both academic and administrative task quality. Given these insights, it is recommended to increase investments in data analytics and business intelligence tools to strengthen decision-making processes. Additionally, this study underscores the importance of advancing the value of BDA to enhance decision-making and comprehensively assess the adoption and performance of digital governance in Ghana's public sector.

The findings indicate a significant relationship between value-driven capabilities (H3), data quality (H4), organizational support (H5), and analytics literacy (H6) in the context of technology characteristics. This suggests that public sector innovation's ability to provide organizational support, foster analytics literacy, improve data quality, and facilitate value-driven capabilities plays a critical role in determining the extent to which organizations adopt and effectively utilize such innovations (Lee et al., 2024).

In line with the guided theory, Larosiliere and Carter (2016), note that, the integration of ICTs within organizations significantly influences task operations. The study emphasize that the technological aspects of a task enable individuals within an organization to interact, collaborate, and participate more effectively in organizational activities. These insights highlight the importance of aligning technological characteristics with organizational needs to maximize the impact of public sector innovation (Arunde et al., 2019).

The findings of this study highlight that public sector innovation provides institutions with an efficient and effective platform for mining and utilizing data to enhance performance. Additionally, the technological characteristics of such innovations support seamless data access for users and allow for customization to achieve desired outcomes. Yoo and Kim (2019) observed that technology adoption increases when the alignment between the nature of the work and the technology is strong. Furthermore, the collection, storage, and utilization of big data require significant attention, emphasizing analytics literacy as a critical component of public sector innovation (Saggi & Jain, 2018). Supporting this, Solangi et al. (2018) identified data analytics literacy as one of the most crucial issues concerning data utilization. The study also underscores the importance of data security, revealing its significant influence on the successful adoption and implementation of public sector innovation.

However, the study revealed that BDA capability was not the most suitable fit for public sector innovation in Ghana. This finding contrasts with the conclusions of Brock and Khan (2017), who emphasized that BDA capabilities play a crucial role in facilitating the implementation of technology. This contradiction suggests that the effectiveness of BDA capabilities may vary depending on contextual factors, such as the specific technological, organizational, and environmental conditions within a region or sector.

The study found that digital governance maturity had no moderating effect on organizational support, analytics literacy, and Big Data Analytics (BDA) capabilities concerning the utilization of public sector innovation. This finding contradicts previous research, such as Wu et al. (2019), which highlighted that IT architecture appropriateness significantly influences the adoption and viability of IT implementation in organizations. Wu et al. (2019) argued that the alignment of IT architecture facilitates smoother technology adoption, leading to enhanced organizational efficiency. Similarly, Chege et al. (2020) emphasized that a well-structured IT architecture supports the integration of new technologies, improving operational efficiency. Tam and Oliveira (2016) further established that technology infrastructure has a substantial impact on task performance. Despite these contradictions, the study acknowledges the ongoing concerns surrounding analytics literacy in the context of data privacy and security. As Siddiqa et al. (2016) highlighted, safeguarding data integrity through secure computational tools and effective distributed storage systems is a critical element of public sector innovation. While this study's findings suggest that public sector innovation and organizational support require minimal reliance on digital governance maturity for performance enhancement, it reinforces the importance of preserving institutional data integrity as a foundational aspect of innovation. Robust data security measures remain essential to ensure the successful adoption and utilization of public sector innovation.

Empirically, this study provides valuable insight into how task-technology and value-driven characteristics influence the implementation of public sector innovation and their consequences on digital governance performance. Drawing on Przegalinska et al. (2025) introduction of task complexities and big data analytics capabilities, we extend the TTF framework to account for the evolving nature of BDA within public institutions. Notably, this research is among the first to examine public sector innovation from a developing country's perspective, addressing a gap in existing literature that has largely focused on developed contexts. In Ghana, for instance, organizations face unique challenges in acquiring both the technical and human resources essential for successful innovation.

To bridge this gap, we synthesize factors such as big data analytics and value-driven capabilities, analytical literacy and digital governance maturity and into the TTF model, recognizing that public sector innovation hinges not only on technological considerations but also on business processes and value propositions. While previous studies have predominantly emphasized technical variables, this work responds to calls for a deeper investigation into the "dependent side" of the TTF model namely, productivity and performance, which our findings affirm as key outcomes of innovation adoption. Although our moderating analyses did not yield significant results, the importance of providing robust IT infrastructure remains evident.

This study also underscores that simply investing in public sector innovation does not automatically lead to positive outcomes. For employees with non-routine tasks, selecting the right ICTs can indeed boost productivity, but achieving the desired impact requires more than just equipment provision. Organizations must also align users'

culture and work practices with their core business processes to fully capitalize on these investments.

Moreover, public sector innovation initiatives should be adaptable to the specific activities and organizational practices of the public sector and other public entities. Overreliance on ICT tools without considering tasks, hierarchies, and decision-making processes can diminish potential value. Consequently, a supportive policy environment that encourages staff and other stakeholders to embrace and effectively use public sector innovation is crucial. This includes granting staff appropriate access to IT infrastructure for collaborative work and instituting ICT policies (e.g., database use policy, internet use policy) to safeguard user information. Lastly, government-led educational and ICT policies can further ensure the protection and security of information, thus fostering a more conducive environment for public sector innovation.

6. Conclusions and limitations

The objectives of the study were to examine the nature of BDA, investigate the factors that influence BDA fit in task-oriented activities, and assess the impact of BDA on Public sector in Ghana. Drawing on the TTF, the study employs and exploratory approach and collected data from 310 public sectors workers in Ghana. The study uses PLS-SEM analysis to analyse the data. The findings revealed that innovations in the public sector are driven by factors such as task complexity, value-driven capabilities, data quality, organizational support, and analytics literacy as key antecedents of BDA use in public sector of Ghana. Unfortunately, the proposition that, big data analytics capabilities influence public sector innovations was not support. The study also found that, public sector innovations through BDA contribute significantly to their digital governance performance in Ghana. The study presents several implications for theory and practice as technology keeps changing the public sectors landscape in Ghana yet, fraught with several challenges in its adoption, use and implementation.

The research was limited by the context in which it was studied and the adopted methodology. While this presents a practical case for a developing economy, future research can leverage other methodologies to explore other geographical context for a broader understanding of the digital governance and how BDA transforms public governance. Again, a comparative analysis could also enhance the generalizability of the future studies. Theoretically, other theories may also be leveraged to explore similar phenomenon.

Acknowledgement

Contributor Statement*: All authors contributed significantly to the work

Conflict Of Interest (COI)*: There is no conflict of interest to declare

References

Abelsen, S. N., Vatne, S. H., Mikalef, P., & Choudrie, J. (2021). Digital working during the COVID-19 pandemic: How task–technology fit improves work performance and lessens feelings of loneliness. *Information Technology and People*. https://doi.org/10.1108/ITP-12-2020-0870

Alexopoulos, C., & Janssen, M. (2020). Benefits and barriers of using open government data: An empirical study. *Government Information Quarterly, 37*(1), 101405. https://doi.org/10.1016/j.giq.2019.101405

Amabile, T. M., & Pratt, M. G. (2016). The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning. *Research in Organizational Behavior, 36*, 157-183.

Anderson, N., Potočnik, K., & Zhou, J. (2014). Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. *Journal of Management, 40*(5), 1297-1333.

Arshad, M., Qadir, A., Ahmad, W., & Rafique, M. (2024). Enhancing organizational sustainable innovation performance through organizational readiness for big data analytics. *Humanities and Social Sciences Communications, 11*(1), 1-15.

Arundel, A., Bloch, C., & Ferguson, B. (2019). Advancing innovation in the public sector: Aligning innovation measurement with policy goals. *Research Policy, 48*(3), 789-798.

Batini, C., Cappiello, C., Leone, C., & Viscusi, G. (2016). Big data quality. *ACM Computing Surveys (CSUR), 49*(1), 1–

41. https://doi.org/10.1145/2926720

Bibri, S. E. (2020). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society, 60*, 102212. https://doi.org/10.1016/j.scs.2020.102212

Boruzie, K. P., Kolog, E. A., Afful-Dadzie, E., & Egala, S. B. (2022). Social network for collaborative learning: What are the determining factors? *Universal Access in the Information Society*. First Online. Springer. https://doi.org/10.1007/s10209-022-00942-3

Brous, P., & Janssen, M. (2020). Trusted decision-making: Data governance for creating trust in data science decision outcomes. *Information & Management, 57*(8), 103369. https://doi.org/10.1016/j.im.2020.103369

Bwalya, K. J. (2018). E-government implementation in developing countries: A review of key success factors. *Journal of Electronic Commerce in Organizations (JECO), 16*(1), 1–14.

Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business intelligence and analytics: From big data to big impact. *MIS Quarterly, 36*(4). https://doi.org/10.2307/41703503

Chege, S. M., Wang, D., & Suntu, S. L. (2020). Impact of information technology innovation on firm performance in Kenya. *Information Technology for Development, 26*(2), 316–345. https://doi.org/10.1080/02681102.2019.1573717

Chhetri, P., Stimson, R., & Western, M. (2021). Digital government maturity and open data use for public service innovation: A moderated mediation model. *Government Information Quarterly, 38*(4), 101614. https://doi.org/10.1016/j.giq.2021.101614

Cingolani, L., McBride, K., & Hammerschmid, G. (2022). Digital government transformation: A structural equation model of antecedents and outcomes. *Government Information Quarterly, 39*(2), 101683.

Curry, E., Anagnostopoulos, T., & Arcidiacono, C. (2021). Digital government transformation: A review of the literature and future research directions. *Information Polity, 26*(4), 369–391.

Didas, M. (2023). The barriers and prospects related to big data analytics implementation in public institutions: A systematic review analysis. *International Journal of Advanced Computer Research, 13*(64), 29.

Dorasamy, N. (2021). The digital divide: A comparative analysis of digital maturity in the public and private sectors. *International Journal of Public Administration in the Digital Age (IJPADA), 8*(1), 1–16.

Egala, S. B., Liang, D., & Boateng, D. (2022). Social media health-related information credibility and reliability: An integrated user perceived. *IEEE Transactions on Engineering Management, PP*, 1–12. https://doi.org/10.1109/TEM.2022.3225182

Egala, S. B., & Afful-Dadzie, E. (2022). Performance of open government data in a developing economy: A multi-stakeholder case analysis of Ghana. *Transforming Government: People, Process and Policy, 16*(3), 318–333. https://doi.org/10.1108/TG-10-2021-0158

European Commission. (2022). A European strategy for data. Publications Office of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0066

Gil-Garcia, J. R., Zhang, J., & Puron-Cid, G. (2020). Conceptualizing smartness in government: An integrative and multidimensional framework. *Government Information Quarterly, 37*(1), 101404. https://doi.org/10.1016/j.giq.2019.101404

Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS Quarterly: Management Information Systems, 19*(2), 213–233. https://doi.org/10.2307/249689

Gupta, M., Meijer, A., & Wieringa, R. (2023). Big data for sustainability: A systematic literature review and research agenda. *Information Systems Frontiers, 25*(1), 215–244.

Hagendorff, T. (2020). The ethics of AI ethics: An evaluation of guidelines. *Minds and Machines, 30*(1), 99-120.

Hair, J. F., Sarstedt, M., Ringle, C. M., & Mena, J. A. (2012). An assessment of the use of partial least squares structural equation modeling in marketing research. *Journal of the Academy of Marketing Science, 40*(3), 414–433. https://doi.org/10.1007/s11747-011-0261-6

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European Business Review, 31*(1), 2–24. https://doi.org/10.1108/EBR-11-2018-0203

Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. *Advances in International Marketing, 20*(January), 277–319. https://doi.org/10.1108/S1474-7979(2009)0000020014

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*, 115-135.

Isaac, O., Aldholay, A., Abdullah, Z., & Ramayah, T. (2019). Online learning usage within Yemeni higher education: The role of compatibility and task-technology fit as mediating variables in the IS success model. *Computers and Education, 136*, 113–129. https://doi.org/10.1016/j.compedu.2019.02.012

Janssen, M., Zuiderveen Borgesius, F. J., & Kruikemeier, S. (2020). The influence of data governance on data quality, trust, and public sector innovation. *Government Information Quarterly, 37*(4), 101504.

Jum'a, L., & Kilani, S. (2022). Adoption enablers of big data analytics in supply chain management practices: The moderating role of innovation culture. *Uncertain Supply Chain Management, 10*(3), 711–720.

Joshi, A., Benitez, J., Huygh, T., Ruiz, L., & De Haes, S. (2022). Impact of IT governance process capability on business performance: Theory and empirical evidence. *Decision Support Systems, 153*, 113668.

Jung, S., & Park, J. H. (2018). Consistent partial least squares path modeling via regularization. *Frontiers in Psychology, 9*(FEB). https://doi.org/10.3389/fpsyg.2018.00174

Kalampokis, E., Tambouris, E., & Tarabanis, K. (2020). Open government data: A systematic literature review. *Information Polity, 25*(1), 3–29.

Kraus, S., Durst, S., Ferreira, J. J., Veiga, P., Kailer, N., & Weinmann, A. (2022). Digital transformation in business and management research: An overview of the current status quo. *International Journal of Information Management, 63*, 102466.

Kuru, K., & Ansell, D. (2020). TCitySmartF: A comprehensive systematic framework for transforming cities into smart cities. *IEEE Access, 8*, 18615-18644.

Lee, J. Y., Kim, B., & Yoon, S. H. (2024). A conceptual digital policy framework via mixed-methods approach: Navigating public value for value-driven digital transformation. *Government Information Quarterly, 41*(3), 101961.

Leslie, D., Mazzi, F., & Cath, C. (2021). Public values and the governance of data for AI in government: A review of the literature identifying ethical tensions and gaps in existing frameworks. *Big Data & Society, 8*(2).

Larosiliere, G. D., & Carter, L. D. (2016). Using a fit-viability approach to explore the determinants of e-government maturity. *Journal of Computer Information Systems, 56*(4), 271–279. https://doi.org/10.1080/08874417.2016.1163995

Magakwe, J. (2025). Advancing governance: Role of data analytics in driving evidence-based decision-making in public administration. In *Recent Advances in Public Sector Management*. IntechOpen.

Mach-Król, M., & Hadasik, B. (2021). Big data analytics in public administration: A systematic literature review. *Informatyka, Automatyka, Metrologia, 21*(4), 1–7.

Mariani, M. M., & Mortati, M. (2023). Smart cities and citizen participation: A systematic literature review. *Cities, 144*, 104639. https://doi.org/10.1016/j.cities.2023.104639

Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. *Government Information Quarterly, 36*(4), 101385. https://doi.org/10.1016/j.giq.2019.06.002

Mittelstadt, B. D., Allo, P., Taddeo, M., Wachter, S., & Floridi, L. (2016). The ethics of algorithms: Mapping the debate. *Big Data & Society, 3*(2). https://doi.org/10.1177/2053951716679679

Mpofu, S., & Chasokela, D. (2025). Data-informed decision-making: Using analytics to drive strategic management in higher education. In *Building Organizational Capacity and Strategic Management in Academia* (pp. 103-138). IGI Global Scientific Publishing.

Nadkarni, S., & Prügl, R. (2021). Digital transformation: A review, synthesis, and opportunities for future research. *Management Review Quarterly, 71*, 233-341.

Ndou, V. (2020). Digital transformation in the public sector: A systematic literature review. *Transforming Government: People, Process and Policy, 14*(3), 487–516.

Osborne, S. P., & Brown, L. (2011). Innovation, public policy, and public services delivery in the UK: The word that would be king?. *Public Administration, 89*(4), 1335-1350.

Pace, D. S. (2021). Probability and non-probability sampling—an entry point for undergraduate researchers. *International Journal of Quantitative and Qualitative Research Methods, 9*(2). https://ssrn.com/abstract=3851952

Przegalinska, A., Triantoro, T., Kovbasiuk, A., Ciechanowski, L., Freeman, R. B., & Sowa, K. (2025). Collaborative AI in the workplace: Enhancing organizational performance through resource-based and task-technology fit perspectives. *International Journal of Information Management*, *81*, 102853.

Saggi, M. K., & Jain, S. (2018). A survey towards an integration of big data analytics to big insights for value-creation. *Information Processing & Management, 54*(5), 758-790.

Shah, S. A., Seker, D. Z., Rathore, M. M., Hameed, S., Yahia, S. B., & Draheim, D. (2019). Towards disaster resilient smart cities: Can internet of things and big data analytics be the game changers?. *IEEE Access, 7*, 91885-91903.

Sreenivasan, R. R. (2017). Characteristics of big data—a Delphi study (Doctoral dissertation, Memorial University of Newfoundland).

Solangi, Z. A., Solangi, Y. A., Chandio, S., Aziz, M. B. S. A., Bin Hamzah, M. S., & Shah, A. (2018). The future of data privacy and security concerns in the Internet of Things. *2018 IEEE International Conference on Innovative Research and Development, ICIRD 2018*, November, 1–4. https://doi.org/10.1109/ICIRD.2018.8376320

Tam, C., & Oliveira, T. (2016). Performance impact of mobile banking: Using the task-technology fit (TTF) approach. *International Journal of Bank Marketing, 34*(4), 434–457.

Urs, S., Nisioi, A., & Roja, A. (2023). Digital transformation in the public sector: The role of leadership. *Transforming Government: People, Process and Policy, 17*(1), 1–21.

Waqar, J., & Paracha, O. S. (2024). Antecedents of big data analytics (BDA) adoption in private firms: A sequential explanatory approach. *Foresight, 26*(5), 805-843.

Wu, S. P. J., Straub, D. W., & Liang, T. P. (2015). How information technology governance mechanisms and strategic alignment influence organizational performance. *MIS Quarterly, 39*(2), 497-518.

Yoo, S. K., & Kim, B. Y. (2019). The effective factors of cloud computing adoption success in organization. *Journal of Asian Finance, Economics and Business, 6*(1), 217–229.

Yusif, S. (2017). Assessing the readiness of public healthcare facilities to adopt health information technology (hit)/e-health: A case study of Komfo Anokye Teaching Hospital, Ghana (Doctoral dissertation, University of Southern Queensland).

Using ICT to Patch the Shortcomings of New Public Management in a Post-Communist Welfare State

Sebastian Sosnowski [a*]

[a] Graduate School for Social Research & Institute of Philosophy and Sociology, Polish Academy of Science Warsaw, Poland, sebastian.sosnowski@ifispan.edu.pl, ORCID number: 0000-0002-2436-0022

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. New Public Management approach in the welfare sector led to outsourcing and disaggregation of the services, which makes it difficult to implement new ICT technologies into such context. In this paper, I analyse the case of Electronic Care System (ECS) implemented in selected municipalities in Poland. These municipalities carry different characteristics of inhabitants and service provision. Additionally, Polish welfare system is a case of transformative system which is a mix of diverse European systems. I analyse secondary data (documents, strategies), interviews and observations regarding the implementation of ECS. Based on that, I draw the main conclusions regarding how context of welfare provision impedes the successful implementation of the ICT within the public institutions. I argue that introduction of ICT in fragmented institutions needs to include diverse perspectives of stakeholders and take into account the values important for the system users. Especially, I focus on how diverse modes of care provision need to be mirrored in the systems, how political and managerial pressures make it more difficult for other actors to navigate through the change. At the end, I ask the question about organisational and cognitive costs of implementing innovations.

Keywords. algorithmic/automated decision making (ADM), elderly care, New Public Analytics (NPA), New Public Management (NPM), welfare state
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1062

1. Introduction

Currently, new technologies are increasingly being introduced into the sphere of social support and welfare policies (Alston, 2019). They are designed to improve administrative efficiency and facilitate the functioning of citizens-beneficiaries, among other things, through automated decision-making (ADM). However, the implementation of such solutions is highly dependent on the context in which a given institution operates (Broomfield & Reutter, 2022), including the approach of the involved stakeholders. In this paper, I analyse the case of the Electronic Care System (ECS) introduced in selected Polish municipalities to support the process of granting and providing care services for the elderly and people with disabilities. I argue that ECS, functioning in the context of Poland's mixed welfare state model, exemplifies thinking described as **post-New Public Management** (NPM), in which the state institutions try to regain control over the privatised elements of public services (e.g. Howard, 2015; Anttiroiko & Valkama, 2016), and I will outline post-NPM features of the researched system. In doing so, I pay attention to context-specificity of the researched case.

The importance of welfare and social security is mirrored in the content of recent EU strategies and budgetary plans (Frączkiewicz-Wronka et al., 2024). European welfare state models are the subject of analysis and categorization, though these studies are largely focused on Western Europe (e.g. Esping-Andersen, 1990; Titmuss & Abel-Smith, 1990). With the ongoing digitization of various aspects of Europeans' lives, welfare states are also integrating new technologies into their daily operations. The so-called **"digital welfare state"** (Dencik, 2022) has become an increasingly discussed subject of research (e.g. O'Neil, 2016; Eubanks, 2017; Gantchev, 2019), particularly due to its direct impact on citizens' well-being. However, there is scarce literature connecting implementation of new technologies with wider context of welfare institutions, including research on countries of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Central and Eastern Europe, which was called by Esping-Andersen "the most under-defined region, a virtual laboratory of experimentation" (Esping-Andersen, 1996, p. 267).

This article aims to fill this gap by describing the case of digitalisation in care services through the ECS in selected Polish municipalities and introducing it in the context of welfare assistance. Poland is an example of a post-communist country where state institutions (including welfare assistance) and society are undergoing a transformation from a centrally planned economy with a strong bureaucratic presence to a market economy in which state administration plays a less dominant role (Golinowska, 2009b; Księżopolski, 2013). I aim to answer the following research questions: 1) What are **the goals delineated by policy-makers** for the ECS and **how do they relate to the idea of NPM**? 2) What is the **role of new technologies** in this case, considering the concept of **New Public Analytics** (NPA; Yeung, 2023)? The presented case study is a part of broader project AUTO-WELF: Automating Welfare – Algorithmic Infrastructures for Human Flourishing in Europe.

The paper is structured as follows. First, I describe the organisation of welfare assistance system in Poland with special attention to current social problem – ageing population. Consequently, I introduce the concepts of New Public Management, post-New Public Management and New Public Analytics that will be a theoretical framework for the analysis. Next, I present the methods of the research and analysis of the data. After that, I describe the main findings from the analysis divided into three main categories: diverse mode of service provision, managerial pressure for innovation and costs of innovation spread among stakeholders. I sum up with remark that implementation of new technologies in the welfare service need a close and thorough analysis of possible future scenarios from different perspectives of involved actors.

1.1 Organisation of Welfare Services in Poland

Social security system in Poland is divided into several pillars, which include health insurance, employment agencies, social insurance and welfare assistance (social services and benefits, mostly directed to families) (Rusiecka, 2023). In this paper, I will focus on the last element of the system, which is also responsible for provision of care services.

As a unitary state with three-level system of administrative division, the control over the welfare assistance and services in Poland is mainly in the Ministry of Family, Labour and Social Policy (MRPiPS). However, the greatest responsibilities to provide social assistance to citizens is in the smallest administrative units – gminas (communes, municipalities). The social assistance system provides support in form of financial or material benefits and services, such as legal and psychological support, social work or care provision for the elderly. Each gmina has a Social Welfare Centre (SWC) that is obliged to provide direct support to gmina's inhabitants in order to fulfil their basic needs (Ministry of Family, Labour and Social Policy, 2019; Dz.U. 2004 Nr 64 Poz. 593, 2004). As a result, gminas define their own strategies and plans for the development of social policy, which is largely decentralized but operates within a uniform legal and institutional framework. Recently, big social programmes were introduced (e.g. 500+ benefit for families with children, "Active Parent" programme for employed parents), which are an example of central social policies. However, the responsibility for such programmes is laid on central Social Insurance Institution (ZUS) rather than on local SWCs.

In the wake of the departure from communism and the systemic transformation of the 1990s, the main focus was on labour market issues and social assistance (Golinowska et al., 2009). The "shock therapy" proposed by Leszek Balcerowicz also involved a significant reduction in funding for social support (Księżopolski, 2011) and such a rapid and dynamic transition to a free-market economy was unprecedented in Europe, carrying high social costs. Marketisation of the economy produced "winners" and "losers" of economic transformation (Debicki & Debicka, 2008) and led to deepening social inequalities (Księżopolski, 2011).

Due to the ambitions of the ruling elites to integrate Poland into the structures of the European Union, social policy goals were largely subordinated to economic development, including activation policies, the flexibilization of employment forms at the expense of workers' rights (Golinowska, 2018), as well as low amounts of social benefits (Księżopolski, 2013). These changes were facilitated by prevailing public sentiments, which embraced the liberal rhetoric of the need for low taxes and a reduction in state interventionism (Rae & Piotrowska, 2022) and insufficient spendings in this domain.

The main focus of social assistance in Poland is on family rather than on individuals. This is also expressed in "familisation" (Esping-Andersen, 2003) of the support system: the relatives have the primal responsibility to support family members and in case of its insufficiency or denial, institutions provide support. Some of the services are subsidiary, meaning that they are partially paid, based on the material situation of the beneficiaries and their families. The welfare state model in Poland is described as "mixed" (Siemieńska & Domaradzka, 2016) between conservative and liberal models. The former is because of great significance of the family obligations within the system. The latter is due to strong orientation of some of the institutions towards employment activisation and to using market mechanisms, such as outsourcing, when institutions are unable to provide services. Moreover, during

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the transformation period, the existing social infrastructure was often privatised due to lack of resources (Siemieńska & Domaradzka, 2020).

Mirosław Księżopolski describes **Poland's welfare state model as a "paternalistic-market hybrid"** (2011, p. 16), which combines elements of state-guaranteed social security with capitalist economic principles, rarely constrained by the state. Private entities have been incorporated into the provision of certain services—such as healthcare, elderly care, and education—to compensate for the shortcomings of the state. The word "paternalistic" denotes not only the degree of state interventions, but also specific mindset about passive citizens: "*The modern Polish state is still largely perceived as an external entity that acts ‹*instead of*› citizens rather than as a service-oriented institution that acts ‹*for*› them*" (Księżopolski, 2011, p. 32). Additionally, this system remains inconsistent, leading to mixed public perceptions (Rae & Piotrowska, 2022). Despite dynamic economic growth, particularly after Poland's accession to the European Union, no significant reforms or increased investments in social assistance followed. Instead, the welfare system remains closely tied to the dominant capitalist economy, with citizens' livelihood largely dependent on their position in the labour market (Księżopolski, 2013). Even the introduction of big social programmes as 500+ (later increased to 800 PLN per month) and "Active Parent" are examples of direct cash benefits respectively to families or to private entities, which limits the role of the state in the family policy and service provision (Siemieńska & Domaradzka, 2020). Additionally, the latter is an example of strong connection between social policy and employment goals.

One of the biggest challenges for European welfare states (Anttiroiko & Valkama, 2016; European Commission. Statistical Office of the European Union., 2020), including the Polish welfare system (Golinowska, 2009a; Księżopolski, 2011; Siemieńska & Domaradzka, 2016) is **ageing population**. This is a result of decrease in both fertility and mortality, as well as increasing life expectancy of European societies. In 2023, the Polish society consisted of **more than one quarter of people aged at least 60 years old**[1]. The senior population is relatively young, with the most numerous group aged between 65 and 69 years old (app. 25% of seniors). Almost two thirds of seniors live in cities or towns. The average life expectancy for males is 75 years, whereas for females – 82 years. In household consisting of solely older persons, the most frequent basic source of income are social benefits, with the highest share coming from retirement pay and pensions. However, 5,7% of households in which lived older person reported rather bad or bad material situation (Wyszkowska et al., 2024). Considering projected decreasing population in the working age (Stachura & Strzelecki, 2023), **one of the challenges in the future would be to provide care and fulfil basic needs of dependent elderly**.

1.2 From New Public Management (NPM) to New Public Analytics (NPA)?

The beginning of changes in public institutions that indicated the adoption of **New Public Management (NPM)** thinking can be traced back to the 1980s, particularly in countries of the so-called Global North, where political leaders came to power advocating reforms. These leaders promoted the need for changes inspired by neoliberal and free-market principles, aiming to reshape the functioning of public institutions that had been weakened by the financial crisis of the 1970s. As a result, public institutions adopted a more managerial approach, characterized by cost-cutting measures in public services, primarily through outsourcing to non-governmental sector entities (Hood, 1991).

NPM has manifested in several political decisions that were aimed at mimicking the managerial style of private entities in public sector, which included marketisation of the services. The hidden underpinning of these reforms was the belief that competition among several service provider would lead to lower prices and increased service quality. In many instances, NPM also brought decentralisation of the existing institutions and introduction of mostly quantitative-based performance measurements and auditing. Inefficient institutions faced budget cuts or top-down pressure to improve the performance (Gruening, 2001). Noteworthy, the implementation of NPM principles was perceived as non-political (Yeung, 2023), allegedly separating politics and administration. However, as presented by Samier, efficiency, effectiveness and focus on economic performance were the organising ideas for NPM institutions (Samier, 2005).

In Central and Eastern European (CEE) countries, **the principles of NPM were adopted during the systemic transformation of the 1990s**. This was largely due to the widespread popularity of this approach in the public administration of Western European countries, and most notably, in the United States. Post-communist states, which lacked sufficient experience and knowledge regarding the functioning of NPM, were more likely to adopt this model rather than the social-democratic approach used in neighbouring Scandinavian countries. This choice was also influenced by international financial institutions, particularly the International Monetary Fund (IMF) and the World Bank. These institutions demanded rapid reforms, primarily aimed at reducing public spending, as a prerequisite for debt negotiations and development aid (Randma-Liiv, n.d.; Randma-Liiv & Drechsler, 2017). This context lead to adaptation of **cost-effectiveness accountability** rather than accountability for the social outcomes

[1] The retirement age in Poland is 60 years for women and 65 for men.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of the reforms (Parker & Gould, 1999).

Empirical research on NPM reforms has identified key problems with this approach. Reliance on the market and outsourcing of services caused **control and accountability deficits** in public administration. Fragmentation of institutions and, in some cases, agencification **hampered managerial responsibilities** of public servants and could have the effect on delivery of **disjointed and inconsistent services** to citizens (Howard, 2015). In the context of CEE, especially Poland and Hungary, there is no strong civil service, which leads to **politicization of administration** and hampers its development (Randma-Liiv & Drechsler, 2017). Fragmentation of the institutions results in diverse dynamics of development. Also, as shown during the COVID-19 pandemic, institutions are forced to response to crisis situation without much prior preparedness (Sosnowski et al., 2021). However, implementation of NPM had positive impact by providing ideas for modern administration and highlighting the importance of administration reforms (Dan & Pollitt, 2015; Debicki & Debicka, 2008).

Public administration has sought to adapt to identified issues through a process of service reintegration and coordination. Changes NPM were also influenced by negative assessments of its effectiveness, the erosion of political control, and a growing sense of insecurity in the modern world. Christensen and Lægreid refer to this trend as the "rediscovery of bureaucracy" (Christensen & Lægreid, 2011, p. 141) or **post-New Public Management** (post-NPM; 2011, p. 132), though it has led to the emergence of complex and hybrid organizational forms. The authors argue that linear or cyclical perspectives on administrative development should be rejected. This shift is particularly driven by the fragmentation of public administration, where different institutions implement changes independently, at their own pace and according to their own priorities. Additionally, the expectations of service users are changing, especially regarding its quality. Nonetheless, the demographic changes and curbing public spendings are the reason that bureaucracies seek to improve performance in order to assure quality increase (Kinder, 2012).

Karen Yeung (2023) introduced the term **New Public Analytics (NPA)** to denote new approach in public administration in the age of digital transformation. NPA manifests in reliance on datafication and automated decision-making, which is supposed to make governance seamless. Disregarding varying degree of sophistication of ICT solutions, NPA approach offers improvement in procedures rather than ideological change in the functioning of administration. ICT is therefore treated as a tool to achieve better measurable outcomes than new paradigm. Yeung highlights the continuity between NPM and NPA, especially in orientation towards market solutions and reliance on evidence-based policy making, allegedly neutral in political implications (Kempeneer, 2023).

However, NPA is built on ideological foundations, which Yeung describes as **"neoliberalism with a techno-solutionist makeover"** (Yeung, 2023, p. 16). Just like NPM, NPA is market-driven and oriented toward competition. Solutions implemented in social policy and welfare often adopt market-based solutions, which are rarely adjusted to the specific organizational context (e.g. O'Neil, 2016). Social problems are perceived as opportunities for technological innovation, but the primary goal remains profit generation. Nevertheless, Shirley Kempeneer argues that the cause of the problem in possible algorithmic injustices is not a new paradigm, rather it is deeply rooted in NPM logic of disaggregation, competition and incentivisation for improvements (Kempeneer, 2023).

In case of Polish welfare assistance, the institutions seem stable. Since the local self-government reform in 1990, the smallest administrational units (gminas) are responsible for the implementation and provision of social assistance to their inhabitants through Social Welfare Centres using material benefits and services. Despite the definition of eligibility criteria for support are defined in the Social Assistance Act from 2004, social workers have discretionary power, e.g. by withholding documentation or "creaming" clients, meaning serving mostly a promising group of individuals (Sosnowski et al., 2021; Trochymiak, 2018). In 2019, the Act on Provision of Social Services by Social Services Centres has created a possibility for local authorities to introduce such Centres (SSC). The aim of this change was to integrate and coordinate fragmentised net of services and dividing social assistance from social services (Szarfenberg, 2021). This aligns with the logic of both NPM (decentralisation and discretionary to manage) and post-NPM (attempt to reintegrate institutions and creating hybrid and complex organisations).

From almost 2500 gminas in Poland, all of them vary in terms of their economic and political development, disfavouring less economically developed ones to develop administrational structures and implement innovations (Debicki & Debicka, 2008). Stanisława Golinowska points out that NPM was largely accepted in Polish administration, mostly because of replacing the burden of service provision and, in some cases, of guaranteeing its good quality (Golinowska, 2018). Parallelly, the decreasing quality of public services created a demand for privately provided ones, especially in education, health and long-term care. Even if private suppliers are subsided by the authorities, the possibility to control the service is limited. As stated by Golinowska:

> *"The functioning of social services, a fundamental pillar of the welfare state, in Poland is **varied and chaotic, with unequal access** contributing to social disparities. However, the general belief among Polish society persists—that access to these services can somehow be ‹arranged›, either through informal means or by having the necessary*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

funds to pay for them. As a result, individuals facing higher risks (e.g., people with disabilities) tend to demand direct ‹cash› rather than services, such as rehabilitation, caregiving, or specialized equipment." (Golinowska, 2018, p. 127-128)

The digitization of public services in Poland is also fragmented, primarily due to the decentralization of institutions. Aside from the existing ministerial statistical system, SWCs use various solutions, all of which must receive ministerial certification (Frączkiewicz-Wronka et al., 2024). The Social Assistance Act specifies, among other things, the scenario for standardised community interviews (pl. *wywiad środowiskowy*), but it does not define whether they should be conducted using new technologies or simply written on paper. In some SWCs, a dual document circulation system is in place: paper-based personal files are maintained for beneficiaries, while at the same time, these documents are scanned and stored digitally.

1.3 Electronic Care System (ECS)

The ECS is one of the examples of using new technologies in welfare assistance in Poland. It is introduced in almost over 20 gminas that are geographically neighbouring, nevertheless caring different characteristics of inhabitants. Almost two thirds of them have big city characteristics (hereinafter: urban gminas). The rest is rural or small-town (hereinafter: rural gminas). Due to involvement of numerous administrative units, the case involves complex network of public organisations (including SWCs and SSCs and municipal authorities) and private companies (responsible for provision of care services and IT infrastructure and software).

Care services for partly independent citizens are provided in-house to help them accomplish daily routines. As described above, the primary obligation to support the elderly is on family members, however in case of their lack of resources, social workers from SWCs may decide to allocate care services also to persons living with their families. The financial aspect of the service depends on the gmina's regulations. If family has sufficient incomes, beneficiaries are obliged to financially contribute to the service. SWC has a discretion to exempt beneficiary from the payment in case of documented circumstances.

The process of granting the service begins with an application from the possible beneficiary, their family members or persons from community. After that, social worker from SWC is obliged to conduct community interview with either the applicant or other household members. During the interview, a lot of personal information, including financial status, health condition or existing relationships, are collected. Based on the information from the interview, social worker issues an administrative decision, which needs approval from the SWC director. The decision includes the information about care services scope, meaning performed tasks and number of hours prescribed to the beneficiary.

The ECS consists of a few components. Social workers responsible for conducting community interviews use Digital Interview app to record them on laptops. Caregivers, employed either by private companies (mostly in urban gminas) or by SWCs, use mobile app of ECS (hereinafter: mobile ECS) to access the information about beneficiaries and assigned tasks to perform during work hours. Mobile app also uses near-field communication (NFC) for caregivers clock-in and clock-out from their beneficiaries apartments. The managers in the SWCs, SCCs and private care companies use software allowing them to create timetables, control the punctuality of the service (based on NFC log-ins) and exchange documentation, including fiscal documents.

The additional features of the system is the profiling algorithm and remote care component. The former is designed based on a data collected in additional questionnaire during the community interview. The algorithm takes into account physical and "mental" autonomy of the service beneficiary and based on assessment allocates them in one of nine profiles of autonomy. Based on this assessment, the software suggests social workers the possible scope of prescribed care services (in weekly hours of the service).

The remote care uses indicators either installed in the apartments of beneficiaries or wearable technologies. The component includes wristbands monitoring the life functions and equipped in emergency button. Wristbands can also detect if the person has fallen down and connect the beneficiary with monitoring centre, which can further call the emergency services. The other technologies used in the remote care are detectors of smoke and carbon oxide, as some of the houses in rural gminas use heating stoves. One of the element are also key boxes used by caregivers and emergency services.

2. Research methods

In this research, we implemented case study approach combining several research methods, including secondary data analysis (existing documentation, policy strategies etc.), in-depth interviews and organisational ethnographic observations. These activities were taken by two team members, including the author. The research received

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

approval from the Research Ethics Committee of the Institute of Philosophy and Sociology of the Polish Academy of Sciences.

As the researched system is an example of public-private partnership, there is a rich documentation of the procurement procedures, design plans and descriptions of the ECS. Also, we paid attention to municipalities' policy documents, especially regarding welfare assistance and their development strategies. This stage helped us to better understand local specificity of the policy area and map the possible interviewees for the further stage of the research.

We conducted several interviews with various stakeholders involved in the process of design and implementation of the system. Among our interviewees are management-level employees of municipalities' offices, employees of private companies, namely IT company commissioned to develop the software and companies providing care services in numerous of researched municipalities, and employees of the social assistance institutions (SWCs and SCCs).

Additionally, we participated in the testing meetings of workers of SCCs and private care companies, which happened in the care services beneficiaries' places of residence. These testing meetings were mostly focused on teaching caregivers how to log in to the mobile app and to use the NFC technology within the app. From these meetings, we collected fieldnotes based on the observations of researchers (Emerson et al., 2011).

Audio recordings of the interviews were transcribed and anonymised. All collected data – documents, fieldnotes, interview transcriptions – were uploaded in the shared workspace in Qualitative Data Analysis (QDA) software. For data analysis, we used a standardised coding system, which was developed and discussed with the team. We also used memos to describe analysis insights.

Case study research are perceived as valuable in the context-dependent environments (Flyvbjerg, 2006), especially when using several research methods and data sources. In this paper, I use case study to "elicit the strategic structure of an event" (Widner et al., 2022, p. 8), namely to describe interactions leading to deployment of ICT systems in the welfare assistance area in "paternalistic-market hybrid" (Księżopolski, 2011, p. 16).

3. Results

In this section I describe the main findings from the analysis of data. I divided it into three main categories: the differences between how gminas deliver the care service (outsourcing or hiring caregivers in SWCs), political and managerial pressures to implement the system, and the last part asks the question about the costs of introducing the innovations. All of the sections describe the implications of these contextual problems for the design and use of technology.

3.1 Diverse modes of care service provision

In the researched gminas there **are different modes of care service provision**. Urban gminas tend to outsource the provision to private companies due to greater number of inhabitants requiring care. In rural gminas social workers reported app. 30 beneficiaries of care services. In urban gminas those numbers were at least ten times bigger. In some cases there are even more than one company operating in an urban gmina. Rural gminas tend to hire the caregivers on employment contracts or more flexible commissioned job contracts.

Nevertheless, irrespective of the type of gmina, social workers and managers in the social assistance institutions highlighted problems in hiring caregivers. They point out to low earnings for physically demanding work and outflow of young people to better paid occupations due to proximity of urban gminas, which give such perspective. Very often the caregivers are female close to retirement age or already older than 60 years old who wants to earn more money. Also, as the researched gminas are attractive for migrants, work in companies is often done by Ukrainian migrants. Age and nationality background is often perceived as something that impedes the successful implementation of the system among caregivers. Additionally, social workers point out to challenges in their own work at SWCs, namely low wages (below the average salary in Poland), high demands to enter the job (especially educational – studies in social policy or social work) and great workload, especially bureaucratic. The described problems are of the systemic nature.

In case of outsourced care service, there are additional actors involved in the provision of the service. Except caregivers employed by the private company, there are coordinators of the service who are responsible to ensure unproblematic cooperation between caregivers and beneficiaries. This takes some of the work of social workers who become mediators only in cases of conflicts between beneficiaries and the company. Social workers are also

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

expected to visit the beneficiary of care service at least every half a year. During this visit they conduct follow-up community interviews and reassessment of the diagnosed needs, in case one is needed.

Despite the introduction of Digital Interviews, social workers are not obliged to conduct it using the computer. Some of the interviewees report that they still go to their beneficiaries with pen and paper forms because they either prefer it this way or conducting the interview on the laptop is not possible. One interviewee mentioned that her beneficiary is a hoarder and it is impossible for her to "find even a place to sit, not mentioning to put a laptop". However, if the social worker wants to use the ECS, they have to provide the data from the community interview into the system, which doubles the work.

Gminas include various activities in their caregiving services, depending on the living conditions of their residents. In one of the smaller municipalities, the scope of services sometimes includes lighting a heating stove in beneficiaries' homes. SWCs' managers point out that in smaller gminas, where caregivers are employed directly by the centre, negotiating the scope of duties is easier. In one municipality, there was a change in service providers - responsibilities previously handled by a local company were taken over by a nationwide firm. The manager of this centre noted that the company's employees began rejecting previous practices and adhering to standards set by urban gminas, despite such stipulations were not included in the contract with smaller gminas. One such example was beneficiaries' hygiene - caregivers refused to lift individuals into bathtubs, as it posed a risk of accidents. In this case, the family of beneficiary decided to individually hire previous contractor – the local company.

> "*They said that if a person is bedridden and there is a bathtub, then changing a diaper is considered a specialised service. And I said, 'But girls, hold on, we signed a contract, and there was nothing like that in it. You didn't mention anything, did you?' Because, you know, we really deal with the most difficult cases.*" (Director of local SWC in a rural gmina)

This shows that dynamic of the relations between gminas and companies is defined mostly by standards set out by bigger and wealthier players. As urban municipalities played a dominant role in designing the system, it did not include experiences of social workers from smaller gminas. This leads to standardising the service from the perspective of institutions, but for inhabitants and beneficiaries it might be a reason to opt out from the public service and decide to get the service in the private company. In this case financial situation of the family plays important role. As put by one of our interviewees:

> "*And when you have a choice, it's very different. And such rich people say: 'oh, thank you, we'll go straight to commercial', yes? And people who save every penny will say: 'we want you'. And it's clear*" (Director of local SWC in a rural gmina)

Nevertheless, the ECS is designed strongly with idea of outsourcing the server, which mirrors the dominant position of urban gminas, which initiated the process of digitalization and are wealthier than rural gminas. It influences the potential use of technology by social workers. During some of the interviews social workers expressed that they will opt out from the system as soon as it will be possible, because the system does not serve their purposes and often doubles the work.

3.2 Political and managerial pressures

One of the goals explicitly expressed by policymakers is to improve the quality of caregiving services. They point out issues related to the current service delivery model, particularly the lack of control over caregivers' punctuality and fulfilment of assigned tasks. One proposed solution was the creation of caregiving service standards by some of the larger municipalities - documents defining the scope of duties and the manner in which caregivers should perform them.

However, this did not solve the issue of monitoring working hours. According to policymakers and SWCs' managers, the solution to this problem would be NFC-based logging, requiring caregivers to clock in upon arrival at the beneficiary's home and clock out before leaving using designated sticker. The system allows logging without scanning the designated stickers, thus depriving decision-makers of real control over the caregivers' location at the time of logging.

From the policymakers' perspective, caregivers manipulate the system by performing certain tasks incompletely or not in accordance with the regulations. One example, highlighted by an interviewee, is the issue of shopping:

> *"So, for example, one caregiver has two recipients and she has to go shopping here and here, she gets paid for this and that, so she goes shopping and shops for these two people at once. And she's paid separately, so that's why they resist. (…) The municipality wants to have control over its money, we want to know what we pay for."* (Urban gmina policymaker)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In the eyes of the interviewee, shopping simultaneously for both beneficiaries is cheating the system, because the caregiver has assigned hours to shop for both of them in separate periods. The issue of shopping was also present in the interviews in rural gminas' SWCs:

> *"On Saturday morning, she goes shopping. We also have caregivers who look for the best prices so that the client doesn't spend too much money - they shop here for a discount etc. If they're shopping for themselves, they'll pick up groceries for their client at the same time. And sometimes, they don't even count those hours at all. They say, 'If I was already shopping for myself, what does it matter to grab a loaf of bread for my Marysia?' So they don't include that time in their working hours."* (Rural gmina SWC director)

In this case, interviewee highlighted the importance of mutual trust in the community. Director and social workers allow caregivers to have more personal relations with beneficiaries and state clearly that they do not feel the need to control the time of the service. The same director said they considered outsourcing the provision of care services, but their calculations have shown it would be more costly than employing caregivers directly in the SWC. These interviewees strongly criticised the idea and implementation of ECS in their SWC. In their opinion, the system works good in case of bigger number of care services, when the control over caregivers is complex due to the number of beneficiaries. In small communities, control over caregivers' work is done either directly or through contacts with neighbours.

> "*We didn't need it at all. The only thing left from it are these laptops, which, honestly, employees don't take with them into the field… And for office work, they're not really suitable because they're so tiny [laughs]. So, they were really expensive—almost 8,000 PLN* (app. 1900 EUR, 1970 USD) *[laughs]—and now they're just lying around somewhere…*" (Rural gmina SWC director)

The other goal expressed in the interviews was attaining data to manage the care services. One of urban gmina policymaker complained that statistical software used by the ministry does not produce easily quantifiable data. This is needed to "*be able to correlate them with other phenomena*". Digital Interview introduced changes into the way community interview is conducted. Namely, IT designers and policymakers decided to include check-boxes instead of text inputs to describe the social, economic and health conditions of the beneficiaries. This entailed categorisation of possible life situations.

Policymakers perceive this change as favourable for social workers:

> "*So, our goal was to make life easier for social workers by automating whatever could be automated - but not at the expense of human interaction. People need more time to work with clients, not to fill out unnecessary, not to use unpolite words, tables that no one needs. That should be done by a computer, a system, an app. A person should be able to ask questions, smile, and complete the form. We also proposed modifying the community interview as much as possible, but it turned out to be impossible. So, we came up with the idea of using checkboxes. If the ministry insists on plain text, then fine - the plain text will be generated from the checkboxes. They'll get what they want, but they won't be able to extract any real insights from it because plain text isn't manageable. Meanwhile, with checkboxes, I can manage the data, segment and group people with similar issues, and create targeted, cost-effective solutions for specific clients.*" (Urban gmina policymaker)

From their perspective, the goal of the ECS is to collect quantifiable data to "*segment and group people with similar issues*". This fragment also shows NPM approach to policy making – the interviewee is using the language of targets, tailor-made services and cost-effectiveness. Nevertheless, the profiling mechanism implemented into the system is an object of critique of social workers (more about it in the next section).

The implementation of ECS also entailed changes in other ICT systems used in SWCs. Before ECS, SWCs used at least 3 different systems. In order to cut the budget of ECS, one of SWCs was forced to change the main ICT system into one of other two used in the majority of centres. These main systems were further changed to be compatible with the software of ECS and to be able to exchange data on beneficiaries. Policymakers emphasised that the decision to switch the system in one of the SWCs was purely budgetary, as in the budget of ECS project there were money only for changes in two systems. As this decision seem rational, it creates organisational problems (social workers need to get accustomed and learned the new ICT system) and creates unclear decisions on how ICT systems are chosen. There is a possible conflict of interest, as one IT company behind ICT systems for SWCs was also commissioned to design and implement the ECS software.

3.3 Who carries the costs of innovation?

This question is asked not only in the financial aspect, but also in the aspect of effort to adjust to the change and learning new system. Noteworthy, the project was supported financially by the EU funds, meaning that system needs to be used at least for the time specified in the agreements. However, some directors of SWCs and social

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

workers already expressed frustration and guaranteed they will opt out as soon as it will be possible.

In the financial sense, the costs of the remote control is split between gminas and beneficiaries, however gmina's council may decide to exempt beneficiaries from the payment and cover 100% of the costs. Social workers pointed out that at first beneficiaries and their families were keen to using remote technologies. The obligation to pay for the service had not been explained clearly, as some of the beneficiaries later were surprised to be asked for payments for the service. Remote wearable technologies could be either bought by the SWCs or rented from the company with a monthly subscription pay.

> "*However, for them, it was already a burden. They pointed that out. Even though their income was, for example, two thousand or just slightly over two thousand, it still made a difference. At the beginning, the ECS and remote control were introduced gradually - there was a project, and it was implemented step by step. First, people received the devices, and later, the payment system was established, which is where the issue stemmed from.*" (Social worker from a rural SWC)

The elderly often fear the technology, as one of the main reasons to opt out from the remote control was concern they might unintentionally destroy the device. As the device resembles a watch, some of the beneficiaries take care of it as if it was a watch – they only wear it occasionally and most of the time they take it off. In such case, families often decide to return the device as it is not used properly. The other reason were mistakes made by technology. In one of the SWCs, social worker told us that one beneficiary opted out from the service because the device mistook leaning over with falling down, which triggered the mechanisms calling the monitoring centre.

> "*Because we assumed that all individuals receiving caregiving services would have wristbands. But what turned out? That wasn't the case—only one-third of them did. You see, the service provider is a private company with a set budget. We wanted to make everyone happy, and on the project level, it all seemed to add up. But when it came to implementation and we went to the people, it turned out that only a third would actually use them.*" (SWC director)

Another issues are with profiling algorithm suggesting the scope of care services assigned to the beneficiary based on collected data. Social workers emphasised missing one of the key elements important to their beneficiaries, namely the financial situation in the household. The algorithm suggest much more hours of care work than beneficiaries are able to afford. The documentation of the ECS also shows that such aspects were not taken into account when designing the algorithm. Because of that, social workers disregards the suggestions from the algorithm and review it as useless element.

Also, the questionnaire used for profiling is described by social worker as complicated and too long. According to the program's assumptions expressed in documentation, social workers should ask specific questions to the beneficiaries. Nevertheless, in the interviews they confessed to either filling this part based on their own assessment of autonomy level or asking different and, in their opinion, easier questions to the beneficiaries and based on the answers filling in the corresponding check boxes.

> "*Yes. Sometimes not directly, because there are many questions with many possible answers. Older people also sometimes perceive things differently and may have difficulty communicating, so I explain everything in very simple language.*" (Rural SWC social worker)

The other aspects of costs in innovation is with cognitive work to learn the new system. It seems that all groups of stakeholders involved in the system have to involve in learning new technology. However, during the observations of caregivers' work with the mobile ECS app, it seemed that it is often too much of technical information they have to learn.

One of the issues is clearly technical language used to explain instructions to caregivers regarding the ECS and app. Upon entering the beneficiary's home, the caregiver is supposed to select the appropriate function on their phone to activate NFC and scan the sticker. During one observation, a caregiver confused the term "NFC" with "NFZ", which is the abbreviation of the National Health Fund (pl. *Narodowy Fundusz Zdrowia*).

Another problem is with the additional work that is asked from caregivers to learn the new app. The observations conducted by us are focused on the logging into the app and scanning the NFC sticker to begin the work hours of a caregiver. However, the app has much more functionalities that are not learned during this meetings. Instead, caregivers are asked by coordinators and social workers to learn the app by "swiping through it" in their free time. Caregivers, despite being potentially digitally excluded due to demographic characteristics or have problems with language due to migratory status, do not have additional training in how to use the app.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4. Summary

The neoliberal political reforms also entailed changes in welfare institutions. NPM preferred outsourcing and cost-effectiveness, especially when implemented in post-communist countries during the transition period. NPM focused also on the performance measurement and led to disjointed and inconsistent service provision. Karen Yeung introduced the term New Public Analytics to describe implementation of new technologies into the NPM thinking or as she called it "neoliberalism with techno-solutionist makeover" (Yeung, 2023). However, the cause of the problem with implementation of new technologies in public administration are rather systemic and stems from the issues caused by NPM approach – disaggregation, competition and incentivisation (Kempeneer, 2023).

This can be seen in the case of ECS in selected Polish municipalities. The underpinning of the program is clearly bureaucratic, as policymakers want to refine data about care service provision and based on them manage the service over the municipalities. However, the implementation of ECS is hampered by disaggregated services. Diverse modes of care provision were not taken into account and the system is focused on the interests of bigger and wealthier gminas. This leads to domination of "big players" – e.g. care companies that can afford to implement the service because of the scale, or IT companies which has adjusted their software to be compatible with ECS. The question what will be the stake for smaller players to entre this domain is still open. However, this domination presents risk to one of very core principles of NPM – competition of market entities.

One of the driving factors behind the implementation of ECS is the pressure from social welfare system managers and political decision-makers at the gminas level. Their assumption is that ECS will give them a sense of control over the tasks performed by caregivers, even though the system is designed solely to measure punctuality. However, the narrative presents it as a significant improvement in service quality. This reflects the typical NPM focus on measurable achievements, even though obtaining quantifiable results in social policy remains ambiguous.

The last issue presented in the paper is the question of costs of technology implementation. As I have shown, the incomparable cognitive costs are put on the caregivers. Their work is underpaid, often done by women close to retirement age or with migratory background. This may make it more difficult for them to learn and understand the new system, and as a result – they will have limited abilities to argue with its outcomes. Additionally, there is not enough work done with beneficiaries regarding clear communication about the financial costs of the system and the aims of wearable technologies.

From the perspective of social workers, caregivers and beneficiaries, it seemed that their experiences were not taken into account when designing the system. Social workers point out that often they are unable to conduct Digital Interviews using computers due to the conditions in the households. Caregivers are not accustomed with technical language used in the mobile app. Beneficiaries are more accustomed to taking good care of the objects they posses and treat the wristbands as precious watches.

In this paper, I shown the importance of including diverse perspectives and experiences in successful implementation of ICT systems in public administration. Policymakers need to think forward about social and political-economic results of their decisions in the field of digitalisation. New ICT systems should not make it difficult new players to enter the market and learn how to use it. It is exceptionally important in the field of public services which are often provided to less favoured populations that may have difficulties with understanding their rights and possibilities in digital welfare states.

Acknowledgement

- **Funding:** Project AUTO-WELF is supported by National Science Centre, Poland (grant no.2021/03/Y/HS5/00263, under CHANSE ERA-NET Co-fund programme, which has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 101004509.
- **Data/Software Access Statement**: Sztandar-Sztanderska, Karolina: AUTO-WELF: Automatyzacja polityk społecznych - infrastruktury algorytmiczne na rzecz dobrobytu w Europie [data]. Instytut Filozofii i Socjologii PAN [producer]. Archiwum Danych Jakościowych [distributor], Repozytorium Danych Społecznych [publisher], 2024. https://doi.org/10.60894/ANHJNA, V1
- **Contributor Statement***: Sebastian Sosnowski (Conceptualisation, data collection, data curation, data analysis, investigation, writing – original draft), Mateusz Trochymiak (Conceptualisation, data collection), Karolina Sztandar-Sztanderska (Data curation, funding acquisition, project administration, supervision)
- **Use of AI***: During the preparation of this work, the author used ChatGPT in order to check the correctness of the language. After using this tool/service, the author reviewed, edited, made the content

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

their own and validated the outcome as needed, and takes full responsibility for the content of the publication.

- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Alston, P. (2019). *Report of the Special Rapporteur on extreme poverty and human rights*. https://undocs.org/A/74/493

Anttiroiko, A.-V., & Valkama, P. (2016). Post-NPM-style service integration: Partnership-based brokerage in elderly care. *International Journal of Public Sector Management*, *29*(7), 675–689. https://doi.org/10.1108/IJPSM-12-2015-0220

Broomfield, H., & Reutter, L. (2022). In search of the citizen in the datafication of public administration. *Big Data & Society*, *9*(1), 20539517221089302. https://doi.org/10.1177/20539517221089302

Christensen, T., & Lægreid, P. (2011). Democracy and administrative policy: Contrasting elements of New Public Management (NPM) and post-NPM. *European Political Science Review*, *3*(1), 125–146. https://doi.org/10.1017/S1755773910000299

Dan, S., & Pollitt, C. (2015). NPM *Can* Work: An optimistic review of the impact of New Public Management reforms in central and eastern Europe. *Public Management Review*, *17*(9), 1305–1332. https://doi.org/10.1080/14719037.2014.908662

Debicki, M., & Debicka, A. J. (2008). Public management reforms: Poland. In G. Bouckaert (Ed.), *Public Management Reforms in Central and Eastern Europe* (pp. 245–267). NISPAcee Press.

Dencik, L. (2022). The Datafied Welfare State: A Perspective from the UK. In A. Hepp, J. Jarke, & L. Kramp (Eds.), *New Perspectives in Critical Data Studies* (pp. 145–165). Springer International Publishing. https://doi.org/10.1007/978-3-030-96180-0_7

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (2011). *Writing ethnographic fieldnotes* (2nd ed). The University of Chicago Press.

Esping-Andersen, G. (1990). *The three worlds of welfare capitalism*. Polity Press.

Esping-Andersen, G. (1996). *Welfare States in Transition: National Adaptations in Global Economies*. SAGE Publications Ltd. https://doi.org/10.4135/9781446216941

Esping-Andersen, G. (2003). *Social foundations of postindustrial economies*. Oxford Univ. Press. https://doi.org/10.1093/0198742002.001.0001

Eubanks, V. (2017). *Automating inequality: How high-tech tools profile, police, and punish the poor* (First Edition). St. Martin's Press.

European Commission. Statistical Office of the European Union. (2020). *Ageing Europe: Looking at the lives of older people in the EU : 2020 edition.* Publications Office. https://data.europa.eu/doi/10.2785/628105

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, *12*(2), 219–245. https://doi.org/10.1177/1077800405284363

Frączkiewicz-Wronka, A., Kozak, A., & Szymaniec-Mlicka, K. (2024). Digitization of social welfare entities and its importance for the effective implementation of social services in the public management system. *Social Entrepreneurship Review*, *2*, 26–38. https://doi.org/10.15678/SER.2024.2.02

Gantchev, V. (2019). Data protection in the age of welfare conditionality: Respect for basic rights or a race to the bottom? *European Journal of Social Security*, *21*(1), 3–22. https://doi.org/10.1177/1388262719838109

Golinowska, S. (2009a). New challenges for the future and the response of the European Union in the context of the European Social Model. In S. Golinowska, P. Hengstenberg, & M. Żukowski (Eds.), *Diversity and commonality in European social policies: The forging of a European social model* (pp. 379–420).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Wydawnictwo Naukowe Scholar : Friedrich-Ebert-Stiftung.

Golinowska, S. (2009b). The national model of the welfare state in Poland. Tradition and changes. In S. Golinowska, P. Hengstenberg, & M. Żukowski (Eds.), *Diversity and commonality in European social policies: The forging of a European social model* (pp. 213–260). Wydawnictwo Naukowe Scholar : Friedrich-Ebert-Stiftung.

Golinowska, S. (2018). *Modele polityki społecznej w Polsce i Europie na początku XXI wieku*. Fundacja im. Stefana Batorego.

Golinowska, S., Hengstenberg, P., & Żukowski, M. (Eds.). (2009). *Diversity and commonality in European social policies: The forging of a European social model*. Wydawnictwo Naukowe Scholar : Friedrich-Ebert-Stiftung.

Gruening, G. (2001). Origin and theoretical basis of new public management. *International Public Management Journal*, *4*(1), 1–25. https://doi.org/10.1016/S1096-7494(01)00041-1

Hood, C. (1991). A PUBLIC MANAGEMENT FOR ALL SEASONS? *Public Administration*, *69*(1), 3–19. https://doi.org/10.1111/j.1467-9299.1991.tb00779.x

Howard, C. (2015). Rethinking Post-NPM Governance: The Bureaucratic Struggle to Implement One-Stop-Shopping for Government Services in Alberta. *Public Organization Review*, *15*(2), 237–254. https://doi.org/10.1007/s11115-014-0272-0

Kempeneer, S. (2023). What is New About the New Public Analytics? Unpacking the New Public Management Causes of Algorithmic Injustice. *Tilburg Law Review*, *27*(2), 33–39. https://doi.org/10.5334/tilr.304

Kinder, T. (2012). Learning, Innovating and Performance in Post-New Public Management of Locally Delivered Public Services. *Public Management Review*, *14*(3), 403–428. https://doi.org/10.1080/14719037.2011.637408

Księżopolski, M. (2011). Dokąd zmierza polityka społeczna w Polsce? *Problemy Polityki Społecznej: studia i dyskusje.*, *16*. https://bibliotekanauki.pl/articles/473529

Księżopolski, M. (2013). Between guarantees of communism and a paternalistic-market hybrid: Polish social policy at the turn of the 20th century. *Economics and Business Review*, *13*(3), 23–41. https://doi.org/10.18559/ebr.2013.3.670

Ministry of Family, Labour and Social Policy. (2019). *Social assistance*. https://www.gov.pl/web/family/social-assistance

O'Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy* (First edition). Crown.

Parker, L., & Gould, G. (1999). Changing public sector accountability: Critiquing new directions. *Accounting Forum*, *23*(2), 109–135. https://doi.org/10.1111/1467-6303.00007

Rae, G., & Piotrowska, K. (2022). Mixed opinions: Public attitudes towards the welfare state in Poland. *Ruch Prawniczy, Ekonomiczny i Socjologiczny*, *84*(4), 137–161. https://doi.org/10.14746/rpeis.2022.84.4.09

Randma-Liiv, T. (n.d.). *New Public Management versus Neo-Weberian State in Central and Eastern Europe*.

Randma-Liiv, T., & Drechsler, W. (2017). Three decades, four phases: Public administration development in Central and Eastern Europe, 1989-2017. *International Journal of Public Sector Management*, *30*(6–7), 595–605. https://doi.org/10.1108/IJPSM-06-2017-0175

Rusiecka, A. (2023). *Social security in Poland (2023)*. ZUS. https://www.zus.pl/documents/10182/167615/Social+Security+in+Poland.pdf/71ffe1b1-c142-48fa-a67b-0c7e1cec6eb6?t=1690378989364

Samier, E. (2005). Toward a Weberian Public Administration: The Infinite Web of History, Values, and Authority in Administrative Mentalities". *Halduskultuur*, *6*, 60–94.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Siemieńska, R., & Domaradzka, A. (2016). Between Constrained Opportunities and Social Expectations: Social Policy in Contemporary Poland. In K. Schubert, P. De Villota, & J. Kuhlmann (Eds.), *Challenges to European Welfare Systems* (pp. 563–586). Springer International Publishing. https://doi.org/10.1007/978-3-319-07680-5

Siemieńska, R., & Domaradzka, A. (2020). Politics of Welfare: The Polish Welfare System in the First Decades of the 21st Century. In S. Blum, J. Kuhlmann, & K. Schubert (Eds.), *Routledge handbook of European welfare systems* (Second edition, pp. 404–423). Routledge.

Sosnowski, S., Gędek, W., Szelewa, D., & Theiss, M. (2021). The Bifurcated System of Social Assistance in Poland: Personal Relations of (Dis)Trust and Impersonal Bureaucratic Institutions. In M. Theiss & D. Szelewa (Eds.), *Integrated Report on Trust and Distrust at the Street-level of Public Policy*. https://entrust-project.eu/files/2021/11/EnTrust_Trust-and-Distrust-at-the-Street-level-of-Public-Policy_Integrated-Report.pdf

Stachura, J., & Strzelecki, P. (2023). *2024 Ageing Report. Poland—Country Fiche*. Economic Policy Committee - Ageing Working Group. https://economy-finance.ec.europa.eu/document/download/568baf8e-3a50-4859-8507-f0d963411213_en?filename=2024-ageing-report-country-fiche-Poland.pdf

Szarfenberg, R. (2021). *Centra usług społecznych – czy poprawią dostęp do usług społecznych i ich jakość?* (Forum Idei). Fundacja im. Stefana Batorego.

Titmuss, R. M., & Abel-Smith, B. (1990). *Social policy: An introduction* (6. impr). Unwin Hyman.

Trochymiak, M. (2018). Uznaniowość w pomocy społecznej. Działania pracowników socjalnych w świetle koncepcji street-level bureaucracy. *Polityka Społeczna*, *9*, 12–19.

Ustawa z Dnia 12 Marca 2004 r. o Pomocy Społecznej, Pub. L. No. Dz.U. 2004 nr 64 poz. 593 (2004). https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu20040640593

Widner, J., Woolcock, M., & Ortega Nieto, D. (Eds.). (2022). *The Case for Case Studies: Methods and Applications in International Development* (1st ed.). Cambridge University Press. https://doi.org/10.1017/9781108688253

Wyszkowska, D., Gabińska, M., & Romańska, S. (2024). *The situation of older people in Poland in 2023* (Statistical Analyses). Statistics Poland (GUS). https://stat.gov.pl/files/gfx/portalinformacyjny/en/defaultaktualnosci/3618/1/6/1/the_situation_of_older_people_in_poland_in_2023.pdf

Yeung, K. (2023). The New Public Analytics as an Emerging Paradigm in Public Sector Administration. *Tilburg Law Review*, *27*(2), 1–32. https://doi.org/10.5334/tilr.303

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Why broadband availability differs across states in the U.S.? Exploring the role of state administrative capacity

Hanim Astuti [a, b*], *Caroline* Stratton [c], *Charles* Hinnant [d]

[a] School of Information, College of Communication and Information, Florida State University, Tallahassee, the United States, hastuti@fsu.edu, 0000-0002-8761-8895.

[b] Information Systems Department, Faculty of Intelligent Electrical and Informatics Technology, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia.

[c] National Digital Inclusion Alliance, the United States, 0000-0002-8116-0879.

[d] School of Information, College of Communication and Information, Florida State University, Tallahassee, the United States, 0000-0002-7425-5685.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. The U.S. government has made various efforts to increase broadband access, even before the pandemic. However, there is still a significant gap in broadband coverage across U.S. states, indicating the persistence of digital divides. Previous research has focused on geographic and socio-demographic factors, often overlooking the role of state governments, including state administrative efforts. In this paper, we explore how the administrative capacity of states influences the coverage of four broadband technologies across states in the U.S. Using secondary data, beta regression is employed to explore the impact of state administrative capacities, i.e., broadband plans, grantmaking, broadband offices, broadband maps, and state regulations, on the coverage of cable, fiber optics, fixed wireless, and fiber/cable at urban, rural, and state levels. The findings confirm the dominance of cable, followed by fixed wireless, while fiber shows limited coverage. Infrastructure-focused broadband plans negatively affect fiber optics' coverage, highlighting implementation challenges. Conversely, grantmaking positively affects fixed wireless but not fiber, highlighting a tendency toward cost-effective, faster-deployment technologies.

Keywords. Broadband availability, adoption, state broadband, state administrative capacity.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1038

1. Introduction

Besides highlighting the important role of broadband internet, the Covid-19 pandemic also exposed the persistent issue of digital divides in the United States. The disparity still exists, especially in terms of geographic, economic, educational, and socio-demographic aspects (Li et al., 2023). In addition to the affordability issue (Bauer, 2023), the low coverage or absence of internet access in some regions in the U.S. is caused by the lack of infrastructure (Busby et al., 2023). Efforts have been made to address the lack of broadband infrastructure, not only from the government but also scholars. At the federal level, scholars analyzed federal policies, market influences (Ali, 2020; Bauer, 2023), and subsidies (Dinterman & Renkow, 2017), while state and local studies have focused on sub-federal governance (Ali et al., 2022), state grants (Bravo & Warner, 2023), and regulation (Galperin et al., 2021).

Unfortunately, there is state-by-state variation in internet coverage across the nation, with some areas having higher coverage and other areas having limited or even no Internet access (Rachfal, 2023), as seen in the 2021 Broadband Development Report (FCC, 2021). Some states such as California, Connecticut, New Jersey, and New

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

York, outperformed their counterparts, with more than 98% of their population having access to fixed broadband. On the other hand, Alaska, Arkansas, Mississippi, and West Virginia fell below the average, with less than 85.5% of their residents having the service. These gaps indicate variation in broadband availability across states.

Regrettably, there is a lack of scholarly literature addressing the diffusion of broadband across states and the factors contributing to the disparities. If there were any, the earlier work focused on broadband speed and different forms of market competition instead of the variability of broadband users among states (Denni & Gruber, 2007). Nonetheless, it can be learned from previous literature that the variations can be attributed to geographic and socio-demographic factors that vary among states (Rachfal, 2023). Some states have more challenging geographic locations, such as rural or high-cost areas with low population density, discouraging telecommunication providers from investing due to the high deployment costs and the uncertain return on investment (Ali, 2021).

Furthermore, other scholars highlighted the critical but frequently overlooked role of state governments' efforts in advancing broadband deployment (Whitacre & Gallardo, 2020). They acknowledged that the diffusion of broadband among states is influenced by the state broadband policies, including the presence of state broadband office and its key functions, such as policies, stakeholder outreach, planning and capacity building, operations and funding, etcetera (Stauffer et al., 2020). These key functions demonstrate the role of administrative aspect of state capacity, or state administrative capacity (Haque et al., 2021). Stratton and Astuti (2024) also demonstrated variations in addition to uniformity among state governments' efforts in the administrative dimension.

Given the lack of discussion about the role of state administrative capacity and the broadband variation among states, this paper aims to answer the following research question: *"How do state administrative capacities correlate with the adoption of broadband technology (fiber, cable, fixed wireless, and fiber/cable) across states in the U.S.?"* As the definition of broadband could cover various technologies, this study analyzes the impact of administrative capacities on the adoption of three broadband technologies—fiber, cable, and fixed wireless as well as a fourth that combines fiber and cable or fiber/cable to capture overlapping deployment in broadband technologies. Beta regression is employed to quantify the impact of different administrative capacities on broadband coverage in the fifty states in the U.S. It is expected that the analysis can help identify which aspects of states' administrative capacities have the most significant effect on broadband availability, in urban, rural, and the state-level areas.

This paper is structured as follows. Section 2 presents the literature study, section 3 describes the methodology, subsequently, section 4 outlines the findings based on twelve beta regression models across the four technologies and geographical areas. Then, section 5 presents the discussion and section 6 concludes this paper.

2. Literature Study

2.1 From Digital Divides to Broadband-Enabled Digital Equity

Digital divide has emerged from its original focus on the "access divide", which highlighted disparities in internet connectivity based on factors such as location, age, and socioeconomic status (Campos-Castillo, 2015; Hindman, 2000), then extended to include the "usage gap" and "capability divide", which consider the skills and motivations needed to effectively use the internet (DiMaggio & Hargittai, 2001; van Deursen & van Dijk, 2014), and an "outcome divide", which focuses on the tangible benefits derived from internet access (Wei et al., 2011). Even though the concepts have evolved, digital equity has been considered as the ultimate goal (Puigjaner, 2016). Central to achieving digital equity is broadband access, which the FCC currently defines as a minimum of 25 Mbps download and 3 Mbps upload, though recent calls suggest raising this to 100 Mbps download and 20 Mbps upload (Congressional Research Service, 2021). Unfortunately, existing studies on digital divides mostly take individual perspectives, leaving the study on institutional efforts and policy initiatives to remain overlooked.

2.2 The Federal Efforts for Digital Equity

The policy initiatives in broadband development expansion across the U.S. have demonstrated a long journey. Starting from the Communications Act of 1934, an act focused on equitable access to communication services across the nation, then the Telecommunications Act of 1996 that fostered the competition in the telecommunications industries. The government also released the Broadband Data Improvement Act to improve the accuracy of federal data on broadband and create the National Broadband Map to encourage better reporting from Internet Service Providers. The American Recovery and Reinvestment Act (ARRA) of 2009 was launched to stimulate the economy during the pandemic through funding like BTOP and BIP that focused on broadband deployment in underserved areas (Kruger, 2011). The federal government then launched CARES Act of 2020 and the American Rescue Plan (ARPA) of 2021 to provide relief and support to Americans due to the Covid pandemic, including broadband support for low-income households through the Emergency Broadband Benefit. The latest, the Infrastructure Investment and Jobs Act of 2021 marked a major focus, emphasizing not only broadband expansion, but also digital equity programs.

2.3 State Government Efforts and Conceptual Framework on State Administrative Capacity

2.3.1 Variations among States Government's Efforts on Broadband Expansion

Due to a policy shift toward devolution, the federal government has allocated a considerable amount of funds and grants to states and local governments (Gainsborough, 2003; Pandey & Collier-Tenison, 2001). States have more flexibility to address problems tailored to the uniqueness of their geographic, demographic, and economic conditions (Adkisson & Peach, 2000; Dilger & Cecire, 2019). Especially due to the Covid, the federal government has allocated grants-in-aid and other categorical grants for states to implement programs to expand broadband infrastructure and increase its adoption. Despite the huge amount of grants, state broadband programs vary across the U.S. due to political, geographical, resource factors, and organizational structures (Stauffer et al., 2020). Stratton and Astuti (2024) demonstrated variations with regards to states' administrative capacity prior to the establishment of the IIJA, such as broadband offices that plan and manage broadband initiatives, state government's collaboration with other entities, the making of state broadband plans, broadband availability maps, and broadband grants.

2.3.2 Conceptual Framework on State Administrative Capacity

To systematically explain why such variations occur across the U.S. states, this study refers to the policy capacity model (Wu et al., 2015) which defines three dimensions of governance capacity necessary to shape policy outcomes: analytical, operational, and political capacities. Analytical capacities refer to the knowledge and skills required to generate, analyze, interpret, and use evidence to evaluate policies, including research skills, data analytics, and policy evaluation. Operational capacity reflects any capabilities required to implement and manage policies, including staffing, budgeting, resource allocation, collaboration, and so forth. Political capacity includes any capabilities required to successfully navigate a complex political situation, such as stakeholder engagement, public communication, political mandates and leadership.

In the context of broadband expansion, state efforts varies and their efforts (Stratton & Astuti, 2024) reflect the combination of these capacities. The variations show that some states have demonstrated the use of detailed broadband availability maps to guide their investment decision on infrastructure expansion which shows an analytical capacity. In terms of operational or managerial capacity, some states have established broadband offices to manage their broadband initiatives, developed broadband plans focusing on infrastructure, and created grantmaking programs for resource management. These activities are part of staffing, planning, and resource allocation which encompass the state's operational capacity. Regarding the political capacity, some states have also demonstrated regulatory efforts as a tool for political authority and negotiation. Furthermore, each of state's efforts is explained as follows.

Broadband office
States vary in managing broadband initiatives. While many states have dedicated broadband offices, others manage broadband tasks within existing departments. States without specific broadband offices incorporate these efforts into broader departmental agendas, like Montana's ConnectMT program (Read & Gong, 2021). Additionally, states frequently collaborate with state and local entities, including broadband task forces and committees. Their efforts in managing broadband tasks varied, suggesting that the type of state broadband office could be linked to the availability of broadband access in a state. Understanding that states that operate independently or located within a strategic departments like commerce could be more specific to focus on their broadband efforts, we propose the following hypothesis:

> *Hypothesis 1: A more independent/specialized type of broadband office has a positive and significant influence on the availability of broadband access.*

Broadband plan
In terms of broadband planning, thirty-five states had issued a broadband plan prior to the IIJA funding requirements (Stratton & Astuti, 2024). These plans varied in detail and also revealed that broadband expansion emerged as a common priority. However, only about half addressed affordability, and fewer still included digital literacy or inclusion initiatives. The variation in the details and the priority of each state in broadband expansion as state in their broadband plans could impact the variation in the broadband availability among states. Thus, we propose a second hypothesis as follows.

> *Hypothesis 2: A state with a broadband plan focusing on infrastructure expansion prior to the IIJA has a positive and significant link to the availability of broadband access.*

Broadband availability map
One of the most noticeable programs mentioned by states in their broadband plans is to develop a state broadband availability map, as a response to the inaccuracy of the FCC's national broadband map. States depend on federal grants to expand their broadband to underserved and unserved areas. However, the allocation of some federal

grants has been hindered by the national broadband map which was not detailed enough to capture unserved and underserved areas in each state in the U.S. (Peikes, 2023). To counteract this, some U.S. states have developed their broadband maps (Read & Gong, 2021) even before the IIJA, where the data sources they utilized were various, such as data obtained from the FCC sources, ISP reports, citizen input, Census Bureau, or a mix of these to obtain a clearer picture of coverage needs (Stratton & Astuti, 2024). States that developed their state broadband map could identify and address the unserved populations more accurately than states without such maps. Therefore, the third hypothesis proposes a link between the presence of the state broadband map and the availability of broadband access.

> *Hypothesis 3: There is a positive and significant association between state's broadband map and the availability of broadband access.*

Grantmaking efforts

States have shown variation in grantmaking efforts, with many of them focusing on infrastructure expansion (Stratton & Astuti, 2024). During the Covid-19 pandemic, many states funded projects to connect underserved and unserved areas (Read & Gong, 2022). Although states developed their broadband funding programs, the mechanisms were similar, often involving grants and loans sourced from the Universal Service Fund, special funds, and other revenues such as service provider fees (An, 2019). Besides, states also use other mechanisms, such as tax incentives and bonds. Mainly, federal grants, particularly ARPA, were the primary source of state's broadband funding. However, aside from that, some states also allocated funding from non-ARPA grants, such as Idaho and Arizona. States with grantmaking efforts before the IIJA could have connected more underserved areas than states without grantmaking efforts. Thus, we argue that there is a link between grantmaking efforts prior to the IIJA and broadband availability.

> *Hypothesis 4: A state with grantmaking efforts prior to the IIJA has a positive and significant impact on the availability of broadband access.*

Broadband internet regulations

Variation is also seen in the states' regulatory approaches to broadband. The State Broadband Policy Explorer (Pew, 2021) presents diverse laws in governing broadband Internet access across states. For instance, California implemented regulations on authorized services and facilities in 2018, and Maine enhanced competition among public providers through joint exercise of powers in 2015. Supportive regulation is essential for promoting broadband deployment, especially in high-cost areas. States with broadband regulations could have more coverage on Internet access. Therefore, we propose the following hypothesis.

> *Hypothesis 5: There is a positive and significant association between a state's regulations governing broadband internet access prior to the IIJA and the availability of broadband access.*

Drawing from the literature, this paper suggests that administrative capacity (in terms of task force/agency, regulation, grantmaking programs, broadband plans, state broadband availability map) influences a state's broadband-technology adoption.

3. Methodology

2.1 Data Collection

This paper is quantitative and secondary research, which aims to investigate the influence of a state's administrative capacities on broadband technology adoption. The majority of the data used in this study is the output of the work of Stratton and Astuti (2024), where the data were sourced from a variety of secondary sources, including federal and state government websites and other authoritative bodies, government reports, state broadband plans, articles, policy documents, and broadband access statistics at a state-level unit of analysis. Additional data were then added in this study, including municipal regulations and the broadband technology adoption. Together, we came up with a state-level database in an Excel file which includes all the variables needed.

To test the hypotheses, five independent variables that represent a state's administrative capacities are used, i.e., type of office, regulation, broadband plans, grantmaking, and state broadband availability map. All independent variables except the type of office are operationalized as binary (0 and 1) due to the nature of the available data and our goal to capture the "presence" as 1 and "absence" as 0 of these administrative aspects. For example, the presence of an infrastructure-focused broadband plan in a state is coded as 1, and 0 if a state did not have any broadband plan focusing on infrastructure. The state's broadband adoption is the dependent variable with three different technologies (fixed wireless, cable, fiber) and one combined technology (fiber and cable). We use the data from the FCC's broadband national map (FCC, n.d.) in 2022 for the dependent variables, considering the availability of the data, and the effect of policies on administrative capacities that were imposed before the IIJA. Finally, the required data is presented in Tab. 1, including the characteristics and the sources of the data.

Tab. 1 - The variables used in the study

Category	Dependent/ Independent	Variable	Type	Description	Data Source
Broadband Adoption	Dependent	Urban covered by fiber	Continuous (%)	Percent of urban areas covered by fiber at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	Rural covered by fiber	Continuous (%)	Percent of rural areas covered by fiber at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	State (Units) covered by fiber	Continuous (%)	Percent of units covered by fiber at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	Urban covered by cable	Continuous (%)	Percent of urban areas covered by cable at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	Rural covered by cable	Continuous (%)	Percent of rural areas covered by cable at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	State (Units) covered by cable	Continuous (%)	Percent of units covered by cable at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	Urban covered by fiber and cable	Continuous (%)	Percent of urban areas covered by fiber and cable at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	Rural covered by fiber and cable	Continuous (%)	Percent of rural areas covered by fiber and cable at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	State (Units) covered by fiber and cable	Continuous (%)	Percent of units covered by fiber and cable at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	Urban covered by fixed wireless	Continuous (%)	Percent of urban areas covered by fixed wireless at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	Rural covered by fixed wireless	Continuous (%)	Percent of rural areas covered by fixed wireless at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
	Dependent	State (Units) covered by fixed wireless	Continuous (%)	Percent of units covered by fixed wireless at 25/3 Mbps in 2022	The FCC's national broadband map as of June 2022 Data
Administrative Capacity	Independent	Type of office	Categorical (1-3)	1=Broadband office under CED/Communication department 2=Broadband office under IT department 3=Broadband office under other departments	State Government Websites State Broadband Plans/ Reports
	Independent	Regulation	Categorical (Binary)	0=State does not regulate competition/regulation before the IIJA; 1=State regulates	State Government Websites State Broadband Plans/ Reports State Broadband Policy Explorer

Category	Dependent/ Independent	Variable	Type	Description	Data Source
				competition/regulation before the IIJA	
	Independent	Broadband plans focusing on infrastructure	Categorical (Binary)	0=No broadband plans/BB plans do not focus on infrastructure; 1=State has broadband plans focusing on infrastructure	State Government Websites State Broadband Plans/ Reports State Broadband Policy Explorer
	Independent	Grantmaking programs	Categorical (Binary)	0=State does not create any grant programs for broadband before the IIJA; 1=State has grant programs before the IIJA	State Government Websites State Broadband Plans/ Reports State Broadband Policy Explorer Pew
	Independent	State broadband availability map	Categorical (Binary)	0=State with no broadband availability map before the IIJA 1=State has broadband availability map before the IIJA	State Government Websites State Broadband Plans/ Reports State Broadband Policy Explorer

2.2 Assumption Check and Data Analysis

The analysis uses beta regression because our outcomes—the percent of areas covered by broadband technologies—are continuous and have values between 0 and 1. Beta regression is ideal to be used for modeling such proportions of values (Ferrari & Cribari-Neto, 2004). Other models—such as logistics regression that requires binary dependent variables, or Ordinary Least Squares that require outside 0-1 range—are not suitable for the analysis. The general formula of beta regression is seen below, where μ_i is the mean of the dependent variable Y_i within the interval of 0 and 1 (such as the percent of broadband coverage), $g(\mu_i)$ is the logit function log, X_i is the independent variables (five aspects of state administrative capacity), and β is the regression coefficients.

$$g(\mu_i) = X_i\beta \qquad (1)$$

A beta regression model is applied to analyze broadband coverage across four technologies and geography. For each technology, we measured at urban, rural, and state. Thus, this results in 12 unique dependent variables, meaning 12 beta regression models. Each model uses five independent variables to test the hypotheses. Because each dependent variable is a proportion with the value between 0 and 1, we apply a logit transformation to handle the 0-1 range so that a linear model can be performed with 0-1 range values (Ferrari & Cribari-Neto, 2004).

Several assumptions were checked before analyzing the regression models, including the linearity check, multicollinearity, and homoscedascity as seen in Tab. 2. The linearity check was performed to assess the linearity between the dependent variable in the logit scale and trange.he independent variables. We employed residual versus fitted plots to conduct this check. Next, the second multicollinearity check is done to investigate the correlation between independent variables through their Variance Inflation Factor (VIF) value (above 5 indicates high multicollinearity). Last, the homoscedascity check is to identify heteroscedasticity through the spread of the residuals/errors. We used residual plots to perform this check.

Tab. 2 - The assumption checks and criteria

Assumption Check	Method	Expected Results
Linearity	Residual vs. Fitted Plot	No clear patterns
Multicollinearity	VIF	VIF < 5 for all predictors
Homoscedasticity	Residual Plots	Even spread of residuals

Running the assumption checks

Initially, we had seven variables, adding *taskforce* and *broadbandplans*. However, a multicollinearity issue was found between *taskforce* and *typeoffice* when we run *cablefiber* models for a state level. Since *typeoffice* is categorical type of data, centering variables to address multicollinearity could not be performed (Aiken et al., 1991), so we removed *taskforce*. Another problem was also found between *infrastructure* and *broadbandplans*. We retained the *infrastructure*, and redefined it as states with a broadband plan focusing on infrastructure expansion (Stratton & Astuti, 2024). We then run another round to ensure that all assumptions were met. Finally, five independents were used in our regression analysis: *typeoffice*, *infrastructure, regulation, broadbandmaps,* and *grantmaking*. Figure 1, Table 3, and Figure 2 represent the sample results of final assumption check we performed.

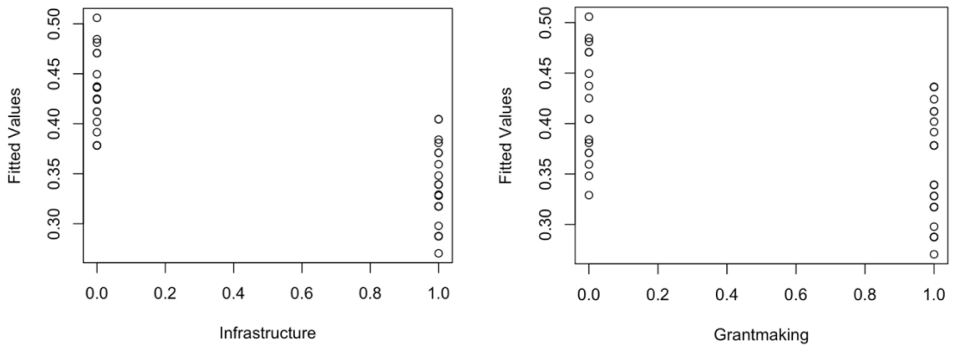


Fig. 1 - Linearity check for two variables on fiber in urban

Tab. 3 - The multicollinearity check using VIF (>5)

		Type of Office	Infrastructure-focus BB Plans	Municipal Regulation	BB Maps	Grantmaking
State	Cable/Fiber	1.34	1.06	1.16	1.17	1.43

		Type of Office	Infrastructure-focus BB Plans	Municipal Regulation	BB Maps	Grantmaking
Urban	Fiber Only	1.31	1.06	1.15	1.21	1.46
	Cable Only	1.33	1.06	1.16	1.19	1.44
	Fixed Wireless	1.32	1.06	1.15	1.20	1.46
	Cable/Fiber	1.31	1.07	1.16	1.17	1.40
Rural	Fiber Only	1.31	1.06	1.15	1.21	1.45
	Cable Only	1.31	1.06	1.16	1.17	1.41
	Fixed Wireless	1.31	1.06	1.14	1.20	1.46
	Cable/Fiber	1.33	1.07	1.16	1.20	1.45
	Fiber Only	1.31	1.07	1.13	1.21	1.46
	Cable Only	1.32	1.06	1.15	1.20	1.45
	Fixed Wireless	1.34	1.06	1.16	1.20	1.47

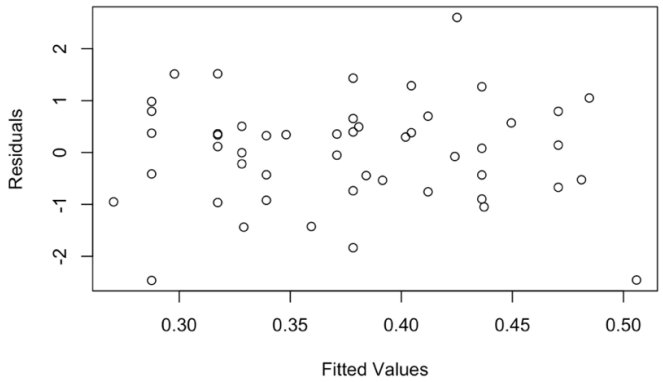


Fig. 2 - Residuals vs. Fitted for homoscedascity check on fiber in urban.

4. Findings

This section explores the link between the different broadband technologies and the states' administrative capacities in rural, urban, and overall state settings.

4.1 Broadband coverage across states based on four different technologies

At the state-wide level, the majority of the U.S. is covered by the fixed broadband, cable and fiber broadband, as seen in Table 4. However, among the four technologies, the cable technology has the highest coverage (79%) than fixed wireless (62.9%) and fiber technology (with only 35%). Regarding the spread, it is indicated that there is a widespread availability of fixed broadband, as indicated by an SD of .081 for cable and fiber technology. With moderate coverage, the wireless has an SD of .18, suggesting significant variation across states. As the technology with the lowest coverage, fiber technology also shows a significant variation (SD = .138) in fiber broadband availability across the states.

In urban areas, the coverage is dominated by cable broadband services, with 94.4% of urban areas having access to Internet access using cable technology. Fixed wireless covers 70% of the urban areas, while and fiber technology has the lowest coverage, with only 37.7%. Comparing cable and fixed wireless, interestingly, the coverage the two technologies indicates that the cable technology serves most of the Internet connection in urban regions. Surprisingly, the SD of fixed wireless (SD = .163) indicates a significant variation in urban areas across states, whereas cable coverage is widespread in urban areas (SD = .030). The fiber technology also shows a significant variation (SD = .153) that underlines the disparities in access using this technology in rural areas. Internet coverage in rural areas is considered low. Most coverage is dominated by cable (46.8%) and fixed wireless (46.7%), while fiber only covers 25.4% of the rural areas. Together, fiber and cable technology only cover 60% of the whole rural areas in the U.S. Speaking about the spread of the technology, the standard deviation of all four technologies indicates significant variation, especially the fiber technology that has the highest variability relative to its average (SD = .147), suggesting widely dispersed technology. Cable technology (SD = .217) and fixed wireless (SD = .467) also show variability, meaning the technology is spread out in rural areas, even though the spread is not as wide as the fiber.

Tab. 4 - The descriptive statistics of the four technologies

Level	Technology	Average	SD	Minimum	Median	Maximum
State	Fiber/Cable	0.854	0.081	0.643	0.862	0.993
	Fiber Only	0.351	0.138	0.061	0.352	0.792
	Cable Only	0.790	0.114	0.523	0.801	0.986
	Fixed Wireless	0.629	0.177	0.286	0.589	0.963
Urban	Fiber/Cable	0.966	0.024	0.905	0.975	0.999
	Fiber Only	0.377	0.153	0.043	0.371	0.799
	Cable Only	0.944	0.030	0.877	0.951	0.995
	Fixed Wireless	0.705	0.163	0.425	0.688	0.978
Rural	Fiber/Cable	0.609	0.173	0.294	0.591	0.954
	Fiber Only	0.254	0.147	0.084	0.231	0.738
	Cable Only	0.468	0.217	0.192	0.416	0.951
	Fixed Wireless	0.467	0.205	0.155	0.424	0.874

To sum up, statewide analysis highlights the disparities in broadband availability, depending on geographic settings and technology type. Broadband coverage is generally high and consistent across different technologies in urban areas, showing widespread access. Rural areas, however, experience more variability in coverage, with significant disparities in access to different broadband technologies. Among all technologies, fiber only is the lowest in coverage in rural and urban areas.

4.2 State-wide broadband coverage and administrative capacity

This analysis aims to see the link between broadband coverage and administrative capacity at the state level. The estimated coefficients and the p-values of the beta regression analysis are presented in Table 5. The findings show that infrastructure has a significant negative effect (-0.446, p-value <0.01) on fixed broadband (fiber/cable) coverage, meaning that broadband plans focused on infrastructure have nothing to do with increasing the Internet coverage. Other variables, show no significant impact. For fiber only technology, it shows a strong negative association to broadband plans that prioritized infrastructure development (-0.593, p-value <0.000). Surprisingly, grantmaking also shows a low significant and negative association with fiber technology (-0.360, p-value = 0.050). Other variables show no significant impact on fiber only coverage. As for cable only, no significant effects are observed from any of the variables, indicating a more stable technology. The last one, grantmaking has a positive significant impact on fixed wireless (0.518, p-value = 0.37), which could indicate that fixed wireless benefits more from state grant programs than other technologies. To sum up, our findings suggest that broadband plans focused on infrastructure deployment significantly influence broadband coverage of fixed broadband and especially fiber technology. However, they appear to have a negative impact on fiber/cable and fiber only networks. Another conclusion is that for fiber only and fixed wireless technologies, grantmaking is significant but varies in direction and magnitude. Other administrative capacity's variables do not show any significant impact.

4.3 Administrative capacity and Urban Broadband Coverage

As seen in Table 5, for fixed broadband (fiber/cable technology), it indicates that infrastructure has a significant negative effect (-0.478, p-value =0.009) on the coverage of this technology in urban areas. Other variables, such as the type of office, grantmaking, broadband maps, and municipal regulations, do not have a significant impact. For fiber technology, infrastructure shows a significant negative impact (-0.410, p-value = 0.021), while other variables do not show a significant effect. Cable technology is not affected by any variables in urban areas, as the analysis indicates that infrastructure and other factors do not significantly influence cable coverage. However, the table shows a positive link between fixed wireless coverage and state's grantmaking programs (0.501, p-value = 0.054) and no link between fixed wireless and other variables. To conclude, state broadband plans focusing on infrastructure tend to have a negative impact on the coverage of fiber and fiber/cable. However, these plans show no significant impact on the coverage of cable and fixed wireless. On the other hand, grantmaking programs demonstrate a significant and positive influence on fixed wireless coverage.

Tab. 5 - Beta regression coefficient summary with significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '°' 0.1 ' ' 1

Level	Technology	(Intercept)	Type of Office	Infrastructure	Municipal Regulation	Broadband Maps	Grantmaking
State	Fiber/Cable	2.347 (.000)***	-0.013 (.901)	-0.446 (.015)*	0.146 (.436)	-0.237 (.391)	-0.182 (.408)
	Fiber Only	0.101 (.708)	-0.033 (.720)	-0.593 (.000)***	0.090 (.5684)	0.049 (0.822)	-0.360 (.050)°
	Cable Only	1.719 (.000)***	-0.039 (.749)	-0.170 (.398)	0.159 (.448)	-0.249 (.411)	-0.126 (.608)
	Fixed Wireless	-0.007 (.985)	0.072 (.562)	0.260 (.206)	-0.064 (.762)	-0.015 (.958)	0.518 (.037)*
Urban	Fiber/Cable	4.025 (.000)***	-0.02418 (.821)	-0.478 (.009)**	-.099 (.593)	-.252 (.367)	-.137 (.526)
	Fiber Only	-0.352 (.270)	.050 (.642)	-0.410 (.021)*	0.141 (.448)	0.085 (.741)	-.280 (.194)
	Cable Only	3.436 (.000)***	.-0.081 (.382)	.-0.255 (.102)	-0.100 (.536)	-0.211 (.378)	-0.107 (.570)
	Fixed Wireless	0.349 (.361)	0.079 (.541)	0.242 (.263)	-0.061 (.783)	-0.017 (.954)	0.501 (.054)°
Rural	Fiber/Cable	0.950 (.007)**	-0.020 (.862)	-0.726 (.000)***	0.108 (.590)	0.138 (.623)	-0.326 (.167)
	Fiber Only	-0.166 (.568)	-0.147 (.139)	-0.781 (.000)***	0.004 (.982)	0.032 (.890)	-0.394 (.049)*
	Cable Only	0.130 (.763)	0.009 (.950)	-0.308 (.202)	0.146 (.560)	0.012 (.972)	-0.224 (.444)
	Fixed Wireless	-0.985 (.010)*	0.150 (.239)	0.288 (.172)	-0.163 (.457)	0.090 (.770)	0.668 (.001)**

Tab. 6 – The summary of the hypotheses

Hypothesis	Statement	Result	Hypothesis Outcome
H1	A more independent/ specialized broadband office has a positive and significant influence on broadband availability.	No significant effect in any model	Hypothesis not supported
H2	A broadband plan focused on infrastructure has a positive and significant impact.	The relationship is reversed, significantly negative in various models (fiber, fiber/cable) in rural and urban.	Not supported (significant but reversed)
H3	A broadband map has a positive and significant impact.	No significant effect in any model	Not supported
H4	Grantmaking has a positive and significant impact.	Significant only is fixed wireless models for state and rural, but not significant for fiber/cable	Supported (especially for fixed wireless)
H5	Broadband regulations have a positive and significant impact.	No significant effect in any model	Not supported

4.4 Administrative capacity and Rural Broadband Coverage

According to the Table 5, fixed broadband (fiber/cable) is negatively influenced by infrastructure-focused broadband plans (-0.726, p-value < 0.001), and not impacted by other variables. Similarly, the coverage of fiber technology is also negatively impacted by broadband plans emphasizing infrastructure deployment (-0.781, p-value < 0.001). In addition, grantmaking tends to have a negative impact on fiber coverage too (-0.394, p-value = 0.049), while other variables do not show any significant effects. Cable coverage in rural areas is not influenced by any variables. In contrast to fiber, the coverage of fixed wireless shows to be influenced positively by a state's grantmaking program (0.668, p-value < 0.001), while other variables tend to have no significant influence on this technology. The findings show a similar pattern as seen in urban areas where infrastructure-focused broadband plans tend to have a negative effect on both fiber/cable and fiber technology coverage. Grantmaking effort by states shows a negative impact on fiber technology. However, a state's effort in grantmaking is likely to increase the coverage of fixed wireless technology. Finally, we present the summary of our findings in the Table 6.

5. Discussion

Based on the findings, this section presents the discussion, especially to seek the possible explanations of the negative significance of broadband plans focusing infrastructure on fiber technology, the positive significance of grantmaking on fixed wireless adoption, and the negative significance of grantmaking on fiber.

The domination of cable technology, but disparities are still pronounced
The descriptive analysis demonstrates that cable technology dominates the Internet coverage in the U.S. at the rural, urban, and the state level, followed by the fixed wireless with moderate coverage, and fiber optic with the lowest one. The result validates the disparities in technology deployment and Internet access coverage, highlighting the challenges faced by the U.S. government in bringing digital equity. The cable technology's domination extends beyond urban areas, as it does in rural areas. According to some scholars, this domination is a result of a combination of various aspects, including regulatory (Berresford, 1999; Cooper, 2016; Garcia & Wilkins, 2001), technological (Garcia & Wilkins, 2001), and economic aspects (Garcia & Wilkins, 2001; Hazlett & Weisman, 2011).

In urban areas, cable technology shows a very high percentage, demonstrating widespread Internet availability across the U.S. urban landscape. However, despite the significant level of cable penetration in urban areas (94.4%) 5.6% of these areas are not covered by the cable broadband services, indicating that over 15 million people may not have access to the Internet. Those who live in these underserved areas are characterized by socio-economic factors, such as low-income households, Black, and Hispanic neighborhoods with the affordability issue to provide the cost of Internet services (Li et al., 2023; Mossberger et al., 2012; Zahnd et al., 2022). From the side of internet service providers, deploying network infrastructure in areas where there is not enough demand for Internet services seems to be non-profitable, because of low return on investment (Joyce, 2019; Rachfal, 2023).

Moreover, even though cable technology dominates the broadband landscape, the disparity in access coverage between urban and rural is highly distinct, with a 47.6% gap. Scholars attribute the disparity to various challenges, such as geographic (Pereira, 2015), economic viability, (Pereira, 2015; Wu, 2021), and regulatory challenges (Ali, 2020). Geographically, rural areas have less significant population densities compared to urban regions, which results in higher costs for deploying network infrastructure and less economic viable. On the other hand, the existing policies do not really address rural needs (Ali, 2020), which exacerbate the rural-urban divides.

The execution challenges of infrastructure-focused broadband plans and its influence on fiber coverage
This study demonstrates that infrastructure-focused broadband plans have a negative impact on fiber coverage at urban, rural, and state-wide level. The result implies an implementation or execution issue of the plans, which are possibly caused by several aspects, including data availability and accuracy, budget issues, intergovernmental organizations and stakeholders dynamics, and regulatory challenges.

Helderop et al. (2019) mention that the absence of precise and detailed data about broadband could impede the correctness of broadband needs and assessment, including fiber broadband. Besides, fiber broadband deployment requires a large amount of investment. However, while relying the funding on state or federal governments is insufficient, some low densely populated areas are less attractive for private service providers to invest (Valentín-Sívico et al., 2022). Nuechterlein and Shelanski (2020) also mention a real challenge, i.e., the mismatch between the capital-intensive deployment projects and the market itself that is not fully prepared which may discourage private network providers to invest. Providers usually seek immediate returns, while the deployment of fiber technology usually has a longer return due to high capital investment, mainly in rural areas and cities with low-density populations (Beardsley et al., 2010; Monath et al., 2003; Rachfal, 2023). If there is an imbalance between the push for deploying the infrastructure and the market demand for fiber technology, the growth of fiber technology could be very low compared to other less expensive technologies (such as cable or fixed wireless). Ultimately, the lack of competition will only benefit the incumbent and suppress prospective new entrants.

Moreover some challenges come from the internal organizations, such as the lack of coordination, and organization's participation among agency officials (Valentín-Sívico et al., 2022). Valentín-Sívico et al. (2022) mention the lack of the regional planning commission's involvement in the broadband initiatives, possibly due to the lack of expertise, insufficient capacity to execute the deployment projects, or limited resources. Besides, governments' priorities could change over time, and different stakeholders could even have conflicting priorities. These hurdles could obstruct fiber deployment.

Furthermore, there are other regulatory and administrative challenges such as complex permitting requirements, compliance with local regulations, and the rights-of-way access processes to place fiber optics which have made the implementation of fiber optics more challenging (Beardsley et al., 2010; Monath et al., 2003; Nuechterlein & Shelanski, 2020). The literature mentioned the physical barrier as another issue, as it needs either to lay out new cables underground or to lay out the cables along the existing utility poles. Both approaches require efforts, for example, bargaining about the rights-of-way access, complying with environmental regulations, and navigating local zoning laws. Besides, from the standpoint of policy outcomes, policymakers tend to seek technologies that show immediate visible results rather than long-term investment with almost no immediate return. As a result, their attention could shift to prioritize cheaper, faster, and less complicated technologies such as cable and fixed wireless so that network coverage can be reached quickly.

State's grantmaking and its role in the coverage of fixed wireless and fiber

The findings of this study confirms that state's funding for broadband has an impact on broadband coverage, especially on fiber coverage and fixed wireless, even though the impact varies in direction. The results show that grantmaking is positively linked to fixed wireless coverage in both rural and urban areas, meaning that grantmaking efforts could increase the fixed wireless coverage in both areas. The findings indicate that grantmaking programs are most likely to prefer wireless technologies.

Scholars mention some qualities of fixed wireless that could be used to justify why grantmaking efforts have a positive link to the availability of fixed wireless. First, fixed wireless is known for its faster deployment time, lower costs, and adequate coverage, which makes it a more economically viable option for states to connect underserved areas (Bravo & Warner, 2023; Rachfal, 2023). Second, this technology can be tailored in various geographic settings, even in a difficult terrain, making it easier to connect rural areas (Zhang et al., 2021). It can also be scaled up to accommodate various user densities (Prasad & Velez, 2010). Third, from the network provider's standpoint, deploying fixed wireless is less complicated than fiber technology due to less extensive regulatory permit, resulting in a faster deployment time.

However, different from fixed wireless, our study reveals that grantmaking has a significant and negative impact on fiber optics in rural areas. It seems that state grant programs before IIJA did not prioritize fiber optic deployments in rural areas because of high-cost investments and longer return, due to the low-density populations and geographic challenges. In addition, the complexity to deal with fiber deployment, such as permitting and securing right-of-way access, could hinder new providers—who have not as well established as incumbents or big players—in competing for state grants. Reflecting from the link between fixed wireless and grantmaking efforts, it is clear that state's grantmaking programs prefer a faster deployment technology like fixed wireless.

No significant role of other administrative capacities in broadband availability

The findings suggest that having broadband office, broadband maps, or municipal regulations is not proven enough to directly increase Internet coverage. Even though having broadband office, broadband maps, and municipal regulations sound helpful, this study shows that those factors have not had an impact as expected. For example, the existence of broadband offices has no impact on broadband coverage of states, which could be attributed to the lack of staff, expertise, shortage of funding, political supports, coordination issues, and the lack of resources to manage the broadband programs and initiatives. It designates a necessity to increase the effectiveness of this office so that this office can be more impactful.

Broadband maps also have no impact, which might be attributed to the inaccuracy issue of the data. As this map served as the guideline, inaccurate maps could lead to a wrong target for the deployment of infrastructure and grant allocation. Assuming that the maps are accurate, it indicates that they are not effectively used by state governments to support the efforts in increasing broadband coverage, such as grant allocation. For service providers, even though they identified the underserved areas on the map, if they have not enough funding to deploy broadband infrastructure, the maps will have no impact on the coverage. Additionally, whether or not a state regulates competition or has broadband-related regulation before the IIJA, it has no impact on the coverage of the state broadband at the rural, urban, and the state level. State-level regulations do not seem to serve as the key role in determining the state's broadband coverage, but there are other factors that are more influential than state's regulatory frameworks. The results imply the importance of funding availability than competition. While regulation about competition is put in place, however, many other factors such as low market demand, not enough funding availability, low return on investment—could discourage network providers, especially non big players, to invest.

6. Conclusion

This paper seeks to answer the question of *"How do the administrative capacities of states correlate with broadband technology (fiber, cable, fixed wireless) adoption across states in the U.S.?".* Our scope was to explore state administrative capacity before the IIJA and its link with broadband coverage across states in 2022. Overall, the findings regarding state administrative capacity highlight the impact of infrastructure-focused broadband plans and grantmaking programs on the availability of broadband across states, even though the direction of the impact varies. The findings show that broadband plans emphasizing infrastructure deployment have a negative impact on fiber coverage. This means that having the broadband expansion plans might tend to slow down the deployment of fiber optics, revealing the tendency that policymakers prioritize lower costs technology with faster results than fiber optics. We also discussed the challenges of executing broadband plans that impede the deployment of broadband infrastructure, including data availability and accuracy, budget issues, intergovernmental organizations and stakeholders' dynamics, and regulatory challenges. Conversely, the findings emphasize a positive influence of administrative effort in terms of states' grantmaking programs on fixed wireless coverage in rural and urban areas, meaning that the more incentives, grants, and awards given by states to network providers, the greater the availability of the wireless broadband. The findings indicate that: 1) funding availability is the main determinant of broadband deployment, and 2) broadband deployment environment in the states in the U.S. favors fixed wireless technology, as it is known for its low cost, quick deployment time, moderate coverage, flexibility, and scalability. Other administrative capacities—including broadband offices, broadband maps, and regulations—do not have any significant impacts, emphasizing issues with the effectiveness of these capacities that call for further investigation.

We suggest some future recommendations which target the demand and supply sides of broadband. First, given that funding availability is the main determinant for broadband deployment particularly for fixed wireless, state governments should prioritize finding sustainable broadband financing models to secure funding for their broadband infrastructure projects. While this study did not find evidence that broadband office has an impact of broadband availability, there is a chance that these offices have experienced a lack of fiscal authority, technical resources, and mechanism of coordination to implement such models. As such, these offices should be given authority, responsibilities, and more resources to plan, coordinate, execute, and monitor the financing models. These internal capacities of broadband offices should be explored to understand the potential of the offices. Second, a plan is just a plan if it is not well monitored and executed. As the execution of broadband plans was indicated to be problematic, the broadband offices should also be given metrics to monitor the implementation of broadband plans. Third, despite its focus on increasing broadband coverage in all areas, the state government should also focus on gradually increasing the coverage of high-speed broadband using fiber optics to prepare for next-generation digital demands. Currently, the broadband deployment environment favors fixed wireless, as it is cost-efficient with shorter deployment time. The state governments should work together with network providers to increase the coverage of fiber optics and its market, including giving more incentives for them to enter the market, encouraging them to be innovative in promoting and providing fiber services. Regulations should be more effective in supporting network providers—especially new entrants—to encourage a more competitive environment. Thus, there is a need to streamline administrative processes to reduce administrative burden in getting the right-of-way access and make the deployment faster.

There are plenty of rooms for future research, such as to investigate the roles and effectiveness of broadband offices. As our findings confirm the absence of influence of broadband offices on broadband coverage, further investigation could focus on the capability of this office in practice, which can be seen from various aspects, such as the amount of annual budget for state broadband office, the expertise of its staff, whether its leader has political support to push important policies, and so on. In addition, fiber optics is the least prioritized when it comes to broadband deployment. Exploring states' approaches to increase fiber optics through a case study could be worth investigating.

Acknowledgement

- **Data/Software Access Statement** (if applicable): -
- **Contributor Statement***: Author 1 (Conceptualization, Data Curation, Formal Analysis, Methodology, Writing); Author 2 (Conceptualization, Data Curation, Methodology, Supervision); Author 3 (Conceptualization, Methodology, Supervision).
- **Use of AI***: During the preparation of this work, the first author used ChatGPT in order to assist in (1) shortening lengthy paragraphs taken from the first author's original prospectus document and (2) increasing the clarity and comprehensiveness of the analysis, in a question and answer format with the tool. After using this tool/service, the first author reviewed, edited, made the content their own and validated the outcome as needed, and takes full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Adkisson, R. V., & Peach, J. T. (2000). Devolution and Recentralization of Welfare Administration: Implications for "New Federalism." *Review of Policy Research*, *17*(2–3), 160–178. https://doi.org/10.1111/j.1541-1338.2000.tb00922.x

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. sage.

Ali, C. (2020). The politics of good enough: Rural broadband and policy failure in the United States. *International Journal of Communication*, *14*, 23.

Ali, C. (2021). *Farm fresh broadband: The politics of rural connectivity*. MIT Press.

Ali, C., Simmerman, A., & Lansing, N. (2022). Towards a connected commonwealth: The roles of counties in broadband deployment in Virginia. *The Journal of Community Informatics*, *18*(2), 48–83. https://doi.org/10.15353/joci.v18i2.4806

An, C. (2019, August 30). *How States Support Broadband Projects*. Pew. https://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2019/07/how-states-support-broadband-projects

Bauer, J. M. (2023). *Federal-Local Realignments of Broadband Policy and Digital Equity in the United States*. Urban Affairs Association Conference, Nashville, TN.

Beardsley, S., Enriquez, L., Guvendi, M., & Sandoval, S. (2010). *Creating a fiber future: The regulatory challenge* (The Global Information Technology Report 2010-2011). World Economic Forum. https://www3.weforum.org/docs/WEF_GITR_Report_2011.pdf

Berresford, J. W. (1999). Access to cable TV systems offering broadband service in the United States. *IEEE Communications Magazine*, *37*(10), 114–116. https://doi.org/10.1109/35.795600

Bravo, N., & Warner, M. (2023). *Closing the Broadband Infrastructure Gap: State Grant Funds and the Digital Divide*. Cornell University.

Busby, J., Tanberk, J., & Cooper, T. (2023, November 8). *BroadbandNow Estimates Availability for all 50 States; Confirms that More than 42 Million Americans Do Not Have Access to Broadband*. BroadbandNow. https://broadbandnow.com/research/fcc-broadband-overreporting-by-state

Campos-Castillo, C. (2015). Revisiting the First-Level Digital Divide in the United States: Gender and Race/Ethnicity Patterns, 2007–2012. *Social Science Computer Review*, *33*(4), 423–439. https://doi.org/10.1177/0894439314547617

Congressional Research Service. (2021). *Raising the Minimum Fixed Broadband Speed Benchmark: Background and Selected Issues*. https://crsreports.congress.gov/product/pdf/IF/IF11875/2

Cooper, M. (2016). Cable Market Power: The Never Ending Story of Consumer Overcharges and Excess Corporate Profits in Video and Broadband. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2756175

Denni, M., & Gruber, H. (2007). *The Diffusion of Broadband Telecommunications in the U.S. - The Role of Different Forms of Competition* (SSRN Scholarly Paper 1353007). https://papers.ssrn.com/abstract=1353007

Dilger, R. J., & Cecire, M. H. (2019). *Federal grants to state and local governments: A historical perspective on contemporary issues* (R40638). Congressional Research Service.

DiMaggio, P., & Hargittai, E. (2001). From the 'digital divide'to 'digital inequality': Studying Internet use as penetration increases. *Princeton: Center for Arts and Cultural Policy Studies, Woodrow Wilson School, Princeton University*, *4*(1), 4–2.

Dinterman, R., & Renkow, M. (2017). Evaluation of USDA's Broadband Loan Program: Impacts on broadband provision. *Telecommunications Policy*, *41*(2), 140–153. https://doi.org/10.1016/j.telpol.2016.12.004

FCC. (n.d.). *FCC National Broadband Map*. https://broadbandmap.fcc.gov/home

FCC. (2021). *Fourteenth Broadband Deployment Report*. https://www.fcc.gov/reports-research/reports/broadband-progress-reports/fourteenth-broadband-deployment-report

Ferrari, S., & Cribari-Neto, F. (2004). Beta Regression for Modelling Rates and Proportions. *Journal of Applied Statistics*, *31*(7), 799–815. https://doi.org/10.1080/0266476042000214501

Gainsborough, J. F. (2003). To Devolve or Not To Devolve? Welfare Reform in the States. *Policy Studies Journal*, *31*(4), 603–623. https://doi.org/10.1111/1541-0072.00045

Galperin, H., Le, T. V., & Wyatt, K. (2021). Who gets access to fast broadband? Evidence from Los Angeles County. *Government Information Quarterly*, *38*(3), 101594. https://doi.org/10.1016/j.giq.2021.101594

Garcia, J. C., & Wilkins, J. (2001). Cable is too much better to lose. *The McKinsey Quarterly*, 185. Gale Academic OneFile.

Haque, M. S., Ramesh, M., Puppim De Oliveira, J. A., & Gomide, A. D. A. (2021). Building administrative capacity for development: Limits and prospects. *International Review of Administrative Sciences*, *87*(2), 211–219. https://doi.org/10.1177/00208523211002605

Hazlett, T. W., & Weisman, D. L. (2011). Market Power in US Broadband Services. *Review of Industrial Organization*, *38*(2), 151–171. https://doi.org/10.1007/s11151-011-9289-5

Helderop, E., Grubesic, T. H., & Alizadeh, T. (2019). Data deluge or data trickle? Difficulties in acquiring public data for telecommunications policy analysis. *The Information Society*, *35*(2), 69–80. https://doi.org/10.1080/01972243.2019.1574528

Hindman, D. B. (2000). The Rural-Urban Digital Divide. *Journalism & Mass Communication Quarterly*, *77*(3), 549–560. https://doi.org/10.1177/107769900007700306

Joyce, W. (2019, July 26). *America's Digital Divide*. Pew. https://www.pewtrusts.org/en/trust/archive/summer-

2019/americas-digital-divide.
Li, Y., Spoer, B. R., Lampe, T. M., Hsieh, P. Y., Nelson, I. S., Vierse, A., Thorpe, L. E., & Gourevitch, M. N. (2023). Racial/ethnic and income disparities in neighborhood-level broadband access in 905 US cities, 2017–2021. *Public Health*, *217*, 205–211. https://doi.org/10.1016/j.puhe.2023.02.001
Monath, T., Kristian, N., Cadro, P., Katsianis, D., & Varoutas, D. (2003). Economics of fixed broadband access network strategies. *IEEE Communications Magazine*, *41*(9), 132–139. https://doi.org/10.1109/MCOM.2003.1232248
Montenegro, L. O., & Araral, E. (2020). Can competition-enhancing regulation bridge the quality divide in Internet provision? *Telecommunications Policy*, *44*(1), 101836. https://doi.org/10.1016/j.telpol.2019.101836
Mossberger, K., Tolbert, C. J., Bowen, D., & Jimenez, B. (2012). Unraveling Different Barriers to Internet Use: Urban Residents and Neighborhood Effects. *Urban Affairs Review*, *48*(6), 771–810. https://doi.org/10.1177/1078087412453713
Nuechterlein, J. E., & Shelanski, H. (2020). Building on what works: An analysis of US broadband policy. *Fed. Comm. LJ*, *73*, 219.
Pandey, S., & Collier-Tenison, S. (2001). Welfare reform: An exploration of devolution. *Social Justice*, *28*(1 (83), 54–75.
Peikes, K. (2023, January 9). *Broadband map holds the key to how much federal funding states will get to expand internet service*. Nebraska Public Media. https://nebraskapublicmedia.org/es/news/news-articles/broadband-map-holds-the-key-to-how-much-federal-funding-states-will-get-to-expand-internet-service/
Pew. (2021, April 12). *State Broadband Policy Explorer*. Pew. https://www.pewtrusts.org/en/research-and-analysis/data-visualizations/2019/state-broadband-policy-explorer
Prasad, R., & Velez, F. J. (2010). WiMAX and Wireless Standards. In R. Prasad & F. J. Velez, *WiMAX Networks* (pp. 451–475). Springer Netherlands. https://doi.org/10.1007/978-90-481-8752-2_12
Puigjaner, R. (2016). Progressing Toward Digital Equity. In F. J. Mata & A. Pont (Eds.), *ICT for Promoting Human Development and Protecting the Environment* (Vol. 481, pp. 109–120). Springer International Publishing. https://doi.org/10.1007/978-3-319-44447-5_11
Rachfal, C. (2023). *The Persistent Digital Divide: Selected Broadband Deployment Issues and Policy Considerations* (Congressional Research Service R47506). https://crsreports.congress.gov/product/pdf/R/R47506
Read, A., & Gong, L. (2021). *Which States Have Dedicated Broadband Offices, Task Forces, Agencies, or Funds?* The Pew Charitable Trusts.
Read, A., & Gong, L. (2022, September 14). *Broadband Proved a Top Priority for State Policymakers in 2020*. https://www.pewtrusts.org/en/research-and-analysis/articles/2021/06/28/which-states-have-dedicated-broadband-offices-task-forces-agencies-or-funds
Stauffer, A., Wit, K. de, Read, A., & Kitson, D. (2020, February 27). *How States Are Expanding Broadband Access*. Pew. https://www.pewtrusts.org/en/research-and-analysis/reports/2020/02/how-states-are-expanding-broadband-access
Stratton, C., & Astuti, H. (2024). Characterizing State Governments' Administrative Capacity for Broadband. In I. Sserwanga, H. Joho, J. Ma, P. Hansen, D. Wu, M. Koizumi, & A. J. Gilliland (Eds.), *Wisdom, Well-Being, Win-Win* (Vol. 14598, pp. 329–337). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-57867-0_25
Valentín-Sívico, J., Canfield, C., & Egbue, O. (2022). Push them forward: Challenges in intergovernmental organizations' influence on rural broadband infrastructure expansion. *Government Information Quarterly*, *39*(4), 101752. https://doi.org/10.1016/j.giq.2022.101752
van Deursen, A. J. A. M., & van Dijk, J. A. (2014). The digital divide shifts to differences in usage. *New Media & Society*, *16*(3), 507–526. https://doi.org/10.1177/1461444813487959
Wei, K.-K., Teo, H.-H., Chan, H. C., & Tan, B. C. Y. (2011). Conceptualizing and Testing a Social Cognitive Model of the Digital Divide. *Information Systems Research*, *22*(1), 170–187. https://doi.org/10.1287/isre.1090.0273
Whitacre, B., & Gallardo, R. (2020). State broadband policy: Impacts on availability. *Telecommunications Policy*, *44*(9), 102025. https://doi.org/10.1016/j.telpol.2020.102025
Wu, X., Ramesh, M., & Howlett, M. (2015). Policy capacity: A conceptual framework for understanding policy competences and capabilities. *Policy and Society*, *34*(3–4), 165–171. https://doi.org/10.1016/j.polsoc.2015.09.001
Zahnd, W. E., Bell, N., & Larson, A. E. (2022). Geographic, racial/ethnic, and socioeconomic inequities in broadband access. *The Journal of Rural Health*, *38*(3), 519–526. https://doi.org/10.1111/jrh.12635
Zhang, Y., Love, D. J., Krogmeier, J. V., Anderson, C. R., Heath, R. W., & Buckmaster, D. R. (2021). Challenges and Opportunities of Future Rural Wireless Communications. *IEEE Communications Magazine*, *59*(12), 16–22. https://doi.org/10.1109/MCOM.001.2100280

Track 15: Re-imagining flexible work in the public service: the shift to remote and hybrid offices

Track Description

Telework and other flexible work arrangements were available to government and private-sector workers long before the COVID-19 pandemic. However, the pandemic accelerated the shift to new work modalities, such as remote and hybrid work, to continue delivering services during the public health emergency. The shift to partially or entirely remote work was strongly supported by digital technologies, which enabled many of the changes. Especially in the public sector, the availability of remote and hybrid offices enabled new ways to complete, register, monitor, and manage civil servants' work. Following the pandemic, governments are rethinking their workforce management with the support of flexible work strategies. In many cases, returning to the office may be unnecessary, decreasing productivity and leading to a poor work-life balance. Furthermore, it remains unclear how flexible work strategies affect the government's ability to recruit and retain diverse talent in the digital era. This track aimed to discuss the use of new technologies, opportunities, experiences, and challenges in adopting remote and hybrid offices for digital government workforce management.

Track Chairs

F. Kleiman, Delft University of Technology, The Netherlands
M. Gintova, Mcmaster University, United States of America

Contents

Are hybrid work arrangements in the public sector fair and equitable? Examining perspectives of Ontario Public Servants 968
M. Gintova

Challenges for monitoring flexible work: trade-offs of formal and informal information systems use 979
F. Kleiman, C. da S. Machado, and N. J. Nogueira

Remote and Hybrid Work in Crime Victim Services: A Scoping Review 989
L. Gillespie, T. Richards, and E. Whitehouse

Are hybrid work arrangements in the public sector fair and equitable? Examining perspectives of Ontario Public Servants.

Maria Gintova [a*]
[a] Department of Political Science, McMaster University, Hamilton, Canada, gintovam@mcmaster.ca, ORCID number 0009-0003-8060-1075.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract: The COVID-19 pandemic has significantly transformed work arrangements and reshaped employees' expectations of their employers. In Canada's public sector, hybrid work, where employees alternate between office and home, has become the new norm. However, the fairness and equity of existing hybrid work arrangements remain understudied. For instance, in 2022, the Ontario Public Service (OPS) mandated three office days per week for all employees, but the latest OPS People Plan (2023-2026) lacks concrete commitments to hybrid work. This paper explores public servants' perspectives on the fairness and equity of hybrid work arrangements within the OPS. Specifically, it examines public servants' views on access to hybrid work arrangements, consistency in their implementation, and the impact of hybrid work on recruitment and retention. By analyzing Reddit posts from 627 OPS subreddit users collected in 2022 and 2023, the study addresses two research questions: 1) How do Ontario public servants interpret fairness and equity in the current hybrid work model? and 2) How can these interpretations inform potential changes in the Ontario Government's approach to hybrid work? The findings reveal vivid discussions on hybrid work arrangements, highlighting concerns with the existing approach as well as the operationalization and implementation of the hybrid work. From a fairness and equity perspective, several key aspects emerged: the uneven burden of hybrid work, lack of consistency in its implementation and enforcement, and the impacts on employee recruitment and retention. The study concludes that significant changes are needed in the OPS approach to hybrid work, starting with a thorough analysis and subsequent incorporation of public servants' perspectives on fairness and equity. This could determine if the Ontario government remains competitive in the digital age.

Keywords: hybrid work, public service, fairness, equity, Ontario
Research paper, DOI: https://doi.org/10.59490/dgo.2025.981

1. Introduction

The COVID-19 pandemic has significantly altered where people work and they are looking for from a prospective employer. In Canada's public sector, the hybrid work model, where public servants alternate between working from the office and home, has become a permanent fixture (Charbonneau & Doberstein, 2024). Remote work, at least part of the week, is now seen as a right rather than a privilege (Gintova, 2024a; Deschênes, 2024; Williamson et al., 2022). With the exception of the United States, where President's recent executive order prescribed federal public servants to "return to work in-person at their respective duty stations on a full-time basis" (White House, 2025), governments in developed and developing countries are signalling that hybrid work is here to stay (Australian Government, 2023; Kleiman et al., 2023; UK Government, n.d.).

Nevertheless, despite claims that government employers are embracing hybrid work, it remains unclear if these arrangements are fair and equitable. For instance, in 2022, the Ontario Public Service (OPS) mandated that all employees, regardless of their position, work from the office three days a week (AMAPCEO, 2022). However, the latest *OPS People Plan* (2023-2026) does not include any commitments or guarantees regarding hybrid work. Additionally, since 2023, Ontario public servants have been required to attest to their presence in the office, which

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

public sector unions have criticized as micromanagement (AMAPCEO, 2023). Furthermore, union challenge of restricting remote work for unionized employees to two days per week because of the three days in the office mandate resulted in the arbitration in favour of the union's position (AMAPCEO, 2024).

It is apparent that fairness and equity in the way hybrid work model is designed can mean different things. Nevertheless, emerging research highlights the need to consider the diversity and needs of public servants while determining work arrangements in the public service post COVID-19 pandemic (Roy, 2022). However, the existing hybrid work model adopted by government employers lacks any anti-racism or diversity considerations, making public servants question the discrepancy between government rhetoric on anti-racism, equity, and diversity, and governments' actions contradicting this rhetoric (Leedham, 2023).

This article aims to explore public servants' perspectives on the fairness and equity of hybrid work arrangements within one of Canada's largest provincial public services -- the OPS. Building on a literature review of hybrid and flexible work arrangements in the public sector, it analyzes public servants' posts on Reddit—a platform where users can anonymously discuss topics in specialized communities (subreddits). Specifically, the study examines insights from 627 OPS subreddit users and addresses two research questions: 1) How do Ontario public servants interpret fairness and equity in the current hybrid work model? and 2) How can these interpretations inform potential changes in the Ontario Government's approach to hybrid work?

The article is structured as follows. First, it provides a literature review and identifies research gaps. Next, it describes the methodology, data collection procedures, and approach to data analysis. This is followed by a discussion of the findings and a conclusion that focuses on future research directions.

2. Literature review

2.1 Flexible work arrangements post COVID-19 pandemic

Scholarship on post-COVID-19 work arrangements in the public sector has recently flourished, with a particular focus on hybrid work arrangements (Champagne, Choinière, & Granja, 2023; Charbonneau & Doberstein, 2024; Deschênes, 2024; Gintova, 2024a, 2024b; Roy, 2022; Williamson et al., 2022). Although flexible work arrangements like telework, flexible hours, and compressed work week were available to public servants before the pandemic, many workers, especially managers and executives, realized the benefits of remote work while working from home during the pandemic (Yuan et al., 2023). Moreover, although the impacts of hybrid work on job satisfaction among public servants are still yet to be fully understood, emerging literature highlights increased performance and work-life balance while working remotely (Barbieri et al., 2024; Williamson et al., 2022). Finally, managing teams remotely and using technology for routine tasks such as meetings and virtual client visits have quickly replaced fully in-person interactions (Gintova, 2024a).

It is important to distinguish between pre-pandemic telework and the evolving hybrid work arrangements. While some scholars use these terms interchangeably or define telework simply as remote work, the public services in Canada have a distinct approach to hybrid work (Charbonneau & Doberstein, 2024). Specifically, hybrid work arrangements apply to all public servants, regardless of position, and are set by the government employer rather than negotiated through collective agreements between the government employer and public sector unions or between the government and an individual employee (Gintova, 2024a).

In Canada, the right to hybrid work has become a significant labor relations issue, with unions representing federal and provincial public servants demanding hybrid work guarantees for their members (Shingler, 2023). However, governments are still struggling to find the right mix of working from home and office (Roy, 2022), as evidenced by the constantly changing approaches to mandatory office presence at the federal level. Since the return to office began, the Government of Canada has changed its hybrid work policy three times: initially allowing individual government departments to determine their own arrangements, then mandating two to three days in the office, and now requiring three days in the office for non-executives and four days in the office for those in leadership positions (Government of Canada, 2024a). Therefore, the debate over the 'right' approach to hybrid work arrangements—balancing existing political constraints while allowing government agencies discretion in operationalization of the hybrid work arrangements—remains ongoing in Canada.

The Ontario Government's approach has remained consistent, requiring employees, regardless of their positions, to be in the office for at least three days unless another arrangement is agreed upon with their reporting manager. However, there are no formalized commitments guaranteeing Ontario public servants the right to remote work (AMAPCEO, 2023). This essentially means that only unionized workers have access to flexible work arrangements (negotiated with the employer pre-pandemic), while non-unionized employees can be required to return to office at any time. Despite this, access to flexible work arrangements, including remote work, is considered an important tool for attracting and retaining workers in the public service (Charbonneau & Doberstein, 2024). This is particularly crucial given the growing concern that governments in Canada are struggling to attract and retain

talent (IPAC, 2016).

2.2 Hybrid work: benefits and challenges

Although hybrid work in Canada is a relatively new phenomenon, studies like the one by Deloitte (2022), show that hybrid workers experience higher job satisfaction compared to other workers, but they also face the challenge of combining remote and in-person work models. The Government of Canada (2024b) claims that the current hybrid work model aims to "foster innovation, collaboration, and productivity" and can be tailored to meet the needs of federal organizations nationwide. However, hybrid work presents several challenges, particularly in implementation. These challenges include issues related to employee control and accountability (Charbonneau & Doberstein, 2024), managing employee expectations regarding onsite requirements (Deschênes, 2024), and a lack of strategic considerations (Lauring & Jonasson, 2025).

The most significant issue in navigating hybrid work arrangements is the current lack of operationalization. Existing research often defines "hybrid" as any work arrangement where employees alternate between working from the office and a non-office location (Lauring & Jonasson, 2025). Consequently, the optimal mix of in-office and remote workdays remains unclear. Despite this, public services in Canada have specified a concrete number of in-office days, but this operationalization lacks concrete evidence. As Charbonneau & Doberstein (2024) note, current hybrid work decisions in various Canadian public services, including the OPS, were made without productivity and efficiency analysis. Furthermore, despite a clear employee preference for remote work, the federal public service did not provide a justification for not considering these preferences before announcing the hybrid work policy (Gintova, 2024a). Similarly, the 2022 OPS Employee Experience survey revealed that 44% of respondents preferred remote work, while 41% favored hybrid work arrangements (Ontario Government, 2023a).

The absence of a strategic approach to hybrid work and the lack of concrete evidence supporting the current model pose significant challenges for the OPS. This also brings the discussion about its fairness and equity to the forefront.

2.3 Conceptualizing fairness and equity of hybrid work

The literature on fairness and equity in hybrid work arrangements within the public sector is notably scarce. Despite scholars' calls to consider the diverse needs of public servants when formulating hybrid work policies (Charbonneau & Doberstein, 2024; Gintova, 2024a; Roy, 2022), there remains a gap in understanding how these policies might disproportionately impact the careers of public servants from equity-seeking groups. Studies on the impacts of alternative work arrangements on public servants in Canada who identify as racialized, disabled, women, and Indigenous are limited, with the notable exception of Mullins et al. (2021), which examines the influence of alternative work arrangements on the work satisfaction and retention of public servants who are caregivers.

Emerging scholarship on fairness and equity in the post-COVID-19 work environment underscores its multi-faceted nature (Aplin-Houtz et al., 2025; Lane & Aplin-Houtz, 2023). For example, Lane & Aplin-Houtz (2023) identify four types of justice perceived by workers: organizational justice, based on perceptions of decision-making; distributive justice, based on perceptions of resource allocation; procedural justice, based on perceptions of implied or inferred bias; and informational justice, based on the perceived adequacy, timeliness, and truthfulness of communicated information. Defining fairness and equity in hybrid work from an employer's perspective is challenging due to the lack of clear definitions in publicly available government documents outlining hybrid work arrangements. For instance, the Government of Canada (2024) claims that its *Common Hybrid Work Model* brings "greater fairness and consistency" to the operationalization of hybrid work across the federal government but does not specify what this entails. Although it does not directly address hybrid work, the *OPS People Plan* (2023-2026) describes an equitable organization as "inclusive, anti-racist, accessible, diverse, respectful, and free from workplace harassment and discrimination, and that supports well-being" (Ontario Government, 2023b).

In this paper, we aim to explore public servants' perspectives on fairness and equity of the existing hybrid work arrangements within the OPS. Specifically, we seek to understand perspectives on three key aspects of fairness and equity: access to hybrid work arrangements, consistency in implementation, and the impacts of hybrid work on OPS employee recruitment and retention.

3. Research design

This paper examines the perspectives shared by current and former public servants in Ontario Government. The OPS with over 60,000 employees is among largest and diverse employers in the province of Ontario and in Canada. The study employs computer-assisted and manual content analysis of Reddit data from the OPS subreddit – a community representing current and former Ontario public servants. It is important to note that although Reddit posts are typically anonymous (unless a user decides to identify themselves), Reddit quotes referenced below are further anonymized for ethical considerations (i.e. no usernames or data collection files are provided).

Analysing Reddit data to gain insights into professional communities is becoming increasingly popular among scholars (e.g. Aplin-Houtz et al., 2025; Gilbert, 2020; Gruzd et al., 2020; Lane & Aplin-Houtz, 2023). These studies demonstrated that these communities provide members with a space for in-depth discussions and advice. Additionally, members of professional communities on Reddit often possess significant expertise (Gruzd et al., 2020). However, Reddit's user base is predominantly white men, which limits the diversity of perspectives on the platform (Gilbert, 2020). Although it is impossible to comment on demographical composition of the OPS subreddit users, our research indicates that the voices of women and people of colour are somewhat represented on it. Nonetheless, we observe a lack of perspectives from racialized public servants.

For this study, we collected a total of 8,274 Reddit posts (4,251 from 2022 and 4,023 from 2023) from 627 unique users. Posts were gathered twice between March and May of each year to capture the periods when discussions about returning to the office and hybrid work were most intense, allowing for a comparative analysis one year into the implementation of hybrid work arrangements in the OPS. The data was collected using Communalytic, a research tool for collecting and analyzing social media data (Gruzd & Mai, 2021). The analysis combined computer-assisted sentiment analysis (using TextBlob and VADER via Communalytic) with toxicity analysis (using Detoxify via Communalytic). Additionally, a manual content analysis was conducted on 827 posts—representing 10% of the collected data—selected through systematic sampling, a widely used approach among scholars for manual coding of social media data (see, e.g., Gintova 2019). Toxicity analysis helped identify rude, disrespectful, or derogatory comments by subreddit members, which were assigned a Detoxify toxicity score over 0.3 (on a scale from 0 to 1) (Pascual-Ferrá et al., 2021). Sentiment analysis using both TextBlob and VADER was applied to interpret the emotions (positive, neutral, or negative) underlying opinions or statements on Reddit (Savela et al., 2021). This approach allowed us to compare the results and overcome the limitations of using a single sentiment analysis library. When referring to neutral or positive Reddit posts in the analysis below, we reference posts that both TextBlob and VADER identify as such (with scores ranging from −0.05 to 1, on a scale from −1 to +1).

Manual content analysis was conducted by three coders with professional experience in the public sector. Each year's posts were coded by two coders, with one coder participating in both years to ensure coding integrity and contituity. The coding book, developed during the initial coding period, was consistently applied in the second round of coding. Codes were assigned through a consensus approach, where coders collectively agreed on the best coding option for posts they initially coded differently. This method maintained coding integrity, as coders discussed emerging codes and themes and consistently applied the coding book (Appendix A).

4. Findings

The analysis shows that return to office and hybrid work arrangement discussions were major discussion topics for both years (49% of coded posts (N=209) for 2022 and 18% of coded posts (N=71) for 2023). Other notable topics included HR, careers, benefits, leadership, and (mental) health. The perspectives included these from public servants in unionized and non-unionized positions (e.g. management viewpoints were represented well). Most of the conversations focused on the concerns of working onsite, operationalization and implementation as well as enforcement of hybrid work arrangements, and resisting working from the office. Discussions on benefits of hybrid work were mostly non-existent. Overall, posts were generally non-toxic and neutral were generally non-toxic and neutral in nature. **Fig. 1** compares hybrid work discussion topic/themes for 2022 and 2023. Below, we focus specifically on concerns, operationalization and implementation as well as enforcement conversations which were focused on the most notable aspects of fairness and equity in the context of hybrid work.

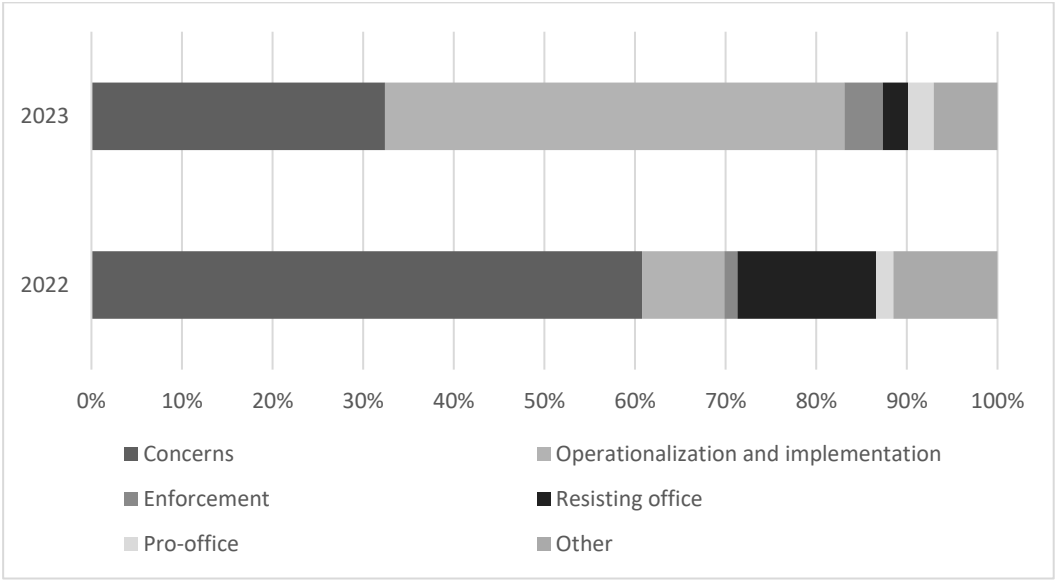


Fig. 1 - Topics/themes for OPS subreddit posts on hybrid work for 2022 and 2023

4.1. Concerns with unfair burdens of hybrid work

Concerns with unfair burdens of hybrid work echoed those noted by Williamson et al. (2022) to a certain extent. Public servants noted that working from office is less desirable for women who are caregivers. However, they also noted that white men in the positions of power benefit the most from the exiting OPS hybrid work model. The first two quotes speak to uneven impacts of hybrid work on women and men and the last one highlights the interplay between hybrid work, power, and systemic racism.

> *Exactly! [Men] are rarely the ones impacted [by work arrangements] especially when the children are sick. Men always find any excuse to get out of the house. My SO always finds excuses to go to the store so he can disappear for a couple hours LOL (OPS member, 2023).*

> *I'm terrified to go into the office, especially as a pregnant person who will be taking public transit. With the 6th wave [of COVID-19] it feels like there is zero way to keep myself safe, even if I wear my mask as much as possible. How on earth do I keep hydrated and eat in a crowded office without being scared of taking my mask off?! (OPS member, 2022).*

> *It's called systemic racism, look it up. [E]very powerful position in my organization is a white, middle-aged male. That isn't by accident. They benefit from a great deal of privilege which is furthered by [working from the office]. They all can afford to have multiple family cars, private parking spots, can afford extra childcare and all of the other costs assumed by going into office (OPS member, 2023).*

The lack of equity and diversity considerations in the Ontario Government's "one-size-fits-all" three-day office mandate is particularly significant. This issue is compounded by the absence of evidence supporting the government's hybrid work policy, as noted by Charbonneau & Doberstein (2024). OPS members feel they are merely pawns in the government's effort to revitalize the downtown core. The following quote encapsulates this perspective:

> *Those [executives] get their orders from [Premier] Ford and that dumb [Secretary of Cabinet] to push us back into buildings run by giant corporations. There's too much at stake for those companies if we're allowed to work from home or if [return to office] is optional. We're just pawns here. (OPS member, 2023)*

As implemented, the existing hybrid work arrangements could further contribute to disproportionately negative impacts on the careers of racialized Ontario public servants, particularly those who identify as women. These perspectives are crucial for understanding the impacts of current hybrid work arrangements. However, this important viewpoint was represented by only two posts on the OPS subreddit. This can be partially explained by the under-representation of racialized public servants in roles where working from home was possible during the pandemic and/or their reluctance to voice their opinions and concerns on the subreddit. It can also be attributed to the limited representation of this group on the OPS subreddit and Reddit more broadly.

4.2. Lack of consistency in implementation

Although discussions about the operationalization and implementation of the three-day office mandate dominated conversations in 2023, it is crucial to note that inconsistencies in its application began in 2022. OPS members noted varying space capacities across different office buildings, leading to initial inconsistencies in the mandate's implementation. This brought up the argument that public servants can “vote with their feet” and consider joining the ministry with more relaxed office presence requirements. The quotes below highlights lack of space for some ministries.

> [*Three days in the office] is literally impossible in many workplaces due to not having enough space/desks to accommodate people (OPS member, 2022).*

> *I have heard rumours of teams that continue to work fully remotely or managers that don’t really care or pay attention to how often folks are in or areas that go twice per week due to space limitations. But I wouldn’t count on finding somewhere that deviates from the direction (OPS member, 2023).*

In 2023, discussions about inconsistent implementation were further enriched by comparing the number of days managers and unionized staff spent in the office. Although no specific requirements were noted in official Ontario government communication, OPS members expressed concerns that this expectation could deter one from pursuing leadership opportunities. The quotes below highlight the issue:

Yes, [my manager] goes in at least 3 days per week, if not more. I also know other Managers that also go in 4-5 days per week. This is not the case for all though (OPS member, 2023).

Lastly, it is important to remember that some OPS roles positions (especially, front line and administrative roles) do not allow for hybrid work arrangements. The quote below emphases this:

Ministries have been directed to have folks in-office three days per week. [Of course] there are also roles that require being on site 100% of the time (OPS member, 2023).

Overall, one year into the implementation of the mandatory three-day office mandate, inconsistencies in its operationalization among the ministries persisted. While limited office space can be seen as an external factor constraining management's options, the most frequently discussed issue was the varying leadership approaches between ministries and even within the same ministry. These discrepancies are also evident in the inconsistencies in enforcement, which we discuss next.

4.3. Lack of consistency in enforcement

As noted above, in 2023, Ontario government has required its employees to attest their onsite presence. Despite the goal being to yield consistency in office presence across the OPS, the OPS members highlighted individual discression of leadership in interpreting what consistutes onsite presence and enforcing the requirement. Two quotes below talk about employee experiences in two different ministries.

You're right. I have a former coworker who is now a manager in a [ministry]. They have told me about this attestation form. The way they handle it is they tell their staff the policy is 3 days a week, but then don't check into it any further than that. Essentially turning a blind eye to it while still maintaining the company line. Also, they have staff who simply ask to [work from home] for medical reasons every single week. My manager friend simply says yes and maintains they still are following policy because medical accommodations and flexibility are encouraged (and who is my manager friend to argue about medical need? They aren't a doctor!) (OPS member 2023)

It's ludicrous how inconsistent it is across ministries, and even within ministries. We sign attestations in my ministry too - but there is no stipulation that [alternative work arrangements) must be pre covid (at least not in my area) and lots of staff have formally requested (and been granted) them for less than 3 days.

This underscores a significant issue within the OPS: the potential for inconsistent treatment of employees based on individual managers' enforcement approaches. Furthermore, the existing hybrid work model's lack of consideration for systemic racism, diversity, and inclusion can exacerbate discriminatory practices by managers, who have the authority to determine their employees' work locations.

4.4. Hybrid work's impact on recruitment and retention

Finally, the current OPS hybrid work model inadvertently excludes individuals living in remote locations without OPS offices from applying for or advancing in their OPS careers. While some OPS members noted inconsistencies in granting employees the opportunity to work fully remotely as part of initial employment contract negotiations, many highlighted career limitations due to the office attendance requirement. The first quote illustrates the possibility of securing a fully remote position despite the mandate, while the second quote discourages a member from seeking promotional opportunities in a specific ministry.

When I got hired (externally) I told the hiring manager I had to be 100% remote or I would decline the offer. It was in my cover letter too. No [alternative work arrangements]. I just work too far (OPS member, 2023).

Must not be [Ministry X]. In [Ministry X] the managers have to sign monthly attestations that they have forced all their staff back 3 days per week.

Members also highlighted that they were looking for completely remote work options as these provide better work-life balance and improve their well-being. The quote below summarizes this viewpoint:

So now I'm looking for fully remote positions. And that's taking a lot of my time so I can have more music time. Apparent in this comment, no kids. This doesn't also factor in other obligations so I'm constantly doing mental scheduling acrobatics when things come up so I can do what I need to (OPS member, 2023).

Finally, for some, the mandatory three-day office requirement has led them to reconsider their career choices and question their future within the OPS. As one member noted:

> *I no longer care for or about a career in the OPS & actively tell people thinking about joining (the very few that could actually be good at the job & qualified) that they would have a WAY better time/career anywhere else. As a recent post-graduate, there are a lot of better options out there where you can look forward to more than stagnant wages & a useless pin after 25 years of service, and avoid the nonsensical, soul-sucking, expensive commutes in the meantime. More importantly, you won't be embarrassed being used as a puppet for our corrupt leaders!! Great job "putting people first" OPS (sarcasm), you have us lining up to be the first out the door!! (OPS member, 2022).*

Discussions on the OPS subreddit reveal that flexibility in choosing work locations is a crucial factor for current and prospective OPS employees when considering employment opportunities. While it is unclear how many of these employees, who prefer remote work, are managers or are actively seeking career advancement, work-life balance and mental well-being are consistently highlighted as key characteristics of remote work.

4.5. Sentiment and toxicity of discussions on hybrid work

The general sentiment of Reddit posts on hybrid work in the OPS community was neutral or positive (54%), with toxic posts accounting for 8%. Most toxic posts (N = 11) appeared in March 2022, the month following the announcement of the mandated return to the office for at least three days a week. Ontario public servants learned about this announcement from the news rather than through direct communication from the OPS employer (Gintova, 2024a), therefore, it is not suprising that they were very unhappy and frustrated.

Since toxic posts discourage participation or cause people to leave an online conversation, the OPS subreddit is a well-maintained community. This can be attributed in part to the active moderation of the subreddit, where moderators remove posts that violate established rules. Additionally, OPS members are not only willing and able to express their viewpoints but are also open to considering others' perspectives.

It is also important to note that OPS members primarily expressed displeasure with the OPS leadership team, particularly the Secretary of Cabinet, and how she handled the issue. They were also discontented with the lack of opposition to political demands and the inability of directors and assistant deputy ministers to defend the interests of their teams. Finally, in 2023, toxic posts criticized the lack of leadership long-term commitment to hybrid work and expressed frustration that employees' needs were continuously being disregarded by the employer.

5. Discussion

The results of the study demonstrate that hybrid work was a prominent discussion topic in the OPS public servant community in 2022 and 2023. The conversations on the OPS subreddit provide important insights for answering the study's two research questions: 1) How do Ontario public servants interpret fairness and equity in the current hybrid work model? and 2) How can these interpretations inform potential changes in the Ontario Government's approach to hybrid work?

Public servants discuss fairness and equity from both employee and employer perspectives. From the employee perspective, fairness and equity are primarily viewed through the lenses of procedural and distributive justice (Lane & Aplin-Houtz, 2023). Specifically, OPS members noted that men, particularly white middle-aged men, tend to benefit the most from being in the office, highlighting the need for procedural justice considerations. Additionally, OPS members residing in remote communities in Ontario emphasized that fully remote work is the only option due to the lack of physical offices in their locations, thus focusing on the resource allocation aspect of distributive justice. From the employer perspective, as the Ontario Government's view of fairness resembles that of the federal government – i.e. similar working arrangements implemented across the government - OPS members focused on the lack of consistency in implementation and enforcement, not just across Ontario ministries but sometimes within the same ministry. Discussions on the subreddit highlighted the varying capacities of ministries to accommodate their workforce in the office, the significant discretion in allowing remote work beyond two days a week and the enforcement of mandatory attendance, and the possibility of "voting with their feet" by seeking opportunities within ministries that are more flexible with alternative work arrangement agreements.

Despite calls by scholars to consider the expectations (Deschênes, 2024), needs and the diversity within the public service (Roy 2022), and the potential disproportionate impacts current arrangements might have on racialized employees (Gintova 2024a) while implementing hybrid work arrangements, it is apparent that Ontario Government have not done any of these. Moreover, the most recent human resources strategy – *OPS People Plan (2023-2026)* – excludes any references to hybrid work completely, while underscoring the OPS employer aspiration to "create an equitable organization" (Ontario Government 2023b). Nevertheless, as the results of the study show, OPS subreddit members consider hybrid work to be an integral component of the human resources strategy. As noted above, some OPS members viewed the opportunity for less presence in the office as an important factor in determining whether they will pursue OPS employment or career advancement opportunities.

Therefore, we emphasize that in order to be a competitive employer and continue on its quest to creating an equitable organization, Ontario Government should rethink its approach to hybrid work. It is quite clear from the results of the study that maintaining status quo could potentially lead to the loss of talent and further decrease in job satisfaction (Gintova 2024b). It is also unclear whether the status quo will continue to disproportionately impact careers and work conditions of the racialized public servants, especially those who identify as women and those who are employed in the positions requiring constant onsite presence. As noted in Gintova (2024a), a comprehensive and transparent gender-based analysis plus can be a good starting point to comprehensively understand equity and fairness of hybrid work though an intersectionality lens.

Furthermore, hybrid work approach needs be grounded in evidence (Charbonneau & Doberstein, 2024). However, this evidence should not include solely operational requirements but an analysis of employees' perspectives and needs. Employee viewpoints on fairness and equity of hybrid work arrangements, as highlighted by this study, are crucial for employing multiple lens to determine what consistutes a fair and equitable hybrid work model. In addition, it is also important to consider for the hybrid work approach to allow for individual ministries' flexibility to customize it (Gintova, 2024a, Roy, 2022) given that this already happening but organically as opposed to strategically. This will also create incentive for leadership within individual ministries to take stoke over their approach to employee engagement and development.

Finally, the *OPS People Plan (2023-2026)* must include concrete commitments to hybrid work. Strategically positioning hybrid work within existing human resource strategies and policies will signal its permanence, regardless of political preferences. Currently, alternative work arrangements, including partial or full-time remote work, are formally available only to unionized employees. A commitment to hybrid work for all OPS employees would demonstrate the employer's broader dedication to fairness and equity in the workplace.

6. Conclusion and future research

This study offers a number of important scholarly and practitioner contributions. From the scholarly perspective, it begins to unpack the concepts of fairness and equity in the context of the hybrid work arrangements in the public sector. It is important to note that, as the results of the study show, these are multi-dimensional and need to be understood both from the public servants' and government employer perspectives. However, further research is required to delve into the perspectives of racialized public servants on fairness and equity of hybrid work in the public sector as Reddit data might not contain those due to platform representativeness limitations.

Second, the study builds on the emerging body of literature on hybrid work in the public service post-pandemic and examines perspectives and sentiments of public servants on hybrid work arrangements between two years. Although we do not note significant change in sentiment surrounding hybrid work between 2022 and 2023, it is important to highlight that the discussions surrounding the issue have shifted from primarily concerns with the approach adopted by government to how the hybrid work arrangements are operationalized, implemented, and enforced. With the specific emphasis on the lack of consistency in implementation and enforcement.

Third, the methodology applied in this study can be adapted for future research in public policy and administration. Specifically, professional communities on Reddit can offer valuable insights into various policy and public administration issues, supporting government decision-making. However, it is crucial to recognize the limitations of Reddit data as previously discussed and to corroborate these findings with other data sources. This is particularly important for research on hybrid work in government. It is essential to include the perspectives of public servants from equity-seeking groups, as the challenges they face may differ from those encountered by non-marginalized public servants.

For practitioners, this study offers a number of considerations and recommendations for hybrid work implementation. First and foremost, existing literature (Charbonneau & Doberstein, 2024) and the results of this study highlight the need for a strategic approach to hybrid work. Without this, governments as employers risk underutilizing benefits of this post-pandemic work arrangement as well as pushback from public servants who might feel that hybrid work arrangements are not a permanent fixture.

Second, hybrid work arrangements should become an integral part of the human resource strategies and policies. As employees no longer view hybrid work as a privilege (Gintova, 2024a; Deschênes, 2024; Williamson et al., 2022), it is crucial to manage the employer's expectation that they can unilaterally determine how hybrid work arrangements are designed and implemented, especially considering the concern that governments in Canada are struggling to attract and retain talent (IPAC, 2016).

Finally, hybrid work arrangements must be based on evidence rather than political agendas. Continued failing to correct this could lead to increased employee dissatisfaction with public service leadership and a loss of talent to other opportunities. Moreover, this could impede the implementation of transformation initiatives, including digital government transformation, thereby obstructing the achievement of these initiatives' intended objectives.

In conclusion, the hybrid work model post-COVID-19 presents both unique challenges and opportunities for governments. However, the examination of this issue by practitioners and scholars should not only focus on the pros and cons of the new workplace model but also address the existing barriers to its fair and equitable implementation.

Acknowledgement

- **Funding or Grant:** This study is funded by XXX (removed for review)
- **Contributor Statement***: removed for review
- **Use of AI***: During the preparation of this work, the author(s) used Microsoft Copilot in order to edit and proofred the manuscript. After using this tool/service, the author(s) further reviewed and edited the manuscript, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Aplin-Houtz, M., Lane, E., Rowsey, A., Schmidt, G. and Javadizadeh, B. (2025), "Working mothers' perceptions of fairness at home and work: a textual analysis of sentimental polarity in social discourse", *Equality, Diversity and Inclusion*, ahead of print. https://doi.org/10.1108/EDI-04-2024-0179

AMAPCEO. (2022). *Fairness and flexibility: Submission to the OPS employer on the future of the workplace policy*. Retrieved from https://amapceo.on.ca/media/7065/download?inline

AMAPCEO. (2023). *Unions respond to OPS employer onsite attendance attestation process*. Retrieved from https://amapceo.on.ca/news/unions-respond-onsite-attendance-attestation-process

AMAPCEO. (2024). *Arbitrator finds in favour of AMAPCEO*. Retrieved from: https://amapceo.on.ca/news/arbitrator-finds-in-favour-of-AMAPCEO-awa

Australian Government (n.d.) *Principles of Flexible Work in the APS*. Retrieved from: https://www.apsc.gov.au/news-and-events/latest-news/principles-flexible-work-aps, accessed 14 July 2023.

Barbieri, B., Bellini, D., Batzella, F., Mondo, M., Pinna, R., Galletta, M., & De Simone, S. (2024). Flexible Work in the Public Sector: A Dual Perspective on Cognitive Benefits and Costs in Remote Work Environments. *Public Personnel Management*, 00910260241275241. https://doi.org/10.1177/00910260241275241

Champagne, E., Choinière, O., & Granja, A. D. (2023). Government of Canada's teleworking and hybrid policies in the aftermath of the COVID-19 pandemic. *Canadian Public Administration, 66*(2), 158–175. https://doi.org/10.1111/capa.12520

Charbonneau, É., & Doberstein, C. (2024). The scarce evidence behind hybrid and telework policies in government. *International Public Management Journal*, 1–15. https://doi.org/10.1080/10967494.2024.2430214

Deloitte. (2022). Hybrid workers seek the best of in-office and remote work. Retrieved from https://www2.deloitte.com/us/en/insights/industry/telecommunications/connectivity-mobile-trends-survey/2023/hybrid-work-challenges-statistics.html

Deschênes, A.-A. (2024). Post-pandemic public personnel retention: A person-organization and person-supervisor fit analysis. *Canadian Public Administration*, *67*(2), 185–202. https://doi.org/10.1111/capa.12572

Gilbert, S. A. (2020). 'I run the world's largest historical outreach project and it's on a cesspool of a website.' Moderating a public scholarship site on Reddit: A case study of r/AskHistorians. *Proceedings of the ACM on Human-Computer Interaction, 4*(CSCW1), 19:1-19:27. https://doi.org/10.1145/3392822

Gintova, M. (2024a). Public Service in Canada post-COVID-19 pandemic: Transitioning to hybrid work and its implementation challenges. *Canadian Public Administration*, *67*(1), 7–23. https://doi.org/10.1111/capa.12550

Gintova, M. (2024b). Understanding public servants' perspectives on return to office and digital government: Lessons learned from Canada. *Transforming Government: People, Process and Policy*, *18(1), 118-130.* https://doi.org/10.1108/TG-07-2023-0091

Gintova, M. (2019). Understanding government social media users: An analysis of interactions on Immigration, Refugees and Citizenship Canada Twitter and Facebook. *Government Information Quarterly*, *36*(4), 101388. https://doi.org/10.1016/j.giq.2019.06.005

Government of Canada. (2024a). *Common hybrid work model*. Retrieved from https://www.canada.ca/en/government/publicservice/modernizing/hybrid-work/common-hybrid-work-model.html

Government of Canada. (2024b). *Modern workplace for the public service*. Retrieved from https://www.canada.ca/en/public-services-procurement/services/infrastructure-buildings/gcworkplace/modern-workplace-public-service.html

Gruzd, A., Kumar, P., Abul-Fottouh, D., & Haythornthwaite, C. (2020). Coding and classifying knowledge exchange on social media: A comparative analysis of the #Twitterstorians and AskHistorians communities. *Computer Supported Cooperative Work, 29*(6), 629–656. https://doi.org/10.1007/s10606-020-09376-y

Gruzd, A., & Mai, P. (2021). *Communalytic: A research tool for studying online communities and online discourse*. Retrieved from https://Communalytic.com

Institute of Public Administration of Canada (IPAC). (2016). *Facing the future: Exploring the recruitment and retention of new public servants in Canada*. Retrieved from https://s3.ca-central-1.amazonaws.com/ipacreports/np-survey-eng.pdf

Kleiman, F., Kleiman, F., De Souza Farias, R., Junca Nogueira, N., Barral De Oliveira Brito, T., Mendes Barbosa, M., Marasca Bertazzi, D. M., & Seara Machado Pojo Rego, R. (2023). New ways for monitoring the public workforce after the pandemic: The management and performance program in the Brazilian Federal Government. *Proceedings of the 24th Annual International Conference on Digital Government Research*. Gdansk, Poland, Association for Computing Machinery: 349–354.

Lauring, J., & Jonasson, C. (2025). What is hybrid work? Towards greater conceptual clarity of a common term and understanding its consequences. *Human Resource Management Review*, *35*(1), 101044. https://doi.org/10.1016/j.hrmr.2024.101044

Leedham, E. (2023). Federal government is failing women, Black and racialized workers in the public service, striking workers say. *Press Progress*. Retrieved from https://pressprogress.ca/federal-government-is-failing-women-black-and-racialized-workers-in-the-public-service-striking-workers-say/

Mullins, L. B., Charbonneau, É., & Riccucci, N. M. (2021). The Effects of Family Responsibilities Discrimination on Public Employees' Satisfaction and Turnover Intentions: Can Flexible Work Arrangements Help? Review of Public Personnel Administration, 41(2), 384–410. https://doi.org/10.1177/0734371X19894035

Ontario Government. (2023a). *2022 OPS employee experience survey results*. Retrieved from https://www.ontario.ca/page/2022-ops-employee-experience-survey-results

Ontario Government. (2023b). *Ontario Public Service People Plan 2023-2026*. Retrieved from https://www.ontario.ca/page/ontario-public-service-people-plan-2023-2026

Pascual-Ferrá, P., Alperstein, N., Barnett, D. J., & Rimal, R. N. (2021). Toxicity and verbal aggression on social media: Polarized discourse on wearing face masks during the COVID-19 pandemic. Big Data & Society, 8(1), 1–17.

Roy, J. (2022). COVID-19, digitization and hybrid workspaces: A critical inflection point for public sector governance and workforce development. *Canadian Public Administration*, 1–7.

Savela, N., Garcia, D., Pellert, M., & Oksanen, A. (2021). Emotional talk about robotic technologies on Reddit: Sentiment analysis of life domains, motives, and temporal themes. *New Media & Society*. Advance online publication. https://doi.org/10.1177/14614448211067259

Shingler, B. (2023). What the federal workers' deal means for the future of remote work. *CBC News*. Retrieved from https://www.cbc.ca/news/canada/psac-agreement-government-union-remote-work-1.6828427

White House. (2025). *Presidential Actions. Return to in-person work*. Retrieved from: https://www.whitehouse.gov/presidential-actions/2025/01/return-to-in-person-work/

Williamson, S., Pearce, A., Connor, J., Weeratunga, V., & Dickinson, H. (2022). The future of working from home in the public sector: What does the evidence tell us? *Australian Journal of Public Administration*, 81(4), 640–648. https://doi.org/10.1111/1467-8500.12556

Yuan, Q., Gasco-Hernandez, M., Gil-Garcia, J. R., Cook, M. E., & Pardo, T. A. (2023). Continuity of Operations and Organisational Resilience during the COVID-19 Pandemic: Lessons from City Governments in the US Northeast Region. *Public Management Review*, 27(1), 29–49. https://doi.org/10.1080/14719037.2023.2222763

UK Government. (n.d.). *Flexible working*. Retrieved from: https://www.gov.uk/flexible-working

Appendix A. Coding Book

Topic/theme	Additional topics/themes	Sample post
Hybrid work	Concerns/ fairness	We're constantly guilted about our carbon footprint, emissions and climate change yet we need to head back to the office…to support downtown businesses? Employers and the government have exposed their hypocrisy and ineffectual tactics.
	Operationalization/ implementation	It is more expensive because you would need to park in the visitor parking. I believe it's like $23 a day. During COVID when we were going 1-2 times a week, Unit park had allowed sharing as long as both staff were not parked in the lot at the same time but now with the 3 days it doesn't work out because there will always be one day overlap.
	Resisting office	Return to the office: a slap in the face. We often talk our frustrations, but we do nothing. How can we organize and protest this? Ideally, if people have the guts, we should all stay home on the days we are supposed to go back to the office. They can't fire us all. Together we could effect change.
	Enforcement	In Health all managers must sign an attestation every month that their staff are attending 3x week (except where there are accommdations, pre-covid-awa, or insufficient space to permit it). Managers who knowing lie when they sign the attestation are putting their jobs on the line.
	Supporting return to office	I think a lot of people on the sub have to remember, for the last two years those whom have dreaded going back have not been bothering their managers with "When will we not have to go back to the office" whereas people like me have been vocal about their design TO return to the office... Squeaky wheel and all. There might also be an implicit bias to the reddit community- or even your friend circle that would lead you to believe no one wants to return... but you might just not be surrounded by those people.
	Other	"Interesting that Millhouse says people need to go the office then points out he's working from home. And the other dude is off base saying PSAC needs to be begging for their jobs and become HR directors."

Challenges for monitoring flexible work: trade-offs of formal and informal information systems use.

Fernando Kleiman [a*], *Camila* da Silveira Machado, *Nathália* Junca Nogueira[c].

[a] Faculty of Technology, Policy, and Management, Delft University of Technology, Delft, the Netherlands, f.kleiman@tudelft.nl, 0000-0003-3336-3484.

[b] Faculty of Engineering, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, 0009-0009-3904-0492.

[c] Faculty of Management, Universidade Federal Fluminense, Rio de Janeiro, Brazil, 0000-0002-5414-9543.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Flexible work has become a trend since the pandemic emergency. All around the world, governments have increased the number of civil servants working in hybrid or full-remote work settings. This new landscape of work practices has raised several new challenges to public administrations, including monitoring work activities. Some governments support the idea that flexible work requires new monitoring methods. Instead of controlling timesheets, a new trend towards results management has emerged. Accordingly, new management information systems have been developed to support the management methods. This paper discusses challenges from data use through the new information systems for flexible work monitoring. Based on a Brazilian Federal government case, we raise new questions regarding the levels of formality of the data and its use. We conclude that flexible work information systems can produce more data regarding work practices. However, the level of formality in the use of the information produced may reduce the data availability to improve decision-making.

Keywords. Telework, Information Systems, results-based management, PGD.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.982

1. Introduction

A new wave of discussions regarding flexible work has emerged. It is known that during the pandemic emergency, businesses and governments were pushed to increase the number of employees working from home as much as possible (Bloom et al., 2024; Kisil, 2024). The need to reduce human contact to decrease the spread of the virus caused society to reorganize activities in many ways. After the emergency was gone, a debate started over the possibilities, benefits, and risks of keeping workers at home, working remotely, or in hybrid settings (Kothawala et al.; Marković, 2024). Though initially, such discussion focused on silver linings from the lessons learned during the hard times, it didn't take long for leaders in the public and private sectors to intervene, independently of evidence (Bloom et al., 2024; Marković, 2024). It has been more than 3 years since the end of the emergency, and there are still a lot of doubts and tensions regarding the topic of flexible work (Schuster, 2024).

On the one hand, the flexible work critiques list arguments that companies should face: remote work generates a lack of engagement, challenges corporate culture and values, creates onboarding issues, etc (Bloom et al., 2024; Marković, 2024). On the other hand, the flexible work supporters present reasons why the practice should be maintained, such as office and transportation costs, environmental impact, time management, etc (Kisil, 2024; Schuster, 2024). The topic has become another polarized discussion in public opinion about pros and cons, with little room for conversation.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

However, work flexibility is not new, and research has focused on understanding challenges and opportunities regarding work flexibility (Klonek & Parker, 2021; Madureira & Rando, 2022; Madureira et al., 2020). Many remote and hybrid work aspects must be considered depending on the approach. For instance, organizational psychology has analyzed factors that enable or hinder the opportunities for flexible work practices. Discussions regarding work design have already suggested that it is key to focus less on individuals and more on teams when improving remote work experiences (Bell et al., 2023; Klonek & Parker, 2021). Research has indicated that work flexibility is a continuum ranging from full onsite work to plain remote, with diverse combinations for hybrid settings (Kisil, 2024; Kleiman et al., 2023).

The development of new work practices has involved adopting new management approaches. For instance, previous results-based management or delivery monitoring activities gained new space to support flexible work (Madureira et al., 2020; Weerakkody et al., 2021). Though it is possible to use regular timesheets to monitor work activities, several new approaches can unleash better performance management, such as results-based-management. The shift from formal control to dynamic performance measurements is challenging but rewarding (Madureira & Rando, 2022; Madureira et al., 2020; Rubin, 1979).

The Brazilian Federal Government has implemented a new way of work monitoring called the Management and Performance Program (Kleiman & Barbosa, 2024; Kleiman et al., 2023). Through this program, teams and individuals overcome strict time controls for outcome planning and delivery. And by doing so, a great load of new data is being produced regarding work in the government (Kleiman et al., 2023; Pojo et al., 2024; Rego, 2022).

Kleiman et al. (2023) has indicated that the new program appears to support better flexible work practices in the government. The possibilities of agreeing on deliveries and keeping track of performance in place of time or activities are promising to achieve improved results. The author suggested that three conditions for the program were (1) the legal framework, enabling civil servants' practices to be supported by law; (2) the cultural shift from individual timesheet control routines to team delivery plan management; and (3) the support of new information systems that facilitate registers and monitoring of the delivery process. Adopting these new registry systems generates great amounts of data that can be used for different purposes.

In this paper, our main research question is: How does the level of formality in using work management information systems influence the data availability to improve decision-making? As an exploratory study, we aim to discuss the consequences of increasing formality using the existing data. Our main hypothesis is that the more formal the use of the information systems, the more bureaucratic the registers are, reducing the systems' data availability that can be used to improve decision-making processes. With an exploratory approach based on the literature and a case study, this paper aims to explore the consequences of increasing levels of formality in information system use.

In the first section, we explain the background, and following, we present this study's methodology. Next, we discuss existing research on the formality of registers in information systems. In the fourth section, we explain the Brazilian Federal government case, giving some context about the changes in the management information systems specifically designed to manage flexible work arrangements. In the fifth section, we apply the concepts to the case, indicating trade-offs for increased formality levels using the existing registers. Lastly, based on the discussions, we present new hypotheses to be tested in future research about information systems to manage flexible work.

2. Background

Historically, the use of data in workforce management has varied through the years, with a direct relationship with technological developments. When only paper-based timesheets (or stamping cards) were available, the time needed for summarization and information production was much longer than the digital control systems that can produce real-time information (Eom et al., 2016; Galanti et al., 2021; Klonek & Parker, 2021). Though the founders of Industrial and Organizational Psychology had already advanced in studies about human behavior and human-machine interactions, so far, the digitalization of the workplace has brought an incredible amount of new data possibilities, together with improved data quality (By, 2007; Madureira & Rando, 2022; Pryor et al., 2008).

A short review of the topic of workplace data management indicates grounded references. Røed and Raaum (2003) defines administrative registers as the ones designed to serve the needs of public institutions (p. 261). In that regard, their research indicates that there tends to be a higher quality of essential information than secondary information, which has fewer checks and updates. The variables less important to the administration may contain errors or inaccuracies, especially concerning the timing of events. Additionally, Karimian et al. (2022) found that information is the basis of decision-making and information flow and that informal information sources are used more than formal information sources in decision-making by managers (p. 99).

On the one hand, management activities refer to tasks and actions for decision-making and usually have an urgency to enable fast choices; on the other hand, control activities check compliance with rules and norms, having data precision as their main priority, as they can implicate consequences. Notwithstanding that, decision-making data

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

also requires precision, as control data demands up-to-date registers. However, the role played by time and precision differs in each case. For the sake of this research, we consider monitoring activities as an action between management and control.

Shifting from a timesheet management mindset to managing work based on results adds another layer of complexity to information management systems. Still, some data characteristics should be discussed before moving forward. Back in 1986, Johnson (1986) stated that informal information compensates for the inadequacies of formal information, complementing it. Formal information systems are approved by senior management, contributing to organizational awareness. Formal performance evaluation information systems focus on accounting and represent performance numerically, while informal information systems are unofficial but may affect decisions.

On the one hand, informal information can be easier to use and understand, increasing confidentiality, timeliness, and qualitative details. Depending on the business nature, it can result in situational variability in decision-making. On the other hand, formal information may result in practical limits on the information systems' conditions to remain up-to-date and flexible for specific management needs (opus cit.., p. 121). The authors conclude that the dependence on formal information systems for decision-making will likely result in short-term and long-term dysfunctionalities, such as negatively affecting attitudes toward that information, especially when setting inadequate mandatory details.

From this perspective, the levels of formality in information systems will vary depending on the information system's objectives. And these levels of formality can also differ in different aspects of the information system. For instance, one dimension of information systems formality can be how people register data. This layer focuses on access levels, accountability for the provided information, and the alternatives for backchecking the register.

Another layer that can be analyzed is the different levels of access within the system. Whether to monitor registers, to adjust and correct them, or to exercise privileges of extraction, there are also levels of formality involved in the access to systems. One last layer is the formality of use applied to the data obtained in the system. Access levels may be connected to people's use of the available data. Once more, different levels of formality in using the registers implicate various objectives upon which the information system is built. The official system incorporates informal information indirectly as adjustments or modifications to formal information. Previous conclusions on informal information studies suggest challenges in variability and semantic definitions.

According to Altaee (2018) an informal information system constitutes a twin system of the formal information system. It supports formal communication and helps the administration with management activities. Additionally, they improve decision-making as decisions depend on the information that the existing systems can provide. In that sense, reducing informal sources of information to only formal channels can also limit the information available for decision-making and harnessing its quality. The content of the information system can also influence the formality possibilities on the register, access, and use of that system. For instance, stock management systems should have different requirements depending on the type of products they are related to. In this paper, we focus on work management systems in government.

Moreover, Pan Fagerlin and Lövstål (2020) define management control as techniques and procedures that foster employees' actions consistent with organizational goals (p.4). Formal and informal controls differ in how explicitly designed or planned they are. They suggest three uses of control systems: interactively, when managers participate directly in their teams' communication and decision-making activities; diagnostically, when used only for traditional feedback based on preset performance targets; and constraining, when used to increase predictability. These three different uses also relate to management styles: participative, facilitative, empowering, and authoritative, more related to command and control.

Lastly, Saundry et al. (2015) indicates a difference in how line managers perform work management, especially in preferring informal approaches to workplace issues. However, as their management responsibility increases, they tend to seek more rigid guidelines, given a lack of confidence and a fear of mishandling issues' repercussions (both legal and organizational). They suggest that "informality can result in inconsistencies in how employees are treated, which can damage employee morale, satisfaction, and trust" (p.430). Thus, formalization is wanted as guidance and a protective shield against criticism and litigation: "Managers can hide behind the formal procedure to justify a decision to discipline an employee and may move to formal sanctions very quickly" (p.431).

In short, the more advanced the methods to register work are, the greater the possibilities for its use. Workforce monitoring has been studied from different perspectives throughout the years. From an information systems approach, management, monitoring, and control are three different data-related activities that implicate requirements for workforce data production. Though this discussion can be extended to any economic sector, this paper focuses on the approach toward governmental activities.

Work management information systems have several peculiarities in their data structure: they deal with large amounts of personal data, they tend to register data according to law-regulated careers, they may refer to several different positions, and they tend to have bureaucratic language. Work registers may strongly impact their users' lives, given that they derive rights, benefits, or losses, given that they will result in a paycheck.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Besides the challenges of setting up the information systems is the register the system is specified for—different ways to monitor work requests that the system is prepared to collect multiple types of information. For instance, from a historical development perspective, work registers have evolved alongside technology. In a simplified view of such development are the different ways work monitoring was conceived: time, activities, and deliveries.

A system that registers only time can be very simple, adding only a few layers to control unplanned events such as leaves, nonattendance, or emergencies. A more sophisticated system can start to include some quality to such registers, i.e., connecting hours to financial sources (projects, budgets, etc.) or describing the time spent. This complexity increases as the registered data advances towards having structured silos to connect the data. Predefined budgets and projects can be defined to simplify the system's use. A common use of time can consist of categories of labelled time spent. Over time, the growing complexity of the details increases the requirements for the information system to work.

Adopting a results-based management approach depends on having an information system capable of collecting appropriate registers to the needed level of detail to make this methodology work and generate useful information for those using the system. A few characteristics can be mentioned in the system specification. A stable result-based management system must define its syntax and semantics so multiple users can understand. Simplifying language and how it can interact with different interpretations is one of the challenges in information system design. Another assumption, especially for governmental data systems, is finding ways to make the data interoperable so that various systems can use it. Work registers, moreover, when connected to deliveries, should be flexible enough that multiple enough to fit multiple purposes, including work effort distribution and performance assessment.

Especially in public service, each country, region, and local government can specify how these characteristics apply to work registers. In this paper, we will discuss the Brazilian Federal case. We will do so by understanding the underlying discussions resulting from a major change in the work management system caused by a new program called the Management and Performance Program, the PGD. Though the case is specific for the country, we expect the discussions and reflections to support new insights for other governments and organizations facing the same challenges regarding the implementation of new information systems to manage flexible work.

3. Methodology

This paper is based on two sources of information. As an exploratory study (Visser, 2015), it starts with a short review of the literature (Ghobadi, 2015; Kuipers et al., 2013; Offermann et al., 2010), aiming to define the main concepts to be discussed throughout the text. Following our main research question, we aim at understanding "how does the level of formality in using work management information systems influence the data availability to improve decision-making?".

This exploratory study discusses the consequences of formality levels, hypothesizing that increased formal use of information systems leads to more bureaucratic registering practices. We aim at understanding if, by having more bureaucratic use, the systems' data availability is reduced, hindering their usefulness for decision-making processes. Based on our research question, we look for discussions on the effects of levels of formality in work management information systems' data registries and the use of their availability for decision-making improvement.

Based on internal documents and previous publications, we present a case study about Brazil's Management and Performance Program (Kassen, 2013; Yin, 1989). We describe the case for analyzing the impact of decisions in its process and develop a Stakeholder Power-Interest grid to understand different perspectives for defining system requirements (Bryson, 2004). Though the case is still in its infancy, facing technical and governance challenges coming from the implementation process, we use it as a reference to reflect on the set of options available to the coming developments. The goal is to shed light on actual choices for designing information systems in practice from a data usage standpoint.

We use the concepts from the review and the insights from the case to discuss trade-offs present in information systems design. The idea is to explore benefits and risks within the available choices and indicate future research streams over the consequences of formal and informal registers and the use of work information systems.

4. Information systems in the Management and Performance program

The traditional way to monitor work in the Brazilian government has always been through timesheets. The goal was to register the amount of time each civil servant dedicated to working for the government, assuming that while they were in the office, they were working (Camões et al., 2023; Ferlie et al., 1996; Madureira et al., 2020). One of the innovations introduced by the New Public Management (NPM) approach in the 1980s was to challenge public administrations to move forward and focus on service delivery (Lane, 2002; Schedler & Proeller, 2000). Within its guidelines were the ideas of making work in governments more flexible. Besides flexibility, NPM focused on improving the efficiency and efficacy of public service, adopting private sector management practices. Those

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

referred to cost reduction and accountability principles that would be transposed to the public service. Though most of the discussions focused on flexible contracts, some authors still mentioned the concept of more efficient ways to manage work in public institutions.

One of the main barriers to changing timesheet management and implementing new workforce policies was the risk of switching from process control to results (Weerakkody et al., 2021). Processes can be easy to measure and monitor, while results can vary and require more complex management. The timesheet control over civil servants' work is a clear example. It is easier to check whether someone came to the office on a certain day and attest to their presence than to set clear outcomes that individuals and teams are supposed to deliver by the end of a defined period, and verify those results (Kleiman et al., 2023).

This was the context in which the Brazilian Federal Government started implementing its management by results policies. In the 1990s, Brazilian politics were shaken by the neoliberal wave. Besides cost reduction, the modernizing efforts were also targeted at improving service delivery by introducing new management methods (Abrucio, 2007; Bresser Pereira, 1998; Silva, 2001). A whole set of rules was designed to update the federal-level government, and one of these measures proposed ways to make work more flexible. Though the focus was on creating mechanisms to reduce the existing public workforce, one program was designed to enable exceptions to timesheet control. Named as the Management Program, it sought to allow workers (mostly researchers) to work based on predefined goals (Kleiman et al., 2023; Pojo et al., 2024; Rego, 2022). Those joining this program would not report the time spent in the office, but the results achieved by the end of the month. The legislation was approved, supplying the needed legal framework for such experiences; however, only a few cases have been reported in the coming years.

It is known that such approach has been adopted in several pilot experiences that happened in more technical or technological governmental fields, such as teams in the national controlling office, the income tax department, or agencies that had a more flexible structure since their start – the idea of having public bodies to regulate specific fields was also an innovation coming from the same legal framework. In parallel to these non-timesheet work registers, cases of remote work were reported in similar fields. Since the 2000s, Information and Technology teams have had experience in enabling their workers to work from home. The overlapping between results management schemes and remote work was not noted until the 2019 pandemic (Brazil, 2024a).

With the sanitary emergency and the push to send as many workers as possible to work from home, the National Human Resources Secretariat within the Ministry of Economy was required to issue legal guidelines for the whole government on how to proceed with work management in the new situation. With the scaled request to control the work of dozens of thousands of workers out of the office, keeping them under the timesheet control was not feasible. A team found the legislation from the 1990s and based their new regulations on the mechanisms previously created – they designed the Management and Performance Program (Programa de Gestão e Desempenho – PGD) (Kleiman et al., 2023).

There was little time for larger developments, and guidelines were issued as available. The first regulation issued, the Normative Instruction 65/2020 (Brazil, 2020) established new government workforce management rules. It defined concepts such as participants, objectives, and steps to be followed to implement the PGD in each unit. At this stage, the PGD was legally defined as a "management instrument that regulates the development and measurement of its participants' activities, focusing on results delivery, through office or teleworking, aiming to improve the public service delivery quality within the federal government". Next, Decree 11.072/22 (Brazil, 2022) was signed by the President, narrowing the PGD to focus on the services provided to society, ruling over how the Program could be adopted and maintained by units, and setting specific procedures for teleworking, such as workload limits. In December 2023, the Normative Instruction SGP-SRT-SEGES/MGI 52/23 (Brazil, 2023, December 21) set new guidelines and procedures over workforce management, adding to the existing legal framework, details on the accountability for workers' activities diverging from their workplans, such as penalties, fees, and other financial consequences of failing to comply with the agreed deliveries.

By that time, the idea of registering time had to be substituted by the register of activities, which the management teams could attest. Such a register had to be delivered in an electronic system, adapted from a previously existing system not specifically designed. Kleiman et al. (2023) has reported that many challenges arose from this transition phase, though registering activities was already more efficient than trying to control timesheets from home. The waiting time for a new software version resulted in challenges for units and teams to reference their registers differently. Spreadsheets and task management tools were temporarily used in a transition towards new unified systems, affecting the quality of the resulting registers.

In a nutshell, in the transition period, an existing management information system was adopted, focusing on individual task registers. The Federal Private Insurance Agency (Superintendência de Seguros Privados- SUSEP) implemented the Workforce Management System (Sistema de Gestão de Pessoas – SisGP), previously developed to monitor requests within the agency. The system's flexibility favoured the PGD program to enable the creation of an extensive list of activities that could be individually assigned to each civil servant. The system was login entry-based, which supported an initial level of confidentiality for the provided information.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

However, as the system was designed to monitor individual tasks, it could only monitor activities at the individual level, making it difficult to analyse aggregated team deliveries or results. The pre-defined list of activities was also challenging. Each government department or unit had to be customized, increasing the complexity of analysing aggregated outcomes or connecting them to broader strategic goals or priorities. Lastly, as a transition system, the individual-level monitoring fostered micromanagement practices, reducing the program's potential to increase engagement. Moreover, the semantic limitation resulting from the predefined task list reduced the usefulness of the available information for decision-making.

A second phase was initiated after this transition stage with innovative procedures to plan, approve, perform, register, and monitor deliveries. In 2024, another legal instrument was issued (Brazil, 2023) to define the PGD as a program to improve the public service institutional performance, connecting individual work plans to the unit's delivery plan and the government's strategic priorities and planning, clarifying the unit's autonomy in starting its programs. These last definitions were aligned with the PGD new version, combining team delivery and individual assessment, creating transparency mechanisms. It also defined the Program's governance structure, creating an Executive Committee responsible for supporting units to implement their programs and issuing additional regulations needed for the Program's improvement. One specific unit was responsible for coordinating the Committee and maintaining the Program's webpage, which included information dashboards, enabling full transparency in the implementation progress by each governmental unit (Brazil, 2024a). An implementation index was defined to enhance such monitoring activity, allowing each unit to check its conformity with the requirements for a full Program implementation. Through such an index, each unit was requested to define their program webpage, containing full information on the program, such as the one from the National Aviation Agency, with full information on individual and team delivery plans (Brazil, 2024b).

Named PGD 2.0, this new phase would foster the units to focus more on team deliveries than individual performance, and to plan results with concrete characteristics (instead of individual activities). It would have a newly designed digital system following the program's logic, result-based-management. The previous information system limitations were converted into requirements to create a new PGD information system.

Though the regulations were flexible towards having various information systems to manage the program, the Ministry of Management and Innovation in the Public Service (MGI) engaged in developing an option for the units that lacked the conditions to produce their own. The main system feature was to enable the perspective of delivery management over the individual task monitoring perspective. Still, the new information system was required to allow individual work registers, which could support individual-level performance evaluations. The new system would focus on team delivery, as the sum of the efforts distributed among team members. Additionally, it would support inter-unit collaboration by allowing common deliveries to be tagged on different teams and team members. The pre-defined task list was replaced by customized deliveries, specified by each team. This new system architecture made interactions visible and enabled a broader analysis of workforce management.

As the government allowed each unit to use its information system, more than 30 information systems started operating. These systems were developed based on the same requirements, aiming to transfer the same mandatory data. Accordingly, the specific system offered by MGI was available to those units opting not to build their own. From an informational availability standpoint, what was observed is a combined process of cultural change and new practices. The inexistence of common ways to monitor work besides monitoring workload through timesheets fostered the development of several new systems. The initial strategy was to base the register on existing information systems, adapted to register work data regarding the new program. A diverse set of stakeholders was engaged to influence the definition of the new work information systems based on their requirements and needs. Using a Bryson (2004) Power-interest grid, we can visualize some of the tensions – Figure 1.

For instance, on the one hand, top management personnel found the opportunity to increase their strategic view of governmental management. In short, that was an opportunity to connect the mid-management layer to top government priorities with the new information produced. This meant improving decision-making in the government by using real-life information from the team´s work. With a high influence on decision-making, they were also interested in defining the system's data requirements, especially focusing on increasing the available data for decision-making.

HR managers, on the other hand, perceived the risk in changing the stabilized timesheet control routines to more dynamic delivery monitoring. Their main fear is explaining new contradictions and imprecisions from new data to the public or control and accountability units. However, with less influence, they were subject to top decision-makers (Brazil, 2024a). Conversely, control and accountability units were also interested in having more detailed information about the functioning of the public service, but from a formal perspective. They raised their eyes toward more sources for punishment, command, and control to increase their controlling capacity.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

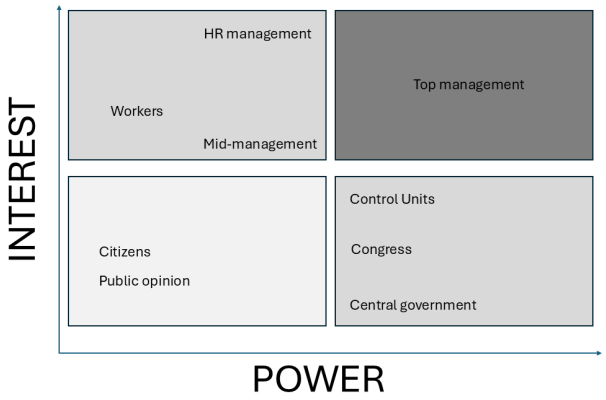


Fig.1 – PGD Power-interest grid, based on Bryson (2004)

Less influential mid-managers could feel the increased duties to fill in the systems. Besides working with their teams, registers would play an important part in their tasks and time. The less detailed or mandatory the register request is, the better. Workers found themselves in a contradictory situation of benefiting from more flexible systems to connect their actual work to public service deliveries. At the same time, they resisted the increase in control over their work and the risk of micromanagement from the top. Though with interests at stake, their influence on the system definition was low.

Since the beginning of data requirements and specifications, requests coming from command-and-control units have generated tensions with the decision-making requirements. While decision-makers' needs tend towards increasing data availability independently of their quality, the risk of the information leading to consequences in terms of conformity and formal analysis goes in the opposite direction. Evaluation and performance metrics can be developed in formal consequential ways, leading to risks in data quality, and informal trend analysis for decision-making can be more prone to imprecise information. The tension between formal and informal registers expands to the consequences of formal and informal use of the available data.

The resulting information systems were diverse, depending on the units they were related. However, the PGD set rules to enhance the benefits of monitoring deliveries. The first idea was to define the team as the unit´s reference for the deliveries. The unachievable idea of individually monitoring what each worker does could be addressed by understanding how teams work and connecting their activities to higher-level goals (Brazil, 2024a). The main outcome was strengthening the connection between governmental planning, strategic objectives, and the results expected from units and teams within the public service. Both managers, at different levels, and workers could benefit from gaining a better understanding of work and the contribution their actions have to the general government´s achievements. Lastly, increased engagement resulting from better comprehension of priorities and deliveries was expected.

The diverse set of information systems and information availability of the program resulted in many data registrations and uses. In the next session, we present some of the trade-offs of such complexity, indicating paths to follow next.

5. Trade-offs in the levels of formality in the use of PGD registers

The latest reported situation of the program is exemplary of the different trade-offs and contradictions regarding the next steps of the system development. Two different information systems are at work to receive information from each PGD unit. One is the central system of information related to the legal formalities, which is manually supplied with the actual situation of each unit. A team of civil servants needs to manually check whether the unit complies with all the six requirements to meet the formal conformity (published acts of institution and rules for having a functional program, system integration via API to transfer program information and a formal representative named to take part in the PGD network formal meetings).

In December 2024, out of 215 units allowed to join the PGD program, 191 actively participated. However, only 148 (77,94%) comply with all the formal requirements. The average compliance index is 94,33% among the 191 participating units. From the system integration perspective, 186 declares to have an operating system to manage its delivery and work plans. 97 institutions are adopting different versions of the PGD standard system, 53 have another publicly available system, and 36 units have declared to have developed their systems. The five units without a system do not comply with the program's requirements and should be disconnected if they cannot fulfill them in time (Brazil, 2024a). Only at the level of formality and conformity with the program regulations, even the objective of requirement compliance is questioned by some of the units.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The second information system is the one built upon API data transfer. The collection of the distributed data from all the program's compounding units into summarized information is the goal of the PGD team. Though system integration is ongoing, the data indicates several challenges. Besides the formality of the data, the PGD experience already indicates increasing complexities coming from the levels of aggregation to be used with this workforce management data source for decision-making.

The idea of offering decision-making dashboards with the program's indicators is still in its infancy. Aiming at going beyond the number of PGD participants, the systems should present data on the work plans, evaluations, and deliveries of the teams from each institution. However, as previously indicated, the perspective of developing management dashboards depends directly on the quality of this data. For instance, all PGD participants, regardless of the system chosen by their units, are expected to fill in their agreed work plans under their team's delivery plans. Mandatory data submission via API officially began in January 2025, and the governance structure of the PGD program has focused its efforts on analyzing the consistency of the data received via API. On the one hand, data transfer failures due to system issues result from bad system integration. On the other hand, due to a lack of data, team training and engagement are noticed due to poor liaison between the senior leadership of the institutions and the heads of the participating units.

Since August 2024, 159 units have sent more than 25,000 delivery plans, related to more than 240,000 work plans. It already sums up hundreds of thousands of individual contributions of the 70,000 PGD participants registered with the API (Brazil, 2024a). Given that evaluation deadlines and scores, defined in the legislation, should be followed, the focus comes back to information quality. As with the existing system, the differences in individual and collective performance, i.e., may result in different perspectives on the information systems. It is expected that the more the command-and-control individual perspective is adopted, the less prone civil servants will be to updating systems with real-life information. The risks of consequences increase their resistance to updating the system dynamically and their willingness to have a better stable picture to be assessed.

As discussed in the literature, what was observed in developing the PGD information system resembles the tensions within other requirements-setting processes for information systems. Consequently, this explorative analysis arrives at a final reflection regarding the new program implementation, the formality of the information use. Based on the insights coming from the literature, after the program reaches its maturity in terms of technology convergence, the API should be able to capture the amount of information needed for the dashboard consolidation. However, as in the literature, the more focused on results and evaluation the use of the information systems is, the less likely it tends to receive actual information from civil servants. The discussion indicates a risk that the PGD program information systems' official and formal use results in more bureaucratic, hence, outdated information. As a consequence, it is hypothesized that the information coming from the PGD information systems might become less realistic and useful for decision-making, by attending strictly to legal requirements or frameworks.

6. Conclusion and future research

Based on the main research question of "How does the level of formality in using work management information systems influence the data availability to improve decision-making?" we performed an exploratory study to discuss the consequences of increasing formality using the existing data. The Management and Performance Program (PGD) resulted from a policy transformation in the Brazilian public administration, which replaced the timesheet workforce management with a delivery-based system.

Driven by the guidelines of New Public Management (NPM) and accelerated by the 2019 pandemic, this shift brought higher levels of autonomy to public servants, empowering teams and managers in their management procedures. The focus on delivery indicates the potential to increase service delivery efficiency despite challenges such as the risk of micromanagement. Converging with the literature findings, the PGD case also indicates that a way to tackle the formal bureaucracy of inaccurate records could be to prioritize team performance based on concrete goals. The new management system shows a path to foster a new management culture in the public sector, more appropriate to support flexible ways to organize work than timesheets.

Though potential remedies to these challenges posed by formalization are not directly discussed, some examples can indicate an agenda for further research. For example, analysing whether increasing the use of informal data sources could improve data flexibility and lead to better decision-making. Or if enhancing system user design could nudge participants to improve their register practices, leading to increased trust in the system's information.

The discussions indicate that the immediate effect of strengthening the system through formality could be to reduce the system's availability of useful management data. Consequently, the data availability reduction would also decrease the new management program's potential to analyze trends, obtain accurate information, and improve decision-making processes. Further research should incorporate more empirical evidence and explore better ways to balance formal management and data availability to increase its importance to policymakers. More evidence is also needed to test the actual consequences of increasing levels of formality in the PGD information system use.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Acknowledgment

- **Contributor Statement**: Fernando Kleiman acts as the main writer of the text. Camila da Silveira Machado and Nathália Juncá Nogueira edited the text, introducing reflections and conclusions on the reported case.
- **Conflict of interest:** All authors work in the implementation of the PGD for the Brazilian federal government, and the views expressed here are solely those of the authors and do not represent the official views of any organization the authors may be affiliated.
- **Use of AI**: During the preparation of this work, the author(s) used Grammarly in order to proofread and language correction of the proposal. After using this tool/service, the author(s) reviewed, edited, made the content their own, and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

References

Abrucio, F. L. (2007). Trajetória recente da gestão pública brasileira: um balanço crítico e a renovação da agenda de reformas. Revista de administração pública, 41, 67-86.

Altaee, M. A. H. (2018). Twinning between informal and formal information Systems. Advances in Management and Applied Economics, 8(1), 37-55.

Bell, B. S., McAlpine, K. L., & Hill, N. S. (2023). Leading Virtually. Annual Review of Organizational Psychology and Organizational Behavior, 10(1), 339-362. https://doi.org/10.1146/annurev-orgpsych-120920-050115

Bloom, N., Han, R., & Liang, J. (2024). Hybrid working from home improves retention without damaging performance. Nature, 1-6.

Brazil. (2020, July 30) Instrução Normativa nº 65, Diário Oficial da União, por Ministério da Economia / Secretaria Especial de Desburocratização, Gestão e Governo Digital / Secretaria de Gestão e Desempenho de Pessoal <https://www.in.gov.br/en/web/dou/-/instrucao-normativa-n-65-de-30-de-julho-de-2020-269669395>

Brazil. (2022, May 17) Decreto nº 11.072, Diário Oficial da União, por Presidência da República/ Secretaria-Geral/ Subchefia para Assuntos Jurídico <https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2022/decreto/d11072.htm> ou(https://www.in.gov.br/web/dou/-/decreto-n-11.072-de-17-de-maio-de-2022-401056788)

Brazil (2023, July 28) Instrução Normativa Conjunta SEGES-SGPRT /MGI nº 24, de 28 de julho de 2023, publicado em 31/07/2023, edição 144 , seção 1, página 57 do Diário Oficial da União, por Ministério da Gestão e da Inovação em Serviços Públicos / Secretaria de Gestão e Inovação < https://www.in.gov.br/en/web/dou/-/instrucao-normativa-conjunta-seges-sgprt-/mgi-n-24-de-28-de-julho-de-2023-499593248 >

Brazil (2023, December 21) Instrução Normativa Conjunta SGP-SRT-SEGES/MGI nº 52, Diário Oficial da União, por Ministério da Gestão e da Inovação em Serviços Públicos / Secretaria de Gestão de Pessoas < https://www.in.gov.br/en/web/dou/-/instrucao-normativa-conjunta-sgp-srt-seges/mgi-n-52-533454345 >

Brazil (2024a) Site Management and Performance Programa. Programa de Gestão e Desempenho. (https://www.gov.br/servidor/pt-br/assuntos/programa-de-gestao/painelimplementacaopgd)

Brazil (2024b) Site National Aviation Agency. Agência Nacional de Aviação Civil. (https://www.gov.br/anac/pt-br/acesso-a-informacao/acoes-e-programas/governanca/anac-mais).

Brazil. (2024, October 7) Resolução CPGD/MGI Nº 1, Diário Oficial da União, por Ministério da Gestão e da Inovação em Serviços Públicos / Secretaria de Gestão e Inovação < https://www.in.gov.br/web/dou/-/resolucao-cpgd/mgi-n-1-de-7-de-outubro-de-2024-588903651 >

Bresser Pereira, L. C. (1998). A reforma do Estado dos anos 90: lógica e mecanismos de controle. Lua Nova: Revista de cultura e política, 49-95.

Bryson, J. M. (2004). What to do when Stakeholders matter. Public Management Review, 6(1), 21-53. https://doi.org/10.1080/14719030410001675722

By, R. T. (2007). Organisational change management: A critical review. Journal of Change Management, 5(4), 369-380. https://doi.org/10.1080/14697010500359250

Camões, M. R. d. S., Gomes, A. d. O., Rizardi, B., & Lemos, J. (2023). Os ciclos de engajamento no trabalho de servidores públicos federais. Revista de administração pública, 57, e2023-0061.

Eom, S.-J., Choi, N., & Sung, W. (2016). The use of smart work in government: Empirical analysis of Korean experiences. Government Information Quarterly, 33(3), 562-571. https://doi.org/10.1016/j.giq.2016.01.005

Ferlie, E., Fitzgerald, L., & Pettigrew, A. (1996). The new public management in action. Oxford University Press, USA.

Galanti, T., Guidetti, G., Mazzei, E., Zappala, S., & Toscano, F. (2021). Work From Home During the COVID-19 Outbreak: The Impact on Employees' Remote Work Productivity, Engagement, and Stress. J Occup Environ Med, 63(7), e426-e432. https://doi.org/10.1097/JOM.0000000000002236

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Ghobadi, S. (2015). What drives knowledge sharing in software development teams: A literature review and classification framework. Information & Management, 52(1), 82-97. https://doi.org/10.1016/j.im.2014.10.008
Johnson, G. H. (1986). The relative use of formal and informal information in the evaluation of individual performance.
Karimian, P., Noruzi, A., & Nazari, M. (2022). Preference Analysis of Formal and Informal Information Sources in Decision Making of Managers in SMEs. Informology, 1(1), 85-102.
Kassen, M. (2013). A promising phenomenon of open data: A case study of the Chicago open data project. Government Information Quarterly, 30(4), 508-513. https://doi.org/10.1016/j.giq.2013.05.012
Kisil, N. (2024). Working in the "New Normal": Exploring the Link Between Hybrid Work and Need Fulfillment Concordia University].
Kleiman, F., & Barbosa, M. M. (2024). Management and Performance Program Chatbot: A Use Case of Large Language Model in the Federal Public Sector in Brazil. Digital Government: Research and Practice.
Kleiman, F., Farias, R. D. S., Nogueira, N. J., Brito, T. B. D. O., Barbosa, M. M., Marasca Bertazzi, D. M., & Rego, R. S. M. P. (2023). New ways for monitoring the public workforce after the pandemic Proceedings of the 24th Annual International Conference on Digital Government Research, Gda?sk, Poland. https://doi.org/10.1145/3598469.3598508
Klonek, F., & Parker, S. K. (2021). Designing SMART teamwork. Organizational Dynamics, 50(1). https://doi.org/10.1016/j.orgdyn.2021.100841
Kothawala, A., Haddad, A. J., Loa, P., Lee, Y., Circella, G., & Bhat, C. R. Hybrid Workers' Activity Intensity: Post-Pandemic Comparison of Telework-Only and In-Person Workdays.
Kuipers, B. S., Higgs, M., Kickert, W., Tummers, L., Grandia, J., & Van Der Voet, J. (2013). The Management of Change in Public Organizations: A Literature Review. Public Administration, 92(1), 1-20. https://doi.org/10.1111/padm.12040
Lane, J.-E. (2002). New public management: an introduction. Routledge.
Madureira, C. G., Rando, B., & Ferraz, D. (2020). The Public Administration Performance Appraisal Integrated System (SIADAP) and the Portuguese Civil Servants Perceptions. International Journal of Public Administration, 44(4), 300-310. https://doi.org/10.1080/01900692.2020.1719510
Madureira, C., & Rando, B. (2022). Teleworking in Portuguese public administration during the COVID-19 pandemic. Work Organisation, Labour & Globalisation, 16(2). https://doi.org/10.13169/workorgalaboglob.16.2.0119
Marković, N. (2024). Key Factors of Remote and Hybrid Work Model–what have we learned after COVID-19? Psychē: Časopis studenata psihologije, 7, 87-103.
Offermann, P., Blom, S., Schönherr, M., & Bub, U. (2010). Artifact types in information systems design science–a literature review. International Conference on Design Science Research in Information Systems,
Pan Fagerlin, W., & Lövstål, E. (2020). Top managers' formal and informal control practices in product innovation processes. Qualitative Research in Accounting & Management, 17(4), 497-524.
Pojo, R., Wehbe, C., & Kleiman, F. (2024). Todo trabalho é híbrido. In A EVOLUÇÃO DO TELETRABALHO - TOMO V: UMA VISÃO MULTIDISCIPLINAR (pp. 296-310). Lacier Editora.
Pryor, M. G., Taneja, S., Humphreys, J., Anderson, D., & Singleton, L. (2008). Challenges facing change management theories and research. Delhi business review, 9(1), 1-20.
Rego, R. S. P. a. C. J., José Celso. (2022). Princípios, Condições e Diretrizes do Programa de Gestão e Desempenho (PGD) para o Governo Federal Brasileiro. O Estado de Sao Paulo.
Røed, K., & Raaum, O. (2003). Administrative registers–Unexplored reservoirs of scientific knowledge? The economic journal, 113(488), F258-F281.
Rubin, R. S. (1979). Flexitime: its implementation in the public sector. Public Administration Review, 39(3), 277-282.
Saundry, R., Jones, C., & Wibberley, G. (2015). The challenge of managing informally. Employee Relations, 37(4), 428-441.
Schedler, K., & Proeller, I. (2000). New public management. Stuttgart/Wien.
Schuster, M. (2024). Studies on remote work: challenges and implications for hybrid work arrangements Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau].
Silva, I. G. (2001). A reforma do Estado brasileiro nos anos 90: processos e contradições. Lutas Sociais(7), 81-94.
Visser, J. (2015). Barriers in open energy data: An exploratory study into open energy data barriers and their mitigation strategies. repository.tudelft.nl. https://repository.tudelft.nl/islandora/object/uuid:e5116152-c133-4f67-b7d8-5223c66c9f68
Weerakkody, V., Janssen, M., & El-Haddadeh, R. (2021). The resurgence of business process re-engineering in public sector transformation efforts: exploring the systemic challenges and unintended consequences. Information Systems and e-Business Management, 19(3), 993-1014. https://doi.org/10.1007/s10257-021-00527-2
Yin, R. K. (1989). Case study research: Design and methods. In Applied Social Research Methods Series (Vol. 5). Sage Publications.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Remote and Hybrid Work in Crime Victim Services: A Scoping Review

Lane Gillespie, Ph.D. [a*] *Tara* Richards, Ph.D. [b] *Emilie* Whitehouse M.S. [c]

[a] School of Criminology and Criminal Justice, University of Nebraska Omaha, Omaha, Nebraska, USA, lanegillespie@unomaha.edu, 0000-0003-1508-3147.

[b] School of Criminology and Criminal Justice, University of Nebraska Omaha, Omaha, Nebraska, USA, tararichards@unomaha.edu, 0000-0001-9239-2192.

[c] School of Criminology and Criminal Justice, University of Nebraska Omaha, Omaha, Nebraska, USA, ewhitehouse@unomaha.edu, 0009-0003-5718-3354.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. Using the PRISMA framework for scoping reviews, we identified 27 studies on remote and hybrid work in the victim services sector that met our inclusion criteria. Studies were examined regarding (1) the data and methods used to examine remote and hybrid work in victim service agencies; and (2) provider-level and client-level outcomes. Findings show most studies are exploratory in nature, rely on qualitative data from professionals only (i.e., not service users), and suffer from methodological limitations (e.g., reliance on small, convenience samples). Further, most studies focus on the transition to remote service delivery during the COVID-19 pandemic and on domestic violence/sexual assault agencies. Findings show that common provider-level challenges include technological barriers, concerns about the security of online services, and the development of rapport with clients virtually; while strengths include personal-professional flexibility, the development of new collaborations, and work productivity/efficiency. Client-level challenges include technology access, digital literacy, and confidentiality and safety concerns, while strengths include increased access to services, reduced cost, and increased anonymity of virtual services. Results suggest that we need additional, rigorous evaluation research to understand how processes and outcomes differ between remote and in-person services. Expanding research to a wider range of types of crime victim service providers and crime victims are also important next steps.

Keywords. Crime victims, virtual victim services, telehealth, victim advocacy.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1040

1. Introduction

Crime victims have a wide range of needs that can vary across victimization types and individuals. Victims may have legal needs such as requests for victim compensation (e.g., monies for funeral expenses for a homicide victim), notification of criminal case progression, court accompaniment, and no contact orders, as well as non-legal needs including medical, housing, and/or psychological support. Victim service providers (VSPs) help facilitate meeting these needs directly or through a "warm hand off" (e.g., a specific referral to another provider) (Richards, 2016). Historically, most VSPs worked with victims face-to-face in a physical setting (Pfitzner & McGowan, 2023). Over the past few decades, however, technological advances in communication such as videoconferencing, mobile chat, and electronic forms and applications (aka apps) have resulted in a wide range of options for remote and hybrid work (Flores, 2019), including for VSPs. Further, the use of "telehealth" or "telemedicine" (where electronic technology is used to provide health services to a patient) has also grown, resulting in an increased level of comfort in discussing sensitive/confidential topics remotely (Villalobos et al., 2023). Electronic services and service provision was further spurred by the COVID-19 pandemic which forced wide expansion of remote and hybrid work (RHW) modalities within the private and government sectors (Aksoy et al., 2022), including within the criminal

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

justice system (Ivković & Maskaly, 2022). As such, many criminal justice and victim service agencies pivoted to fully remote service offerings and continue to offer remote services to clients (and remote or hybrid work options for employees). While virtual services may increase accessibility for clients and improve efficiency and work-life balance for professionals, they come with challenges regarding technology access and safety (Arunprasad et al., 2022). Prior scoping reviews have examined studies of technology-based solutions (eHealth) for psychosocial support among sexual assault (SA) (Bach et al., 2024), intimate partner violence (IPV)(Anderson et al., 2021; El Morr & Layal, 2020; Linde et al., 2020), and violence against women (Eisenhut et al., 2020) survivors. However, it is unclear what is known about the challenges and opportunities for crime victims, regardless of victimization type, seeking services remotely *or* the impact of RHW on victim service professionals. As such the current scoping review aims to answer the following questions: (1) What data and methods are used to examine RHW in victim service agencies? (2) What is known about RHW in victim service agencies regarding provider-level outcomes and client-level outcomes.

2. Methods

A scoping review is a "systematic approach to map evidence on a topic and identify main concepts, theories, sources, and knowledge gaps" (Tricco et al., 2018, p. 467). Scoping reviews are useful in an emerging field to determine the "scope" of a body of literature on a topical area and report on the types of evidence available and the ways such evidence has been collected (Munn et al., 2018). In the current scoping review, we examine the existing research on RHW within victim service agencies and the ways in which this knowledge has been gathered.

2.1 Stages of Scoping Review

Below we describe details on each of the four stages included in the current scoping review: (a) establishing eligibility criteria; (b) identifying relevant studies; (c) screening relevant studies; and (d) charting and organizing data. The PRISMA framework for conducting and reporting scoping reviews (Tricco et al., 2018) was utilized. Our protocol was preregistered with Open Science Framework.

2.2 Eligibility Criteria

Studies were considered eligible for inclusion if they (a) reported findings from an empirical study (i.e., not literature reviews, theoretical articles, commentaries or conceptual papers); (b) were written in English; and (c) examined remote and/or hybrid work in community- and/or systems-based victim service agencies. No studies were excluded based on the year of study. Unpublished theses, dissertations, and reports were included.

2.3 Information Sources and Search Process

MeSH and other terms combined with Boolean Operators (OR and AND) were used to create the following search equation: ("remote" OR "hybrid" OR "online" OR "web-based" OR "virtual") AND ("victim*" "survivor*" OR "victim services"). The search equation was run for title, abstract, and keywords in 4 electronic databases: PubMed, PsycINFO, SCOPUS, and Web of Science and in abstract and summary text in ProQuest Dissertations and Theses and ProQuest Social Science Premium Collection (which includes NCJRS Abstracts). We also searched Google Scholar using a combination of "remote work and victim service agencies" and "hybrid work and victim service agencies"; the first 10 pages of records sorted by relevance were reviewed. We also reviewed the reference lists of included studies.

2.4 Study Selection

All records were reviewed, and after removing duplicates, two Co-Investigators independently screened articles based on the title and abstract (Stage one review). Disagreements in screening were resolved using a third screener, a trained, doctoral-level research assistant. Studies screened in at this stage were read in full by one of the Co-Investigators and the doctoral-level researcher (Stage two review). Again, disagreements were resolved using the third screener. Inclusion/exclusion was tracked at each stage using the PRISMA flow chart (See Figure 1). Rayyan software was used to manage and organize the review process.

At Stage one, 1,998 records were identified. After removing 712 duplicates manually and using the duplicate detection function in Rayyan, 1,286 records were included in the Stage one review. During the Stage one review, 1,245 records were excluded because they did not meet the inclusion criteria leaving 41 records for the Stage two review. At Stage two, the 41 remaining records were read in full; 14 records were removed because they did not meet the topical inclusion criteria. The remaining 27 records were included in this scoping review. In addition, the reference pages for these 27 records were reviewed for additional records that met the inclusion criteria; none were identified.

2.5 Data Charting

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Key information about included records (i.e., included after Stage two review) were extracted and charted including author(s), year, study location, sample, data, research questions, and main findings regarding provider-level challenges and benefits and client-level challenges and benefits.

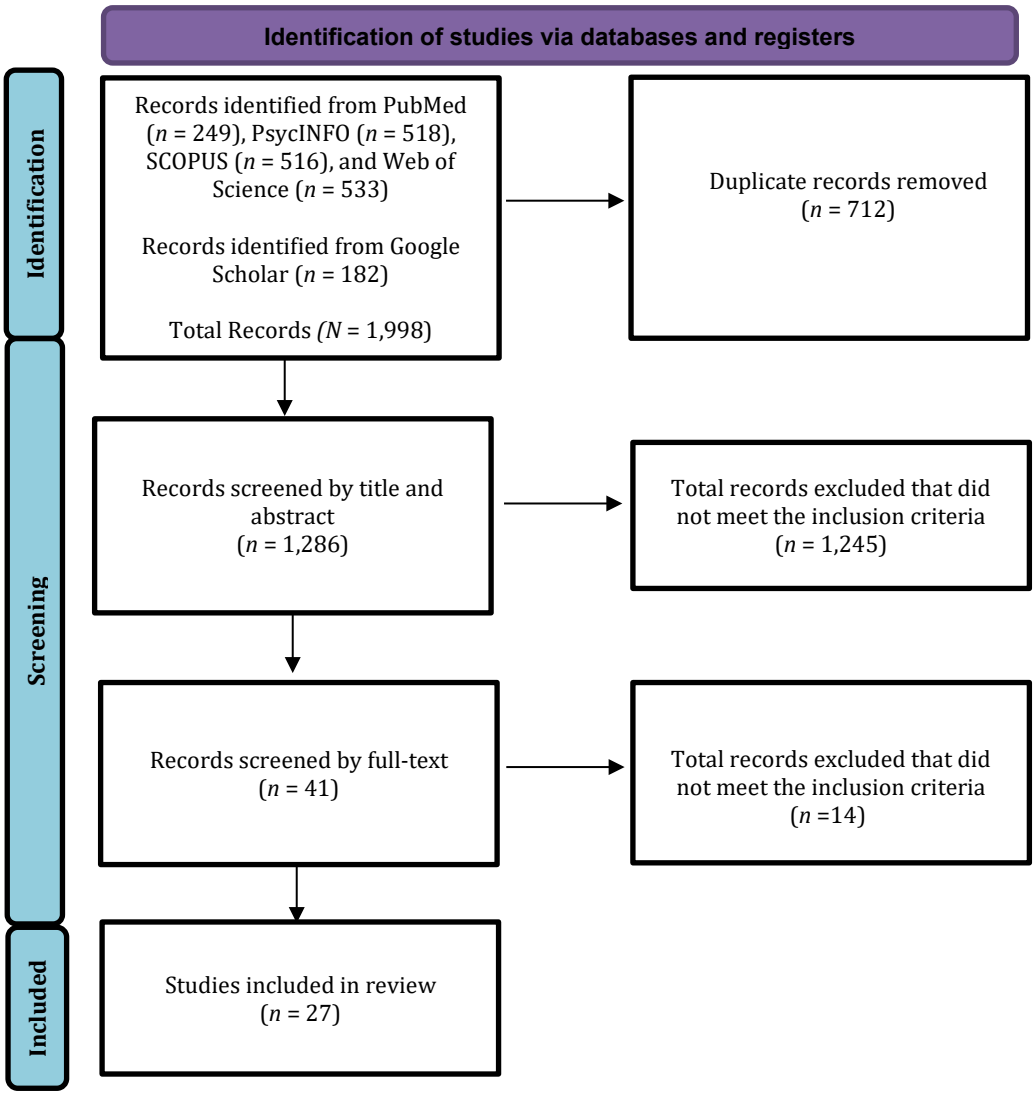


Figure 1. Identification of studies via databases and registers using the PRISMA framework.

3. Results

The 27 articles included in this scoping review span publication dates from 2011 to 2025, with only three studies taking place prior to the onset of the COVID-19 pandemic (i.e., Chen 2019; Gloor & Meier, 2020; Hassija and Gray, 2011). The studies were conducted in the following countries: the United States (*n* = 15), Australia (*n* = 3), United Kingdom (n = 2), Portugal (*n* = 2), Canada (*n* = 1), England (*n* = 1), Spain (n =1), and Scotland (*n* = 1). Virtual service delivery ranged from video- and teleconferencing, to application-based services, chat-and voice-based hotlines, texting/emailing, and synchronous and asynchronous remote counselling among other services (See Table 1).

Most studies (*n* = 15, 55.6%) reported on qualitative research only, either using open-ended survey responses or interview methods. Two studies (7.4%) used only quantitative methods, while a mixed methods approach was adopted in the remaining 10 studies (37.0%). Sample sizes for qualitative studies varied widely, with as few as seven participants engaging in interviews to as many as 564 participants completing surveys with open-ended responses; samples sizes for quantitative analyses were relatively small ranging from 15 to 352 participants. Given these small sample sizes, it is unsurprising that the quantitative studies relied on descriptive and bivariate statistics rather than multivariate analyses. Most studies (*n* = 23, 85.2%) focused on the transition to remote victim services and remote and hybrid victim service work environments during COVID-19. All these studies used convenience samples and acknowledged their exploratory nature; only two reported response rates (18.7% and 26.5%, respectively). These studies mostly focused on the perspectives of professionals working for domestic violence (DV) and/or SA response organizations, although one study interviewed child protective service workers (Renov

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

et al., 2021), one surveyed professionals who supported victims of torture (Santamarina et al., 2023), and two interviewed a range of professionals, including providers who supported child abuse and trafficking victims (Voth Schrag et al., 2021a, 2022). Further, only four studies included the perspectives of crime victims.

As noted above, three studies took place or used data collected before COVID-19. The first assessed change in PTSD and depressive symptoms as well as client satisfaction associated with a synchronous videoconferencing therapy for DV and SA victims in a rural area who did not have access to in-person therapy (Hassija and Gray, 2011). The second examined the feasibility and acceptability of an asynchronous counselling service for DV victims (Gloor & Meier, 2020), while the third described support providers' use of technology to contact and serve trafficking victims as well as trafficking victims' concerns regarding technology use (Chen et al., 2019).

3.1 Virtual Victim Services During COVID-19 Challenges and Benefits to Service Providers

As noted above, 23 studies focus on virtual victim services after the onset of COVID-19 and predominantly examined service providers' perspectives. As seen in Table 2, there was significant overlap across studies regarding the challenges and benefits for VSPs. Nineteen studies discussed provider challenges with providing virtual services. In three studies, VSPs identified difficulties in "accessing technology" or with internet connectivity specifically while three indicated that they had problems obtaining the necessary hardware (e.g., computers, tablets, phones) or that they had to use their personal computers/phones to provide virtual services. In addition, service providers in seven studies reported having limited technical or digital literacy or limited knowledge regarding digital videoconferencing or videotelephone platforms (e.g., Zoom, Skype) and one study mentioned problems obtaining information technology support from their organization. Popular videoconferencing sites did not have the necessary encryption and safety features required to meet some providers' policies, so providers had to search to find platforms that were compliant. Likewise, two studies discussed providers having to learn about technology safety and teach their clients; finding that "technology safety is part of the job now" (Voth Schrag, 2022, p. 230).

Providers also discussed the challenges in assessing victim's physical safety and home environment virtually with several providers specifically mentioning the difficulties in reading body language with videoconferencing technology and the lack of any cues (e.g., body language, tone of voice) with chat, email, and application-based services. Four studies found that providers were concerned about their ability to build trust and rapport virtually, and in turn, about the quality and effectiveness of the services they were providing (see for examples, Evans et al., 2023, Speed et al., 2020) and two studies noted that clients were less likely to show up for virtual appointments. Remote work was also isolating for many providers, with six studies discussing the difficulties in connecting with co-workers to seek advice about clients and/or debrief after an especially difficult client interaction. Providers across several studies also indicated that remote work decreased their work/life balance because it blurred the lines between their work, which focused on traumatic events, and their home, which was their safe space. Two studies mentioned new difficulties in setting boundaries between work and home when they transitioned to providing remote services.

In addition to challenges, 12 studies identified benefits to providers. Providers noted that videoconferencing had expanded their access to trainings (three studies), had notetaking and recording features that assisted them in their client and co-worker interactions (one study), and increased their ability to engage with new partners despite physical distance (three studies). Providers also noted the cost effectiveness of remote services to their clients and/or virtual staff trainings (two studies) and their newfound ability to provide services to clients even when clients travel or relocate (i.e., continuity of services; one study). In three studies, providers noted that virtual visits had increased their productivity through efficiency (i.e., no travel time between appointments) and that their clients had better attendance at remote appointments (two studies). In two studies, providers noted that remote work gave them *better* work life balance, with providers citing more personal flexibility in working from home and more control over their physical workspace (i.e., to create a positive workspace) as specific benefits.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Table 1. Summary of Studies Included in Scoping Review*.						
	Author/Year	**Study Location**	**Sample**	**Purpose**	**Qualitative/ quantitative**	**Remote modalities/services**
1	Evans et al. (2023)	Ohio, USA	Agency workers (n = 170; 26.5% response rate).	Surveys asked about how the COVID-19 pandemic changed victim service work.	Qualitative	Videoconferencing
2	Roebuck et al. (2022)	Canada	VSPs and adult volunteers (N = 564).	Surveys asked about spending more time working from home during the COVID-19 pandemic as a service provider.	Qualitative and quantitative	Videoconferencing
3	Voth Schrag et al. (2021a)	USA	VSPs for IPV, SA, child abuse, or human trafficking (n = 33).	Semi-structured interviews focused on approaches used by the interpersonal violence workforce to address social distancing needs during COVID-19.	Qualitative	Teleconferencing
4	Waid et al. (2022)	Midwestern state, USA (rural)	Administrators and/or supervisors of direct service staff from federal, state, and local entities or non-profit, community-based settings serving victims of crime (n = 9).	Interviews focused on how service providers adapted to work with victims, the types of victimization experienced, the training received, and any technical or financial assistance received during the COVID-19 pandemic.	Qualitative	Videoconferencing; Participants were working remotely or in a hybrid format.
5	Bibi (2021)	North Dakota, USA (rural)	VSPs in rural agencies (n = 8).	Interviews focused on the strategies agencies developed during COVID-19 and how they can better serve victims/survivors in rural communities.	Qualitative	Videoconferencing; Participants were working remotely or in a hybrid format.
6	Cambell et al. (2023)	Detroit, Michigan, USA	Advocate/counseling staff (n = 12) at largest SA service agency in Detroit.	Interviews focused on how the agency responded to pandemic restrictions, how their clients engaged with these changes in service, and what they saw as key lessons learned from the pandemic regarding services and organizational planning.	Qualitative	Videoconferencing and online crisis chat hotline.
7	Caridade et al. (2021)	Portugal	Support professionals from the Portuguese National Support Network for victims of DV (n = 196).	Surveys focused on the type of support provided to victims during the COVID-19 pandemic compared to before the pandemic; their level of training to provide support remotely; the advantages and barriers of remote support, and their institutional policies regarding remote support.	Quantitative	Phone, email, social applications, and videoconferencing; Participants were working remotely or in a hybrid format.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

8	Carrington et al. (2021)	Australia	Domestic and family violence service providers in Australia (n = 362).	Surveys asked about the impact of the COVID pandemic and associated lockdown restrictions experienced by the DV workforce and their clients.	Qualitative	Phone, email, social applications, and videoconferencing; Participants were working remotely or in a hybrid format.
9	Chen et al. (2019)	USA and Southeast Asia	Staff members at VSPs and survivors of trafficking (n = 17).	Semi-structured interviews focused on how VSPs use technology in their interactions with clients and what, if any, concerns exist around this technology usage.	Qualitative	Phone, hotline, SMS, social media (e.g., Facebook), and email.
10	Gloor & Meier (2020)	Zurich, Switzerland	Counselling service users during first 10 months (n = 200) and during a six-week period (n = 33); Experts in information technology (IT) (n = 3) and counselling (n = 3).	Review of user data and user survey data; interviews with experts in IT and counselling to examine the development, performance, and acceptance of the remote counselling service.	Qualitative and quantitative	Asynchronous web based individual counselling service via a protected area on the provider website.
11	Downes & Barbosa (2024)	United Kingdom	All Advocate Educators and Clinicians in the Identification and Referral to Improve Safety (IRIS)-Network (n = 187), and convenience sample of clinicians in IRIS-trained practices (n = 8) and patients/service users (n = 4).	Survey and interview data examined whether confidentiality can be guaranteed in remote consultations; IRIS training effectiveness and acceptability to clinicians when delivered virtually; and virtual IRIS advocacy support effectiveness and acceptability to patients.	Qualitative and quantitative	Virtual training and service delivery for IRIS program (i.e., DA screening and referrals to victim services).
12	Santamarina et al. (2023)	Madrid and Barcelona, Spain	Professionals (n=21) and torture survivors (n=21) from a sample of Istanbul Protocols (IP) interviews between 2019 and 2021.	Surveys asked about the evaluation process, satisfaction, difficulties encountered, and compliance with therapeutic aspects and compared across remote and in person formats.	Qualitative and quantitative	Videoconferencing.
13	Pedersen et al. (2023)	North East Scotland and Orkney Islands, UK (rural)	Managers of domestic abuse services (n = 12).	Semi-structured interviews focused on the move to digital and telephone provision of support due to COVID-19.	Qualitative	Telephone and online.
14	Speed et al. (2020)	United Kingdom	Service providers at gender-based violence organizations (n = 52; 18.7% response rate).	Surveys on the impact of COVID-19 gender-based violence services operations and support to victims.	Qualitative and quantitative	Telephone helpline/webchat or online.
15	Wood et al. (2022)	USA	IPV and SA service workers (n = 352) from 24 states.	Online surveys about service adaptation and technology use at work before and during the COVID-19 pandemic.	Qualitative and quantitative	Videoconferencing, texting, computer chats, email, phone call, and video calls (e.g., Facetime).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

16	Perez (2022)	California, USA	DV service providers, including case managers, therapists, and program coordinators (n = 9).	Interviews focused on the barriers, benefits, and strategies in providing services during COVID-19.	Qualitative	Telephone and videoconferencing.
17	Sleath et al. (2025)	England	Sexual violence service professionals (n = 22) and service users (n = 221) from 15 Sexual Assault Referral Centers.	Surveys asked about pandemic impact on survivors of sexual violence and abuse and their help-seeking and recovery journeys; pandemic impact on service delivery and staff; and challenges and opportunities.	Qualitative and quantitative	Telephone and videoconferencing.
18	Wood et al. (2020)	USA	Individuals with active safety concerns from violence, threats, stalking, or abuse (n = 53).	Surveys about the use of virtual and phone services during COVID-19.	Qualitative and quantitative	Virtual counseling and/or advocacy services.
19	Domingo-Cabarrubias et al. (2023)	Victoria, Australia	Legal practitioners (n = 7) who support victims of domestic/family violence.	Interviews explored benefits, limitations, risks, and future innovation opportunities in remote legal support during the COVID-19 pandemic.	Qualitative	Telephone, videoconferencing, Skype or Zoom, email, online chat, text messaging, websites, self-help centers, and online tools.
20	Renov et al. (2021)	USA	Child Protective Service (CPS) caseworkers and administrators (n = 37).	Interviews assessed how the COVID-19 pandemic changed the way CPS staff conducted investigations and provided services to families in the CPS system.	Qualitative	Virtual home visits, care portal.
21	Klein et al. (2022)	Midwestern University USA	Hotline staff and volunteers (n = 9).	Interviews assessed perspectives regarding the benefits and challenges of offering a chat service, as well as the strategies used to adapt services to the chat modality.	Qualitative and quantitative	Telephone and web-based hotline.
22	Pfitzner and McGowan (2023)	Australia	Victim-survivors who sought domestic/family violence advice or support (n = 61).	Surveys asked about experiences and challenges in accessing support during lockdowns; the method by which remote support was provided during lockdowns and whether that method was helpful; what service providers could have done better during lockdowns.	Qualitative and quantitative	Telephone support, hotline.
23	Voth Schrag et al. (2022)	USA	VSPs for IPV, SA, child abuse, or human trafficking (n = 33).	Semi-structured interviews asked about strategies used to help clients address violence, threats, stalking, or abuse since the coronavirus pandemic began and changes as the pandemic unfolded.	Qualitative	Teleconferencing, telephone/web hotline, texting/chat, Google voice numbers, email; Uber account for transportation.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

24	Ferreira et al. (2024)	Portugal	Professionals from DV support service (n =24).	Semi-structured interviews focused on the primary challenges faced by DV professionals during interventions.	Qualitative	Video and phone calls.
25	Nahar et al. (2023)	Dallas-Fort Worth, Texas, USA	VSPs (n = 15).	Interviews examined experiences providing telehealth services during COVID-19.	Qualitative	"Telehealth services".
26	Voth Schrag et al. (2021b)	Southwestern State, USA	For interviews: campus and community-based advocates (n =23) For surveys: survivors (n = 63). Participants were drawn from 3 universities.	Interviews and surveys asked how advocates were using technology with emerging adults who are survivors of IPV and sexual violence in the year immediately preceding the COVID-19 pandemic; and what survivor recommendations for advocacy and service engagement via technology were.	Qualitative	Text messaging, apps, My Plan, email, phone; Website for making appointments.
27	Hassija and Gray (2011)	Wyoming, USA (rural)	Clients referred to the Wyoming Trauma Telehealth Treatment Clinic (WITIC) for psychological services after DV/SA (n = 15).	Pre-and post-treatment PTSD and depression symptoms were assessed as was client satisfaction.	Quantitative	Videoconferencing-based psychological services delivered using secure technology.

*Full citations are available upon request.
Common Acronyms: IPV=intimate partner violence; DV=domestic violence; SA=sexual assualt

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3.2 Virtual Victim Services During COVID-19 Challenges and Benefits to Service Victims

Nineteen studies discussed victim challenges with virtual services; however, only four studies included the perspectives of service users (i.e., victims). In eight studies, difficulties with victims accessing technology or accessing hardware such as computers, tablets, and phones was noted, while eight discussed victims' challenges navigating technology, limited digital literacy, or discomfort using technology. Further, two studies described challenges working applications or videoconferencing platforms as particularly difficult for older clients and clients with complex health needs. Four studies noted that virtual services felt impersonal; for example, one victim said that they wanted to talk with someone face-to-face for a "a proper chat" (Sleath et al., 2025 p. 146). Another study reporting victims' perspectives discussed how the quality of virtual services was dependent on the provider and their knowledge and skills to provide remote services (Pfitzner & McGowan, 2023).

The most noted concern was about victim safety and confidentiality when accessing virtual services. Twelve studies mentioned concerns about victims having a private space to connect with service providers (i.e., to access confidential services), as well as the risk for victims seeking services while in physical proximity to their perpetrators. Likewise, three studies specifically mentioned victim's fear about using virtual services because their abuser monitored their digital devices (e.g., checked their call or browser history, read their email, etc.).

Fifteen studies also addressed victim benefits regarding virtual services. Increased flexibility and access to services was highly valued (12 studies) with multiple studies specifically noting that virtual serives did not require transportation or childcare and expanded access to rural victims. The immediacy of services in virtual formats such as text/chat-based services was also noted in one study. Other identified benefits included virtual translation systems that allowed for broader language access and the ability of videoconferencing to hold virtual visits or assessments without victims needing to be in the same physical space, and sometimes without even seeing their perpetrators (i.e., using breakout rooms). Studies also discussed the benefits of increased anonymity in virtual services for disclosing victimization and/or accessing services (five studies). For example, some noted that it was easier for victims to discuss their victimization remotely (i.e., less fear, stigma, shame) while others noted that remote services reduced victims' fear of physically accessing a victim service provider and being recongized by someone they know (see Pedersen et al., 2023; Pfitzner & McGowan, 2025).

3.3 Challenges and Benefits of Virtual Victim Services Outside of COVID-19

Four studies were focused on virtual victim services outside of the COVID-19 pandemic context. In the oldest study from 2011, clients obtained trauma-focused psychotherapy services from a university-based therapy clinic via videoconferencing at domestic violence/rape crisis centers in their home areas (Hassija and Gray, 2011). Survivors experienced large reductions in PTSD and depressive symptoms overall and by trauma type, and reported high satisfaction with services. Similarly, Gloor & Meier (2020) piloted an asynchronous counselling service for victims of DV accessible via a specially protected area on the support provider's website. Review of user data and user survey data showed that users increased over time by 50%, that 57.5% of users engaged in multiple sessions, and that 52.5% of users accessed the service outside of traditional work hours when in-person counselling services are not readily available; more than 93% of users rated the responses from counsellors as 'very comprehensible', 'very helpful', and 'very sensitive'. Further, Klein et al.'s (2022) formative evaluation described the feasibility and acceptability of a chat-based hotline for college students. Their work showed that students were willing to use the chat hotline at similar rates as a voice hotline. Hotline staff perceived that "chatters" felt greater safety to disclose and more control over their disclosure in chat over voice hotlines (1) given the greater anonymity and (2) ability to write out and edit their chat messages. At the same time, chat hotline staff reported more pressure to type the "right thing" than they did in responses via the voice hotline and concerns that they could not always perceive the chatter's emotional state or emotional needs through text alone. Finally, Chen and colleagues (2019) explored support providers' use of technology to contact and serve victims of trafficking as well as trafficking survivors' concerns regarding technology use through in-depth interviews. Providers noted that their primary way to make/recieve contact with survivors was through remote means such as voice hotlines, SMS, email, or via social media and that continued support was often delivered remotely until a survivor could escape their trafficker. A wide range of difficulties for survivors were identified including their often limited access to technology and/or the control of their digital devices by the perpetrator. Results are presented in Table 2.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Table 2. Summary of Provider and Client Level Findings Related to Remote Victim Services.				
	Provider level challenges/negative outcomes	**Provider level benefits/positive outcomes**	**Client level challenges/ negative outcomes**	**Client level benefits/positive outcomes**
1	(1) Mixed feelings about the utility and effectiveness of virtual services (e.g., reduced effectiveness in therapeutic work with children, clients being less likely to show up for virtual appointments, or difficulties related to internet access technology).	(1) More personal flexibility in working from home.	(1) Difficulties with accessing technology, (2) difficulties navigating the technology, (3) challenges exacerbated for victims with disabilities (e.g., Deaf).	(1) Increased access to services (e.g., more flexibility, no need for transportation, childcare).
2	(1) Working from home decreased work-life balance which in turn a decrease in mental health, (2) difficulties negotiating and setting boundaries, (3) virtual format makes it difficult to draw on co-worker support.	(1) More personal flexibility in working from home, (2) remote work improved work life balance, (3) remote work at home allows for more control over their physical workspace (i.e., a "positive space" to work).	none discussed.	(1) Increased access to services (e.g., more flexibility, no need for transportation, childcare).
3	Regarding virtual services (1) empathic connection is harder, (2) assessing environment (e.g., for home visits on children) is challenging, (3) technological challenges, (4) boundary maintenance, (5) technology safety is part of the job.	none discussed.	(1) Difficulties with accessing technology, (2) difficulties navigating the technology.	(1) Increased access to services (e.g., no need for transportation, childcare), (2) immediacy of services, (3) language access, (4) anonymity & comfort disclosing.
4	(1) Security on videoconferencing sites (e.g., Zoom), (2) reduced networking opportunities when using a virtual format.	(1) Note taking and recording features in videoconferencing platforms, (2) reduced costs of training staff virtually, (3) increased access to collaboration through virtual meetings	none discussed.	(1) Increased ease of serving victims and perpetrators in the same meetings (e.g., using breakout rooms, coming and going as needed without seeing each other).
5	(1) Concerns about patient acceptance, especially regarding the privacy and intimacy of virtual exams, (2) space limitations for machinery in small EDs, (3) lack of staff training, (4) concerns regarding the quality of exams.	(1) Telemedicine can improve patient care and evidence collection in SA cases, (2) 24/7 IT support is key to addressing technical challenges.	none discussed.	none discussed.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

6	(1) Security on videoconferencing sites, (2) Identifying a videoconferencing site that would meet strict agency requirements (e.g., could not use Zoom).	none discussed.	Telehealth options were not widely utilized by the client population of this agency (e.g., low income, urban population) due to (1) difficulties accessing technology, (2) inadequate privacy to utilize telehealth, (3) limited comfort in discussing traumatic events remotely.	none discussed.
7	(1) Limited knowledge/training on technology/in providing support remotely.	none discussed.	(1) Difficulties accessing technology, (2) difficulties navigating the technology, (3) risk of control of digital devices by the perpetrator, (4) proximity to the offender (i.e., inadequate privacy to utilize telehealth).	(1) Reduced financial costs, (2) reduced inhibition, fear, shame.
8	(1) Difficulties conducting services remotely (e.g., difficulty building rapport/trust, interpreting body language), (2) difficulties assessing client's environmental risk/home conditions/physical safety, (3) clients were less likely to show up for virtual appointments, (4) lacked equipment, (5) limited knowledge/training on technology/in providing support remotely.	none discussed.	(1) Difficulties accessing technology, (2) difficulties navigating the technology, (3) risk of control of digital devices by the perpetrator, (4) proximity to the offender (i.e., inadequate privacy to utilize telehealth), (5) exacerbated challenges for victims with disabilities or complex health needs.	none discussed.
9	(1) Limited knowledge/training on digital platforms, (2) boundary maintenance, (3) technology safety is part of the job.	none discussed.	(1) Difficulties accessing technology, (2) difficulties navigating the technology, (3) risk of control of digital devices by the perpetrator, (4) proximity to the offender (i.e., inadequate privacy to utilize remote services), (5) victims may not believe the VSP can be trusted (due to relationship only being virtual).	(1) Increased comfort level communicating digitally (i.e., "less raw" p. 92).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

10	(1) Trained counselors who are dedicated to the online service (only) are needed (2) professional technical support is essential, (3) technical realization of the service was challenging (i.e., balancing safety/security requirements, user ease, and user interface).	none discussed.	none discussed.	(1) Increased flexibility (i.e., 52.5% of users accessed outside of traditional work hours), (2) users noted increased comfort level communicating digitally.
11	(1) Most clinicians felt more confident identifying and asking about DA in person versus virtually, (2) more confident responding to disclosures of DA in person versus virtually (3) nearly 49% had received a disclosure of DA virtually, but only about a third reported making a referral to an Advocate Educator during a remote consolation, (4) most Advocate Educators were concerned about difficulties in concentration or IT issues with online training, (5) difficulties in assessing service users safety or risk virtually, (6) difficulties in asking sensitive questions virtually.	(1) Most clinicians felt confident identifying and asking about DA virtually, (2) most clinicians had asked about DA virtually, (3) most clinicians preferred online training to face-to-face.	(1) Nearly half of Advocate Educators reported a delay/difficulty in getting their service users to survivors' groups or other relevant services.	(1) Most Advocate Educators reported their users were just as positive about the remote support as the face-to-face support, (2) users reported increased access, (3) users reported decreased fear/stigma in disclosing virtually.
12	More professionals in the remote format compared to the face-to-face format (1) needed an interpreter, (2) reported privacy issues/inadequate interview location, (3) problems in connection/ material resources, (4) timing problems, (5) difficulties in understanding the survivor's emotional response.	none discussed.	Fewer survivors in the remote format reported (1) feeling well emotionally immediately after the process, (2) feeling well emotionally after the process was findings, and (3) post-process resilience (4) more felt they needed subsequent psychological support.	(1) All survivors in the remote format reported being satisfied overall (2) being satisfied with the interview process and report writing.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

13	For videoconferencing/ online services (1) difficulties obtaining needed hardware (e.g., computers, phones, tablets), (2) limited knowledge/training on digital platforms, (3) difficulties with internet connectivity. For telephone services, (4) inability to build rapport/read body language, (5) need to concentrate harder led to exhaustion, (6) remote format made it difficult to draw on co-worker support.	(1) Potential to train staff virtually, (2) increased access to collaboration through virtual meetings.	For videoconferencing/ online services (1) difficulties with internet connectivity, (2) limited knowledge about digital platforms, (3) concerns about privacy/abuser proximity, (4) lack of easy access to a computer, (5) fear of control of digital devices/tracking online contacts by the perpetrator.	Providers reported (1) a more flexible approach of remote services being welcomed by some users, (2) preference of phone contact versus videoconferencing, (3) increased access to services (e.g., in rural areas).
14	(1) Difficulties obtaining needed hardware (e.g., computers, phones, tablets), (2) difficulties accessing IT support, (3) concerns about quality of virtual services for victims.	none discussed.	(1) Concerns about privacy/abuser proximity, (2) limited knowledge about digital platforms.	none discussed.
15	Professionals reported (1) limited knowledge/training on digital platforms and in providing support remotely, (2) difficulties conducting services remotely (e.g., difficulty building rapport/trust, interpreting body language), (3) difficulties assessing client's safety/how they are doing, (4) difficulties accessing/connecting to internet, (5) remote format makes it difficult to draw on co-worker support.	none discussed.	(1) Discomfort using phone/technology to receive services, (2) lack of privacy/ concerns about proximity to the perpetrator.	none discussed.
16	(1) Clients were not answering calls/ following up with services.	(1) Law enforcement was more willing to engage victim service partners because it was over the phone (i.e., they did not have to wait for victim services to show up), (2) easier access to the home environment to observe family dynamics, (3) can provide services to clients located anywhere in the US.	(1) Discomfort using phone/technology to receive services, (2) lack of hardware, (3) concerns about victim safety, (4) concerns about client privacy and confidentiality.	(1) Increased accessibility (e.g., more convenient, no need to drive to their office, for childcare).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

17	(1) Difficulties conducting services remotely (e.g., difficulty building rapport/trust, interpreting body language), (2) boundary maintenance in working from home, (3) remote format makes it difficult to draw on co-worker support.	(1) Remote services are cost effective.	Most service users surveyed reported that online/telephone service delivery reduced their engagement in help-seeking and support due to difficulties building relationships, interpreting body language (i.e., "having a proper chat").	A minority of service users reported that remote services (1) increased accessibility (e.g., more convenient, no need to drive to their office, for childcare) and that it was (2) easier to disclose over the phone.
18	none discussed.	none discussed.	Concerns about (1) confidentiality, (2) tech safety, (3) technical issues (e.g., delays, technology interruptions), (4) wanted to talk face to face/in person.	Almost half (42%) of respondents had used virtual counseling or advocacy services at a violence prevention or intervention agency since the pandemic. (1) increased accessibility (e.g., more convenient, no need to drive to their office).
19	(1) Difficulties conducting services remotely (e.g., difficulty building rapport/trust, interpreting body language).	none discussed.	(1) Lack of access to technology/hardware, (2) virtual forms in English only/need for translation, (3) concerns about tracking/monitoring online activity by the perpetrator, (4) concerns about privacy/proximity to the perpetrator, (5) digital literacy.	none discussed.
20	(1) Difficulties assessing client's environmental risk/home conditions/physical safety, (2) difficulties with virtual interviews with young children (i.e., easily distractable, hard for them to manage digital device).	(1) Better work-life balance through remote/hybrid work, (2) increased productivity/ability to see their clients more often through virtual visits.	(1) Concerns about privacy/proximity to the perpetrator, (2) need for hardware like phones.	(1) Online care portal increased access to needed goods, (2) improved engagement with families through virtual alternatives.
21	(1) Absence of vocal cues/can be difficult to know a "chatter's" emotional state/needs, (2) difficulty building rapport/expressing empathy, (3) some chats are very dense with multiple topics making responses cumbersome, (4) more pressure to type the "right" thing, (5) pre-generated shortcuts could seem impersonal.	(1) Staff can respond from anywhere in a private/confidential way.	none discussed.	(1) Chat allows for increased privacy/anonymity, (2) written form allows for more control over how users present the information (i.e., they can write out/edit their story via chat).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

22	none discussed.	none discussed.	(1) Concerns about privacy/proximity to the perpetrator, (2) virtual services felt impersonal, (3) not all service providers had the same level of virtual service delivery skills (i.e., quality was dependent on the practitioner)	(1) Increased accessibility (i.e., more flexible hours), (2) increased anonymity by not having to access services in person
23	(1) Tech safety is now part of the job for everyone.	(1) Seeing clients more frequently (for shorter interactions) through virtual interactions like emails, (2) increased engagement with partners through virtual meetings, (3) expanding engagement with new communities (e.g., having iPad at the multicultural center with service center's zoom information ready to go), (4) rideshare apps increased access to easy/efficient transportation (i.e., no need for vouchers).	(1) Digital literacy and tech safety needs, (2) concerns about proximity to the perpetrator, (3) concerns about privacy/confidentiality.	none discussed.
24	(1) Isolation of remote work/not seeing co-workers, (2) challenges building and maintaining rapport/personal connections with clients, (3) need to develop technical skills.	none discussed.	(1) Digital literacy needs, (2) concerns about proximity to the perpetrator.	none discussed.
25	(1) Limited digital literacy, (2) challenges building and maintaining rapport/personal connections with clients, (3) isolation of remote work/ not seeing co-workers.	(1) Better attendance by clients for virtual appointments, (2) increased efficiency/productivity.	(1) Concerns about proximity to the perpetrator, (2) concerns about privacy/confidentiality, (3) limited access to hardware, (4) limited access to internet, (5) perpetrator monitored digital devices, (6) limited digital literacy.	(1) Increased accessibility/flexibility

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

26	(1) Need to set boundaries, (2) tech safety is part of the job now.	(1) Technology allows for more options for the "best way" to communicate with a survivor.	(1) Concerns about privacy/ confidentiality, (2) technical glitches can retraumatize survivors (e.g., sad/romantic hold music, preform emails sent months after disclosures).	From survivors: (1) 43% of survivors reported using technology (phone, text message, e-mail, or secure message system) to connect with their advocate more than once. From advocates: (2) increased accessibility/flexibility/speed of response.
27	none discussed.	none discussed.	none discussed.	Survivors experienced large reductions in PTSD (d = 1.17) and depressive symptoms (d = 1.24) overall and by trauma type (DV: (d = 1.00, d = 1.33; SA: d = 2.18, d = 1.05, respectively), and reported high satisfaction with services (M = 52.93 out of 55).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4. Discussion

The present review aimed to describe what is known about hybrid and remote work (RHW) in crime victim services and how such knowledge has been developed. Using the PRISMA framework for scoping reviews, 27 studies were identified that met our inclusion criteria. Given the development of remote services across government sectors and the necessary expansion of RHW since the onset of the COVID-19 pandemic, conducting a review of research in this area is prudent to inform future practice and research in the victim services field.

Although technology has led to increased options for remote service delivery for several decades, studies identified through this review are relatively recent, published since 2011. Only three studies report on data collected prior to 2020, as most studies focused on the transition to remote services in response to the COVID-19 pandemic. There is limited global diversity in this body of research with all studies stemming from the Western world and more than half stemming from the United States. Regarding data and methods (RQ 1), most studies (93%) utilized qualitative data or took a mixed-methods approach. Existing studies are largely exploratory and descriptive in nature, most using small, convenience samples limiting generalizability.

Provider-level outcomes (RQ 2) were organized in terms of challenges and strengths. Common challenges included technological barriers (e.g., access to computers, phones, internet), security of online service provision (e.g., digital security of videoconferencing platforms), the development of rapport with clients virtually, and negative impacts on providers' work-life balance. Strengths/benefits included personal flexibility in work location, the development of new collaborations, efficiency (e.g., reduced travel time), training access, and increased frequency of communication with clients due to remote options (e.g., phone, chat, text, video, etc.).

Client-level outcomes (RQ 2) were also organized in terms of challenges and strengths. Most research on client-level outcomes was from the perspective of service providers. Challenges identified across studies include technology access and digital literacy, hardware access (e.g., phone, computer, etc.), less utility for some populations (persons with disabilities, persons in urban low-income areas, older persons), provider's skill in delivering remote services, and confidentiality and safety concerns with remote services given perpetrators' potential proximity and digital abuse. Strengths/benefits included increased access to services, efficiency in services, reduced cost, and digital communication feeling more comfortable and/or anonymous. Further, there is some indication that clients may equally satisfied and/or more satisfied with technology-facilitated services, although providers may be less satisfied with these service options (e.g., Pedersen et al., 2023; Santamarina et al., 2023).

Existing studies provide valuable insights on experiences with remote and hybrid victim service delivery. However, the vast majority of what we know about virtual victim services - especially during COVID-19 - stems from the perspectives of DV and SA service *providers*, not other VSPs, and not service *users* (i.e., crime victims). Additionally, there have been few evaluation studies that examine outcomes for victims who use or professionals who deliver remote/technology-based victim services and/or the effectiveness of various forms of technology-enhanced or remote service delivery. Expanding research to other types of crime VSPs, crime victims/clients, and enhancing evaluation efforts are important next steps. Finally, while other facets of criminal justice and social services have developed research in the context of human resource management, this has not yet been a focus of hybrid and remote victim service provision research. Research in this vein may be beneficial in terms of enhancing staff retention, reducing burnout, and addressing safety.

In addition to the limitations of existing research, limitations to the current review include that the search – while robust – may not have identified all relevant articles, including those not published in English and/or not captured by our search terms. Although we feel it is important to examine victim services distinct from related, and at times overlapping, services (e.g., healthcare services) there may be relevant findings in a broader literature that contextualize benefits and challenges of remote crime victim services.

5. Conclusions

In conclusion, there is a need for continued and robust research on RHW in victim services. There are common themes across the 27 studies identified in this review. Having flexible service options provides choice, accessibility, and accommodation to crime victims. Some populations may benefit more from remote/virtual services than others, and there may also be differences between providers and clients in terms of their comfort with remote service options. Just as victim safety is a critical concern in offering in-person services, it is also a concern in the offering of virtual services. For providers, there is a need for training in effective online service delivery. Critical to the success of remote services is the infrastructure to make it possible: hardware, digital literacy, broadband internet access, and technological security and support. Remote and hybrid service options have the potential to expand the reach of victim service work, and as technology continues to evolve so too will avenues for meeting the needs of crime victims and supporting those who work with them.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Acknowledgement

- **Contributor Statement**: Author 1: Conceptualization, Data Curation, Formal Analysis, Investigation, Writing-Original Draft; Author 2: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Writing-Original Draft; Author 3: Formal Analysis, Investigation.
- **Use of AI**: none to report.
- **Conflict Of Interest (COI)**: "There is no conflict of interest".

References

Due to space constraints, references for the 27 studies included in the scoping review are available from the authors by request

Aksoy, C.G., Barrero, J.M., Bloom, N., Davis, S.J., Dolls, M., & Zarate, P. (2022). Working from home around the world. *Brookings Papers on Economic Activity, 2022*(2), 281-360. https://dx.doi.org/10.1353/eca.2022.a901274

Anderson, E. J., Krause, K. C., Meyer Krause, C., Welter, A., McClelland, D. J., Garcia, D. O., Ernst, K., Lopez, E. C., & Koss, M. P. (2021). Web-based and mHealth interventions for intimate partner violence victimization prevention: A systematic review. *Trauma, Violence, & Abuse, 22*(4), 870-884. https://doi.org/10.1177/1524838019888889

Arunprasad, P., Dey, C., Jebli, F., Manimuthu, A., & Hathat, Z. E. (2022). Exploring the remote work challenges in the era of COVID-19 pandemic: review and application model. *Benchmarking, 29*(10), 3333-3355. https://doi.org/10.1108/BIJ-07-2021-0421

Bach, M. H., Ahrens, C., Olff, M., Armour, C., Krogh, S. S., & Hansen, M. (2024). eHealth for sexual assault: A systematic scoping review. *Trauma, Violence, & Abuse, 25*(1), 102–116. https://doi.org/10.1177/15248380221143355

Eisenhut, L., Hegarty, K., & Taft, A. (2020). Information and communications technology use to prevent and respond to violence against women: A systematic review. *Cochrane Database of Systematic Reviews, 2020*(5). https://doi.org/10.1002/cl2.1277

El Morr, C., & Layal, F. (2020). A scoping review of technological tools for supporting victims of domestic violence. *International Journal of Medical Informatics, 141*, 104169. https://doi.org/10.1016/j.ijmedinf.2020.104169

Flores, M. F. (2019). Understanding the challenges of remote working and it's impact to workers. *International Journal of Business Marketing and Management, 4*(11), 40-44. https://ijbmm.com/paper/Nov2019/824043604.pdf

Ivković, S. K., & Maskaly, J. (2022). Crime, criminal justice system, and the COVID-19 pandemic. *International Criminology*, *2*(1), 1-4. https://doi.org/10.1007/s43576-022-00053-2

Linde, K., Muench, F., & Koss, M. P. (2020). eHealth for sexual assault: A systematic scoping review. *Trauma, Violence, & Abuse, 21*(4), 649–661. https://doi.org/10.1177/1524838019877668

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, *18*(143), 1-7. https://doi.org/10.1186/s12874-018-0611-x

Pfitzner, N. & McGowan, J. (2023). Locked out or let in? Learning from victim-survivors' remote help-seeking experiences during COVID-19. *Journal of Gender-Based Violence*, XX(XX): 1–20. https://doi.org/10.1332/23986808Y2023D000000007

Richards, T. N. (2016). *Victim advocates.* In W. Jennings (Ed.), "The encyclopedia of crime and punishment". Malden, MA: Wiley-Blackwell.

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac., D., ... Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine*, *169*(7), 467-473. https://doi.org/10.7326/M18-0850

Villalobos, B. T., Dueweke, A. R., Orengo-Aguayo, R., & Stewart, R. W. (2023). Patient perceptions of trauma-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

focused telemental health services using the Telehealth Satisfaction Questionnaire (TSQ). *Psychological Services, 20*(1), 107–121. https://doi.org/10.1037/ser0000605

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 16: Smart Cities for Social Cohesion

Track Description

In the era of cities and under the UN 2030 Agenda for sustainable growth, cities aim to secure social sustainability and coherence (e.g., deal with affordable energy, poverty, hunger, equal opportunities in education, jobs, and health, etc.) and enhance their performance to become friendlier and able to host their increasing populations. Additionally, new types of businesses emerge, while the coexistence of autonomous things and people poses another challenge that cities are beginning to phase out. Smart Cities are enablers of smart growth, social cohesion, and industrial transformation by adopting cutting-edge technologies (e.g., IoT, AI, Blockchain). The goals of smart cities are to generate opportunities that engage, upskill, and enhance equity in their communities. This track aimed to gather research and practices on smart cities' development strategies, policy models, citizen engagement, and technological innovations, and on the Smart and Inclusive Cities, emphasizing participation, access to technology, and the ability of citizens and the community to keep on functioning and prospering despite the challenges that they can face (i.e., inequity, poverty, violence, environmental threats, etc.).

Track Chairs

L. Anthopoulos, University of Thessaly, Greece
S. A. Chun, City University of New York, United States of America

Contents

Bridging the Metaverse and Social Cohesion in Smart Cities 1009
E. Kontogianni and L. Anthopoulos

Context-sensitive measurement: Addressing the local context in smart city assessment 1024
M. M. Ribeiro, E. Przeybilovicz, and D. Soares

Digital Inclusion and Social Cohesion in Smart Cities: Overcoming Barriers in the Digital Age 1037
C. Karelis, Z. Lachana, I. Gorelova, C. Alexopoulos, N. Lavdaria, F. Bellini, and Y. Charalabidis

European urban strategic initiatives involving emerging technologies for addressing climate change 1048
M. P. R. Bolívar, C. A. Muñoz, L. A. Muñoz, and R. de la T. Martínez

Opportunities and Challenges for Management and Governance in Smart Cities in Brazil 1064
L. Paseto, M. R. M. M. Corso, and A. P. de L. F. de Carvalho

Towards social cohesion: understanding local migration governance's barriers in global south smart cities 1071
R. A. Palacios, E. M. Luciano, and G. V. Pereira

Bridging the Metaverse and Social Cohesion in Smart Cities.

Elli Kontogianni [a*], *Leonidas Anthopoulos* [b]

[a] Department of Business Administration, University of Thessaly, 41500 Geopolis Campus, Larissa Ringroad, Larissa, Thessaly, Greece; e-mail: ellkontogianni@uth.gr.

[b] Department of Business Administration, University of Thessaly, 41500 Geopolis Campus, Larissa Ringroad, Larissa, Thessaly, Greece, e-mail: lanthopo@uth.gr.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. It is estimated that the metaverse has the potential to affect peoples' and communities' lives. As an integrative virtual space that offers immersive experiences to its users, the metaverse can foster virtual interactions that not only mimic but also enhance real-world social activities and relations. With its ability to narrow or eliminate physical boundaries, the metaverse presents potential opportunities for enhancing social cohesion in diverse communities. Social cohesion - characterized by a sense of belonging, mutual trust, and collaboration - plays a vital role in connecting community members. This article provides a systematic review of existing literature on the metaverse's implications, to explore its potential to promote social connections and inclusivity in communities, both essential elements of social cohesion. The study reviews articles sourced from the scientific repositories ScienceDirect, Web of Science, Google Scholar, and Scopus. The results show that the metaverse has the potential to bridge economic, social, and cultural gaps by facilitating social interactions, broadening access to education, fostering engagement as well as by creating new economic opportunities. These advancements can encourage a sense of unity and belonging, especially in the context of smart cities, where innovation and community building come together.

Keywords. Metaverse, Implications, Social Cohesion, Smart Cities, CitiVerse.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.983

1. Introduction

The metaverse is rapidly emerging as a transformative digital space with the potential to impact various aspects of individuals' lives. The metaverse has been recently defined as "an integrative ecosystem of virtual worlds offering immersive experiences to users, that modify pre-existing and create new value from economic, environmental, social and cultural perspectives" (ITU, 2023). This definition outlines the metaverse's potential to reshape the relationships between people as well as societies within physical and virtual spaces. Given its potential to shape daily life significantly, a thorough examination of its implications is essential. However, it is important to especially focus on the impact of the metaverse on communities and more specifically, to examine whether the metaverse can contribute towards social integration. Social cohesion, defined as *"the capacity of a society to ensure the well-being of all its members, minimizing disparities and avoiding marginalization, while fostering a sense of belonging, trust, and shared values among its members"* (Council of Europe, 2005), is vital for thriving communities. This article explores the relation between the metaverse and social cohesion within cities and communities. Addressing this issue is challenging, since the metaverse seems to have begun to transform from a science fiction concept into a tangible reality enabled by advances in technologies (Lee et al., 2021), reshaping human interactions and redefining the way communities are formed.

This transformative potential extends to urban context in the form of the "CitiVerse", an urban application of the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

metaverse. Metaverse in cities -the so-called CitiVerse- (ITU, 2024) can be catalysed by the existence of installed Information and Communications Technologies (ICT), and more importantly by emerging ones like Digital Twining and Artificial Intelligence (AI), which are both targeted by smart cities. According to Anthopoulos (2017) and Díaz-Díaz et al. (2017), a smart city can be seen as an ICT-based urban innovation that aims to address challenges that cities face, such as efficiency, quality of life, and sustainability. Being such an urban innovation, smart cities generate public value and drive social cohesion, integrating technological progress with community needs. Furthermore, Camboim et al. (2019) refer to the smart city as an ecosystem of urban innovation, while Appio et al. (2019) identify it as a collaborative ecosystem that fosters innovation and establishes relationships between its stakeholders (citizens, government, businesses).

The existing literature on smart cities and digital transformation mainly explores the role of emerging technologies such as Internet of Things (IoT), AI and Blockchain in enhancing urban efficiency and governance (Anthopoulos, 2017). However, there is a notable gap in research concerning how the metaverse can contribute to social cohesion within smart cities. This research contributes to bridging this gap by examining the role of the metaverse in promoting social cohesion through its integration in urban ecosystems. The remainder of this article includes the following: Section 2 discusses the theoretical background of this article, and in particular the concepts of smart city, metaverse, CitiVerse, and social cohesion. Section 3 contains the systematic literature review methodology that was followed, while Section 4 outlines the systematic review results. Finally, Section 5 focuses on the implications of the metaverse related to social cohesion, and Section 6 contains the conclusions of the article.

2. Background

This section outlines the theoretical background relevant to the subject of this article. Firstly, it explores the smart city concept, emphasizing the use of ICT to enhance efficiency, sustainability, and quality of life. Following, the evolving concept of the metaverse as well as its integration into real-world cities, the so-called CitiVerse are presented. To conclude, this section discusses the key factors of social cohesion.

2.1 Smart City

Trying to find a single, comprehensive definition of "smart city" is not entirely feasible as there are several different approaches to this concept. They range from ICT-based cities to smart resource management, to mobilizing partnerships between different stakeholders using ICT, to cities that apply new technologies to innovate, or even cities that innovate politically and managerially (Anthopoulos, 2017).

According to Díaz-Díaz et al. (2017), the term "smart city" refers to urban innovation where, mainly through the use of ICT and innovation, challenges of modern cities, such as efficiency, quality of life, climate change, and sustainability are addressed. In a smart city ecosystem, technology, infrastructure, data, services, stakeholders, the physical environment, and governance are interconnected (Anthopoulos, 2017), which consequently conveys that a smart city is characterized by connectivity, sustainability, security, and technology (Grossi & Trunova, 2021). Moreover, Barrutia et al. (2022) describe a smart city as one that aspires to become smarter by prioritizing efficiency, equity, and sustainability. They also argue that a pivotal attribute of smart city's intelligence lies in the comprehension of citizens' expectations and the subsequent satisfaction. Various stakeholders interact, transferring knowledge and creating shared value, in a participatory and flexible governance that invests in digital infrastructure (Camboim et al., 2019; Cosgrave et al., 2014).

Furthermore, according to Bibri et al. (2022), the most prominent digital processes supporting data-driven smart cities are digital instrumentation, digital hyper-connectivity, datafication, algorithmization, and platformization. Digital infrastructure of the smart city produces enormous volumes of data from devices like IoT sensors, enabling real-time analysis and city governance. Hyper-connectivity based on technological advancements like IoT and 5G connects systems, devices, and individuals, organizing smart cities. Additionally, datafication in smart cities, driven by digital hyper-connectivity, has enabled algorithmization and platformization. Datafication turns social activities into quantifiable data that can be tracked in real-time and analysed through AI algorithms. Algorithmization converts urban activities into structured instructions for AI and big data systems, enabling smart cities to make data-driven decisions based on predictive analysis. Digital platforms, which combine technology with organizational structures, are expanding in governance, economy, and services, and are inducing a shift in social, political, and economic practices. These platforms enable citizen participation, and permit public-private partnerships. The metaverse, driven by data and platformization, is impacting urban life by integrating digital technologies into smart city infrastructure. As such, the metaverse is perceived as a central force in shaping the future of urban life, presenting new forms of digital governance and infrastructure.

2.2 Metaverse

The concept of the metaverse has its roots in science fiction, first coined in 1992 by the author Neal Stephenson in his novel "Snow Crash" (Stephenson, 1992). In this book, Neal Stephenson described a virtual world where users,

represented by avatars - digital representations of people's physical identities - could interact with each other in an immersive virtual environment. The last decades, the metaverse has evolved from a science fiction concept into a reality, due to the advancements in digital technologies like the IoT, Digital Twins, Augmented Reality (AR), Virtual Reality (VR), AI, and Blockchain (Lee et al., 2021). Various virtual spaces have already been developed, such as Second Life (https://secondlife.com/) and later Decentraland (https://decentraland.org/), both of which allow users to create, socialize, and trade within shared digital spaces.

With the ongoing technological developments, the metaverse possesses the ability to significantly change the way people work, socialize, learn and entertain themselves. Kontogianni and Anthopoulos (2024) are considering whether the metaverse can affect people's lives by generating value. They conclude that it offers several opportunities for economic, public, and social value generation. The metaverse holds economic value for both industry and consumers. Moreover, public benefits focus on citizen empowerment and improved government efficiency, while socially, the metaverse promotes employment growth and provides immersive experiences in areas like entertainment and education.

The metaverse can further benefit smart cities as it holds the potential for the overall transformation and maintenance of the smart city environment by seamlessly integrating the digital and physical worlds while keeping people at the centre of its operational framework. The smart city concept can be augmented through the implementation of an interconnected city's representation approach, endowing users and residents with the capacity to be actively involved in the strategic planning processes, generating new value for cities through the concept of increased public participation (ITU, 2023b), thus bonding the community. Yaqoob et al. (2023) emphasize the metaverse's transformative role in smart cities, detailing its key advantages for various smart city applications. One major benefit is enhanced teamwork and collaboration, as the metaverse enables real-time communication, skill development, and AI-led innovation across diverse disciplines. Additionally, training and testing processes, particularly in fields like medicine, can be improved through the use of extended reality (XR) technologies by providing realistic simulations. They also argue that the metaverse creates new business opportunities through virtual retail, and trading, expanding the digital economy within smart cities. Moreover, the use of digital twins further enables urban planning and infrastructure management by replicating real-world objects with real-time data. Social connections enabled in the metaverse strengthens human connections by overcoming geographical and accessibility challenges, offering immersive experiences for community building. Furthermore, the metaverse redefines entertainment experiences, through virtual events and metaverse tourism, making cultural and entertaining activities more accessible. Lastly, they highlight metaverse's contribution to environmental sustainability in smart cities by replacing physical transportation with virtual experiences, which can significantly lower energy use and carbon emissions.

2.3 CitiVerse

The term "CitiVerse" is a compound word derived from the combination of the terms "cities" and "metaverse". CitiVerse can be understood as the integration of the metaverse into real-world cities, facilitating the interaction between tangible and intangible entities of the physical world within a city's envisioned digital framework. Although the term CitiVerse has not yet been scientifically defined, the International Telecommunications Union (ITU) proposes that CitiVerse can be perceived as an *"interconnected and distributed hybrid and virtual worlds representing, and synchronized with, their physical city and community counterparts to offer new and improved capabilities to cities and communities"* (ITU, 2024). The concept of CitiVerse delineates a particular physical expanse, constrained by the geographical and/or administrative parameters of a physical city. According to Zhao et al. (2022), by applying metaverse in cities, it is feasible to provide functional services through simulation, prediction, and optimization while maintaining an accurate depiction of the physical components of the urban environment. Users can have a highly realistic experience of the city by immersing themselves in this virtual world, exploring the city, and interacting with its infrastructure and its simulated population.

The CitiVerse, as proposed by NCP Flanders (2023), has the potential to influence various urban sectors including energy, transportation, water supply, waste management, and education by leveraging technologies such as IoT, AI, Digital Twin, and Blockchain. It can enhance the interactivity and responsiveness of cities, and address the challenges presented by aging infrastructure and population growth, optimizing the utilization of existing resources. The integration of the CitiVerse concept will contribute towards the creation of urban spaces that promote interactivity and inclusivity which helps in social bonding.

Furthermore, Vanderhorst, Heesom, and Yenneti (2024) introduce the concept of a "Meta Smart Twin City" which integrates digital twins methodology, smart urban environments, and blockchain technology in order to create more sustainable, efficient, and intelligent urban environments. Digital twins -virtual replicas of physical entities- enable real-time monitoring and simulation. When applied to urban environments, they enable improved planning, management, and operational efficiency. The use of blockchain technology ensures secure and transparent data transactions, further enhancing the reliability of digital infrastructures. The authors also present a comprehensive framework for integrating these technologies into the physical world, emphasizing the use of IoT devices, reality capture tools, immersive technologies like VR and AR, and AI to optimize urban management. While these

innovations offer significant potential, the authors highlight the ethical, social, and technical challenges that must be addressed to ensure their long-term effectiveness.

Some cities have already announced their intention to develop their own CitiVerses, which will meet the needs of their citizens. One of them is the city of Seoul which has initiated the process of developing a CitiVerse, referred to as "Metaverse Seoul" (Seoul Metropolitan Government, 2023). Metaverse Seoul aims to provide urban services and improve current ones by acting as a virtual duplicate of the city. Within the Metaverse Seoul framework, there will be virtual administrative offices specializing in services regarding education, culture, and tourism, and simultaneously, users will be able to digitally simulate visits to diverse tourist landmarks such as Seoul City Hall, Seoul Plaza, Blue House, Gwanghwamun Square, and the Bukchon Hanok Village, among others. Apart from the city of Seoul, the "Dubai International Financial Centre Metaverse Platform" constitutes a part of the Dubai Metaverse Strategy, which was launched in July 2022, pursuant to the objective of furnishing an enriched customer experience to its inhabitants, notably within the spheres of tourism, education, public services, retail, and real estate (UAE Government, 2023).

2.4 Social Cohesion

The study of social cohesion began in the late 1800s and has been examined by many academic fields, including sociology, mental health, and public health (Fonseca et al., 2019). As Bruhn (2009) pointed out, social cohesion is a complicated social construct, given the diverse geographical locations, the political representatives, and the economic systems of human societies around the world. That is why we meet many definitions of this concept. Starting from 1897, Durkheim defines social cohesion as *"the characteristic of society that shows the interdependence in between individuals of that society"* (Durkheim, 1897) reaching to 2013 that Parsons (2013) views social cohesion as a degree of stability and order that is derived from common norms and values. As noted by Fonseca et al. (2019), social cohesion can be comprehensively understood by examining it across three different levels, each contributing to the complexity of the concept. These levels include the level of the Community, the level of the Individual, and the level of the Institutions, influencing each other. Cohesion emerges at the intersection of the three identified levels. The relationship between the three levels and the components of each level are addressed by the framework they created to describe social cohesion, based on the literature. The developed framework presents possible factors that are relevant to social cohesion per level, in an indicative manner. According to this framework, at the level of the Community, the main factors include the social environment, the relationships and the ties, and the performance and the common objectives of the community. At the level of the Individual, self-motivation, perceptions, norms and values, and participation and performance are indicated as primary factors, while at the level of the Institutions the mentioned factors are the conflict management and the decision making, the human rights, and the environment.

Furthermore, the purpose of Schiefer and van der Noll (2017) was to examine the literature on social cohesion to identify its core elements. They identified six key dimensions of social cohesion: social relations, identification, orientation towards the common good, shared values, equality/inequality, and subjective/objective quality of life. Proposing that (in)equality, quality of life, and shared values are better understood as outcomes of social cohesion rather than core components, they define social cohesion as *"a descriptive, multifaceted and gradual phenomenon attributed to a collective, indicating the quality of collective togetherness"*.

3. Methodology

The systematic literature review, as a research methodology, gives rise to the identification, evaluation, and interpretation of all relevant studies concerning a specific research question or concept. All studies considered in a systematic literature review are referred to as primary studies, whereas a systematic review is considered as secondary. Its importance lies in the fact that it synthesizes the existing study equitably (Kitchenham, 2004). This method was applied to identify the implications of the metaverse. Preliminary research in scientific repositories Google Scholar, Scopus, Science Direct, and Web of Science concerning the metaverse's implications was conducted to gather data on the metaverse's implications, with the numerical findings presented in Table 1.

Tab. 1 - Literature findings (August 2024).

Sources	Results
Scopus	7
ScienceDirect	9
Web of Science	3
Google Scholar	104

As the number of the studies reach 123, it was considered necessary to apply a systematic methodology to delimit the results. The methodology used, follows the guidelines mentioned by Kitchenham in her paper "Procedures for performing systematic reviews" (Kitchenham, 2004) which help to opt for quality studies. This approach was selected as it follows a standard protocol that develops in three phases, with the following particular stages (Figure 1):

Phase 1 – Planning the review: Includes the identification of the need for a review and the development of a review protocol.

Phase 2 – Conducting the review: Includes the implementation of the review protocol.

Phase 3 – Reporting the review: Includes the presentation of the results.

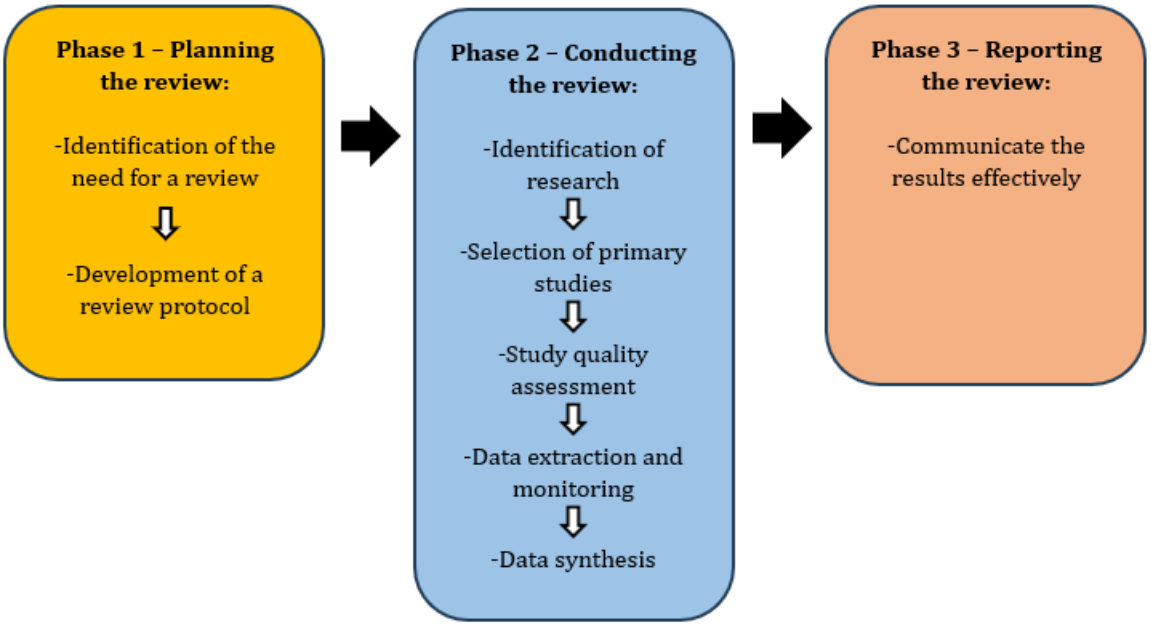


Fig. 1 - A systematic review into three main phases.

Phase 1. In the existing literature, numerous articles examine the implications of the metaverse. However, most of them focus on specific sectors, and there is a lack of studies that unify the overall findings on the metaverse. Hence, the need for a systematic review is deemed imperative. Furthermore, examining the implications of the metaverse will provide insights into its impact on cities and communities. In order to carry out the systematic literature review, a review protocol, which is described in Phase 2, was defined. The protocol includes elements such as the research questions, the search strategy for primary studies, the criteria for inclusion and exclusion of studies, the quality control criteria, and the data extraction strategy.

Phase 2. The research question that the review is intended to answer was defined. As the implications of the metaverse need to be studied, it is important to identify which sectors seem to be affected by the metaverse according to the findings so far. As such, the research question that emerges is "Which sectors are affected by the metaverse based on current findings?"

The search strategy included an automated search in digital libraries, which was conducted in August 2024. The selected digital resources included Google Scholar, Scopus, Science Direct, and Web of Science. The search term used was “metaverse implications” applied to the title, abstract, and keywords of the articles. Following, inclusion and exclusion criteria for primary studies were defined and applied, in order to evaluate the gathered articles and to determine which of them will be included. The inclusion and exclusion criteria used were as follows:

Inclusion criteria:

- Articles published in journals and conference proceedings.
- Articles discussing the metaverse’s implications.

Exclusion criteria:

- Articles referring to the metaverse in general, without reflecting any implications.
- Articles written in languages other than English.

Apart from the primary article selection criteria mentioned above, it is equally important to assess the quality of the final sample of studies in order to produce more detailed article selection criteria and to weigh the importance of the results of each study, which will be requisite subsequently in the synthesis of the results. The criteria for quality assessment in the review process included:

- the clarity and documentation of the terms, methods, and results cited in the article,
- the accessibility of the data used (i.e. providing organizations, DOI),
- the detailed description of the methodology followed, and
- the comprehensive presentation of the results.

The search conducted using the term "metaverse implications" initially returned 7 articles from Scopus, 9 from ScienceDirect, 3 from Web of Science, and 104 from Google Scholar (Table 1). The Inclusion criterion 1 resulted in a subset of 89 articles, 78 of which were journal articles and 11 were conference articles. After studying the remaining articles, 69 more were excluded based on the inclusion/exclusion and the quality assessment criteria. Consequently, the number of articles was limited to 20, comprising 6 articles from Scopus, 7 articles from Science Direct, 3 articles from Web of Science, and 4 articles from Google Scholar. Finally, after the removal of duplicate articles, the final sample consisted of 16 unique articles (Figure 2).

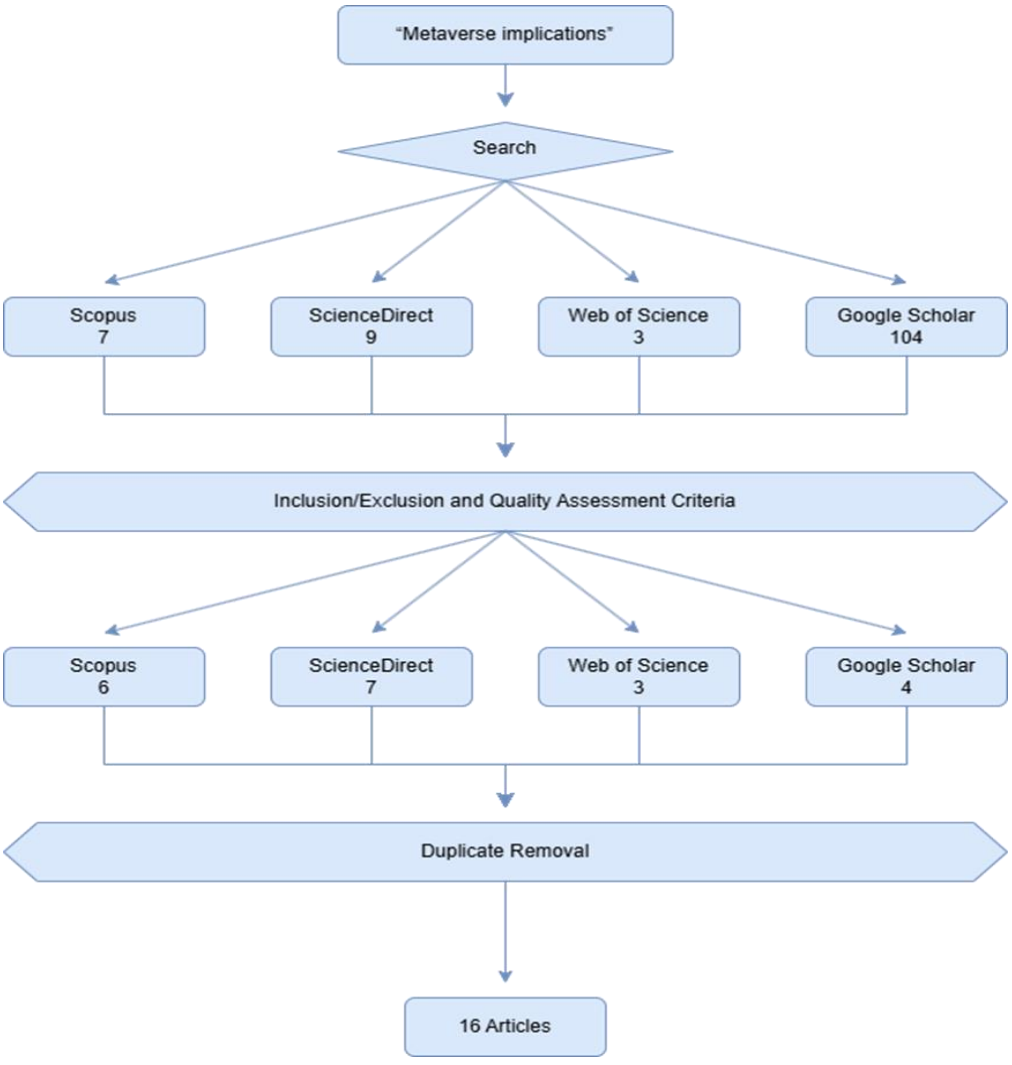


Fig. 2 - Selection process of the final sample of the review articles.

To complete the second phase, the final sample of 16 articles was studied in detail and analysed. Key insights regarding the implications of the metaverse were meticulously extracted from each article and subsequently organized according to the sector they addressed. Upon completing this initial categorization for every article, broader thematic categories were synthesized to enhance the clarity and coherence of the results' presentation. This structured approach ensured a comprehensive understanding of the metaverse's implications in different areas.

Phase 3. This phase involves the comprehensive presentation and critical evaluation of the findings from the systematic review. A coherent presentation, which facilitates an in-depth understanding of the main implications of the metaverse is presented in Section 4.

4. Systematic Review Results

This section describes the findings of the research and is organized in two subsections. Section 4.1 outlines the initial sample of articles, while section 4.2 provides a summary of the results from the analysed articles.

4.1 Quantitative Analysis

The number of studies examining the implications of the metaverse up to August 2024 are presented in Table 1. The search returned in total 123 articles, 7 from Scopus, 9 from ScienceDirect, 3 from Web of Science, and 104 from Google Scholar.

Furthermore, Figure 3 illustrates the distribution of different types of these publications. Journal articles constitute the majority, representing 63% of the total. Book chapters constitute 13% of the publications, while conference papers represent the smallest proportion at 9%. The remaining 15% (other) includes final theses, dissertations, call for papers, etc. Additionally, Figure 4 illustrates the number of publications for the search term "metaverse implications" per digital library. The majority of studies come from Google Scholar (85%), followed by ScienceDirect (7%), Scopus (6%), and Web of Science (2%).

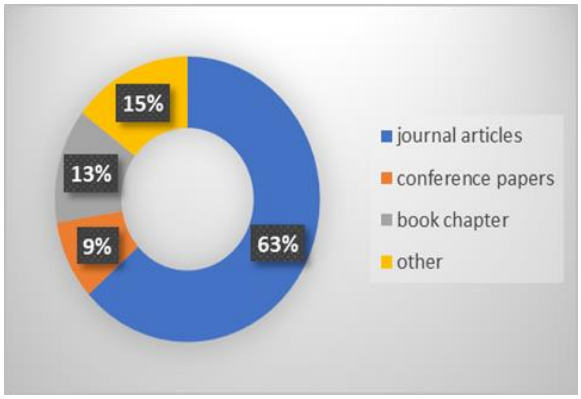


Fig. 3 - Types of publications.

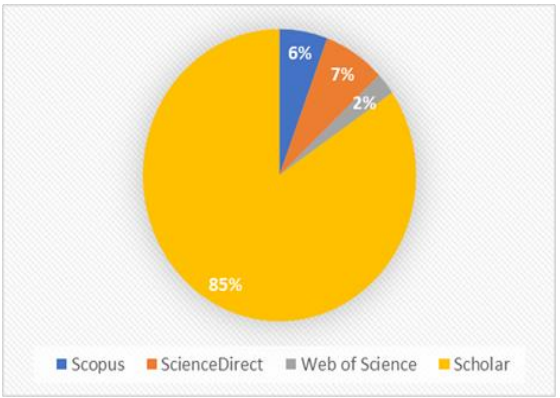


Fig. 4 - Number of publications for "Metaverse Implications" search term per digital library.

The initial study was published in 2020, the sole publication for this year. For 2021, the number of publications increased only to two. From 2022 onwards, there is an increase in the number of publications, with 14 publications recorded for that year, followed by a significant increase to 62 publications for 2023. By August 2024, 44 publications had been documented for that year (Figure 5).

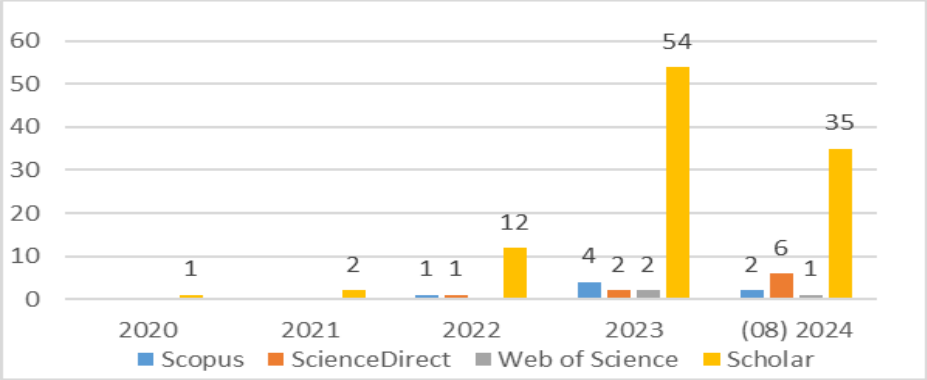


Fig. 5 - Number of publications per year and per digital library.

Figures 3, 4, and 5 present key statistical insights on the implications of the metaverse. Especially Figure 5 highlights the growing academic interest in the impact of metaverse, showing a notable rise in publications over time. This trend reflects an increasing focus on understanding the metaverse's role in digital transformation, indicating its emerging importance in shaping the digital future.

4.2 Qualitative Analysis

Using Kitchenham's methodology, the authors analysed a total of 16 articles from the original sample. Each article was systematically studied to identify all the implications of the metaverse discussed within. In response to the research question, the identified implications were categorized based on the sectors they pertain to. Subsequently, all identified implications were grouped by relevance into broader categories, encompassing all sectors referenced in the 16 articles examined.

Trying to provide a systematic analysis of the articles reviewed, the Table 2 was structured. The first column of this table introduces the broader categories that were defined, which serve as general themes that encompass the subcategories identified in the second column. In the third column, the associated references are listed.

The broader categories that were created are: Economic and Business Implications, Educational and Skill Development, Environmental and Sustainability Impacts, Healthcare and Well-being, Industry Implications, Security and Privacy Concerns, Social and Ethical Implications, and Technological and Innovation Impacts. The "Economic and Business Implications" category includes economic impacts (Metz & Gurău, 2023; Dwivedi et al., 2023; Dwivedi et al., 2022), business-oriented impacts (Schmitt, 2023; Jung et al., 2024; Lim et al., 2024; Dwivedi et al., 2022), marketing strategies (Bilgihan et al., 2024; Lim et al., 2024), and brand development (Bilgihan et al., 2024). The category of "Educational and Skill Development" covers the metaverse's potential in enhancing education and training (Salvetti, 2023; Jung et al., 2024; Pellegrino et al., 2023; Dwivedi et al., 2022; Pentangelo et al., 2024; Al-kfairy et al., 2024; Han et al., 2023), and opportunities for content creators (Bilgihan et al., 2024), while the "Environmental and Sustainability Impacts" category covers the environmental consequences (Pellegrino et al., 2023), urban ecosystem implications (Pellegrino et al., 2023), and sustainability issues (Pellegrino et al., 2023; Dwivedi et al., 2022). The "Healthcare and Well-being" category embraces the metaverse's role in healthcare (Jung et al., 2024; Al-kfairy et al., 2024), in mental health support (Din & Almogren, 2023), and overall well-being (Dwivedi et al., 2022; Din & Almogren, 2023). Furthermore, the "Industry Implications" category includes impacts on various sectors, such as the military (Metz & Gurău, 2023), hospitality (Jung et al., 2024; Dwivedi et al., 2022), retail (Dwivedi et al., 2022), tourism (Jung et al., 2024; Dwivedi et al., 2022; Din & Almogren, 2023; Suanpang et al., 2022; Baker et al., 2023), and the fashion industry (Donvito et al., 2024). The "Security and Privacy Concerns" category consists of issues like data protection (Jung et al., 2024), privacy (Bilgihan et al., 2024; Dwivedi et al., 2022; Al-kfairy et al., 2024), security ((Metz & Gurău, 2023; Dwivedi et al., 2023; Schmitt, 2023; Jung et al., 2024; Dwivedi et al., 2022), misinformation (Dwivedi et al., 2023), and legal challenges (Metz & Gurău, 2023; Dwivedi et al., 2023). The "Social and Ethical Implications" category involves social and political attitudes (Dwivedi et al., 2023; Schmitt, 2023; Pellegrino et al., 2023; Lim et al., 2024; Dwivedi et al., 2022; Al-kfairy et al., 2024; Din & Almogren, 2023), ethical considerations (Dwivedi et al., 2023; Schmitt, 2023; Bilgihan et al., 2024; Pellegrino et al., 2023; Lim et al., 2024; Al-kfairy et al., 2024), and the impact on users (Al-kfairy et al., 2024), on consumers (Bilgihan et al., 2024; Lim et al., 2024; Dwivedi et al., 2022), and on vulnerable populations (Dwivedi et al., 2023; Din & Almogren, 2023). Lastly, the "Technological and Innovation Impacts" category incorporates technological advancements (Bilgihan et al., 2024; Dwivedi et al., 2022), and innovation (Lim et al., 2024; Dwivedi et al., 2022). These categories provide a structured framework for a comprehensive exploration of the areas affected by the application of the metaverse, as discussed in the articles studied.

Tab. 2 - Implications and Broader Categories.

Broader Categories	Implications' Sectors	Associated References
Economic and Business Implications	• Brand development • Business Implications • Economic Implications • Economic and Financial Crimes • Marketing • Marketing Strategies	• (Al-kfairy et al., 2024) • (Bilgihan et al., 2024) • (Dwivedi et al., 2022) • (Dwivedi et al., 2023) • (Jung et al., 2024) • (Lim et al., 2024) • (Metz & Gurău, 2023) • (Schmitt, 2023)
Educational and Skill Development	• Content creators • Education • Educational and Skill Development • Educational and Training Advantages	• (Al-kfairy et al., 2024) • (Bilgihan et al., 2024) • (Dwivedi et al., 2022) • (Han et al., 2023) • (Jung et al., 2024) • (Pellegrino et al., 2023) • (Pentangelo et al., 2024) • (Salvetti, 2023) • (Schmitt, 2023)
Environmental and Sustainability Impacts	• Environmental Impact • Implications for urban ecosystems • Sustainable marketing • Sustainability	• (Al-kfairy et al., 2024) • (Dwivedi et al., 2022) • (Pellegrino et al., 2023) • (Schmitt, 2023)
Healthcare and Well-being	• Health • Healthcare • Mental Health • Well-Being	• (Al-kfairy et al., 2024) • (Din & Almogren, 2023) • (Dwivedi et al., 2022) • (Dwivedi et al., 2023) • (Jung et al., 2024) • (Schmitt, 2023)
Industry Implications	• Fashion industry • Industries • Military Implications • Retailing • Tourism • Tourism and Hospitality	• (Baker et al., 2023) • (Din & Almogren, 2023) • (Donvito et al., 2024) • (Dwivedi et al., 2022) • (Jung et al., 2024) • (Metz & Gurău, 2023) • (Suanpang et al., 2022) • (Schmitt, 2023)
Security and Privacy Concerns	• Data Privacy • Law Enforcement and	• (Al-kfairy et al., 2024)

	Governance • Legal Issues • Manipulation and Misinformation • Privacy • Safety • Security • Terrorism	• (Bilgihan et al., 2024) • (Dwivedi et al., 2022) • (Dwivedi et al., 2023) • (Jung et al., 2024) • (Metz & Gurău, 2023) • (Lim et al., 2024) • (Schmitt, 2023)
Social and Ethical Implications	• Consumers (Behavior/ Experience) • Ethical Considerations • Political Implications • Social Impact • Social Interactions • Societal - Behavioral • Societal Norms • User Behavior/Experience • Vulnerable Populations	• (Al-kfairy et al., 2024) • (Bilgihan et al., 2024) • (Din & Almogren, 2023) • (Dwivedi et al., 2022) • (Dwivedi et al., 2023) • (Lim et al., 2024) • (Pellegrino et al., 2023) • (Schmitt, 2023)
Technological and Innovation Impacts	• Business Innovation • Innovation • Technological Investments	• (Bilgihan et al., 2024) • (Dwivedi et al., 2022) • (Lim et al., 2024) • (Schmitt, 2023)

The analysis highlights the impact of the metaverse on key sectors such as business, security, education, society, technology, environment, healthcare, and various industries. Moreover, it underlines the metaverse's transformative potential to reshape economies, redefine social interactions, drive technological innovation, and create new opportunities while also presenting challenges that should be addressed.

5. Discussion: Metaverse and Social Cohesion

The systematic literature review first highlighted the quantity and types of studies examining the implications of the metaverse. Subsequently, this article pointed out the areas affected by the metaverse as indicated in the analysed articles. Further delving into these areas and examining them more closely reveals that the metaverse can significantly promote social cohesion within the smart city context.

Primarily, the metaverse can transform education by creating virtual environments that foster inclusivity, accessibility, and collaboration. By bridging physical and cultural gaps, the metaverse allows students from different socio-economic and geographical backgrounds to interact and collaborate, reducing barriers to education and communication (Pentangelo et al., 2024). Students from developed or developing regions, with many or few resources for education, can participate equally in these learning environments, bridging therefore educational inequalities. Moreover, the immersive nature of metaverse technologies enables students to engage in social interactions that resemble real-world experiences, fostering a sense of community and belonging (Lim et al., 2024). Immersive technologies (like VR and AR) offer new ways to engage students and improve learning outcomes (Al-kfairy et al., 2024). The metaverse facilitates personalized learning experiences, enhances communication and collaboration, and introduces new ways of teaching and learning, by enabling students to not only hear about concepts but to immerse themselves in the learning experiences (Pellegrino et al., 2023). Additionally, the integration of AI, Blockchain, and immersive tools within educational environments ensures security, and transparency for all users, further enhancing social integration (Han et al., 2023). This inclusiveness promotes social cohesion by creating equal opportunities for education and by promoting interaction and collaboration among students. Such educational and collaborative environments can help bridge divides and build cohesive, well-integrated communities that value diversity and mutual support.

Furthermore, healthcare can become a medium for promoting social connections and mental health. In a metaverse environment, healthcare can extend beyond traditional medical treatment. Virtual healthcare environments offer personalized healthcare services for vulnerable groups such as the elderly and people with disabilities, reducing social isolation and promoting a sense of community engagement (Din & Almogren, 2023). The integration of technologies like XR can enhance patient care, revolutionize surgical practices, and elevate the education and training of medical professionals. By combining XR with traditional treatments, such as those for post-traumatic stress disorder, anxiety and fear conditions, and pain management, the metaverse can offer an individualized, cost-effective alternative to conventional treatments (Jung et al., 2024). Additionally, by creating supportive spaces where patients can communicate with healthcare professionals, the metaverse can reduce waiting times, relieve pressure on healthcare systems, and create safe, anonymous environments where patients can comfortably share their concerns (Jung et al., 2024). Thus, the metaverse can contribute to mental wellbeing, a key component for building connected urban communities. However, challenges such as data privacy and potential addiction to such virtual environments may arise from the use of metaverse (Jung et al., 2024).

In addition, virtual marketplaces, created by the metaverse, can provide equal access to economic opportunities by connecting people across several economic layers (Dwivedi et al., 2022). By facilitating global transactions and offering new models of remote work, the metaverse can integrate emerging and frontier economies into the broader digital economy, fostering economic inclusion (Schmitt, 2023). Moreover, the metaverse's capabilities for global collaboration and virtual workspaces enhance productivity and connect people globally. By creating a global network, geographical barriers are broken down and a sense of common purpose and inclusivity among the various participants is promoted (Schmitt, 2023). This inclusivity not only promotes economic growth but also promotes social cohesion by ensuring that no community is left behind. Similarly, the integration of metaverse technologies in smart cities can enhance these benefits by enabling digital infrastructure, promoting economic growth and improving urban quality of life. As smart cities utilize advanced technologies such as IoT and AI to optimise urban services, the metaverse can also help by offering immersive platforms for collaboration, virtual commerce and innovative urban planning.

Along with these, the metaverse's immersive nature can redefine social interactions and enhance a sense of belonging. Virtual spaces provide opportunities for individuals to engage with others, which can reduce loneliness and promote cultural exchanges (Din & Almogren, 2023). Additionally, the metaverse supports the hosting of events and social activities that reinforce common values and mutual trust. Especially in the context of smart cities, which prioritize the integration of technology and sustainability, the metaverse can promote the development of interactive spaces where citizens can participate in a variety of activities. As a result, the integration of metaverse in smart cities can strengthen social bonds and community networks, promoting citizens' interactions and engagement. However, challenges such as the potential for unethical behaviour must be addressed through robust governance and ethical guidelines (Dwivedi et al., 2022; Al-kfairy et al., 2024).

Additionally, as sustainability aligns seamlessly with the principles of smart cities, the metaverse can contribute in several ways to this effort. By promoting virtual tourism, the metaverse holds the potential to reduce the environmental impact of physical travel, and thereby fostering a sense of shared responsibility among citizens (Suanpang et al., 2022). Other than virtual tourism, the metaverse can also reduce the need for physical mobility by facilitating activities such as work, education, and entertainment in virtual spaces. By creating shared virtual environments within smart cities, citizens can collaborate, learn, and engage in several activities, fostering a sense of community and inclusivity with less environmental impact. Moreover, the metaverse can positively impact urban ecosystems involving citizens in city planning and decision-making. Citizen participation ensures that urban development serves all groups of citizens equally. Such initiatives in smart cities can support social cohesion by promoting transparency, participation and inclusiveness while utilizing advanced digital technologies.

While the potential benefits are promising, the role of the metaverse in promoting social cohesion requires addressing significant challenges. These include ensuring digital equality to prevent the exclusion of less privileged groups, implementing effective governance to address issues such as cyberbullying, hate speech and unethical behaviour, and protecting privacy (Dwivedi et al., 2023; Dwivedi et al., 2022).

In conclusion, in the smart city context, the metaverse can be a catalyst for strengthening social cohesion, by bringing people together regardless of physical, cultural, and economic differences. It offers innovation in education, new ways of communication, new models for healthcare, and opportunities for economic growth, promoting inclusivity and social well-being. However, to fully realize these benefits, it is necessary to implement safeguards that promote ethical use, protect privacy and ensure equal access for all. Careful integration of the metaverse in the context of smart cities can, thus, pave the way for more cohesive, inclusive and connected communities.

6. Conclusions

This article attempted to highlight the role of the metaverse in promoting social cohesion, especially in the smart

city context. As the metaverse is increasingly becoming a part of people's lives, it is of high interest to explore its impact on both individuals and communities.

In this paper a systematic literature review was conducted to explore the existing literature on the metaverse's implications on people. The outcomes were utilized to identify how social cohesion, especially within cities and communities is associated with them.

The review has extracted some useful findings: the metaverse can offer significant opportunities to promote social cohesion, in particular in the context of smart cities. By improving education, expanding access to healthcare, promoting economic participation and facilitating social interaction, the metaverse can create more connected and inclusive communities. As a result, people from all social backgrounds can participate, collaborate and thrive together. In an era when cities are digitally transformed, the metaverse has the potential to bring community members closer together by enhancing social interactions and connections, encouraging civic engagement and participation, and developing a sense of social belonging – all essential components of social cohesion. However, challenges such as the digital divide, security and privacy concerns and ethical behaviour in virtual spaces need to be addressed. Effective governance, strong regulatory frameworks and collaborative efforts need to be put in place to ensure accessibility and inclusiveness of the metaverse.

From a broader perspective, the metaverse presents both promising opportunities and considerable challenges. On the one hand, it has the potential to transform the urban experience by creating immersive, accessible, and innovative spaces for education, economic growth, social interactions, and civic participation. It can serve as a tool for reducing physical barriers, enabling global connectivity, and enriching smart city experiences. On the other hand, digital exclusion, data privacy, and governance remain key issues. The rapid expansion of virtual spaces raises questions concerning equitable access, the potential for aggravating socioeconomic disparities, and the ethical considerations of digital interaction replacing real-world social relationships. Despite these challenges, the metaverse has enormous potential to promote social cohesion in smart cities. By balancing technological innovation with ethical governance and inclusive policies, smart cities can leverage the metaverse to create more inclusive, equitable and resilient urban environments.

These findings contribute to the growing discussion on digital urbanism, and the evolution of smart cities, highlighting the metaverse as a critical contributor. In addition, these insights offer guidance to policy makers, urban planners and technology developers to design metaverse-driven solutions that promote social cohesion in communities. Priority needs to be given to strategies to mitigate digital exclusion, ensure ethical use of metaverse technologies, and promote equal participation.

While this study provides valuable insights, it is subject to certain limitations. A limitation of this research is the relatively small number of articles analysed, as only a small subset met the applied inclusion criteria. Furthermore, the evolving nature of metaverse technologies, driven by continuous advancements in AI, VR, and blockchain, makes long-term predictions challenging.

Some future thoughts concern the analysis of the implications of the metaverse by sector in order to develop a more detailed framework of its impact on both people and society. Moreover, future research should explore long-term social effects of metaverse-based urban planning, incorporating qualitative approaches to understand users' experiences and perceptions. As we move forward, continued research and collaborative efforts will be essential to navigate this evolving digital landscape, ensuring that the metaverse becomes a key for strengthening the society as a whole. By addressing these research directions, future studies can contribute to a more comprehensive understanding of the role of the metaverse in promoting social cohesion within smart cities.

Acknowledgement

- **Contributor Statement**: Conceptualization, Leonidas Anthopoulos; Data curation, Elli Kontogianni; Formal analysis, Elli Kontogianni and Leonidas Anthopoulos; Investigation, Elli Kontogianni and Leonidas Anthopoulos; Methodology, Elli Kontogianni and Leonidas Anthopoulos; Project administration, Leonidas Anthopoulos; Resources, Elli Kontogianni and Leonidas Anthopoulos; Software, Leonidas Anthopoulos; Supervision, Leonidas Anthopoulos; Validation, Elli Kontogianni and Leonidas Anthopoulos; Visualization, Elli Kontogianni; Writing—original draft, Elli Kontogianni; Writing—review & editing, Elli Kontogianni and Leonidas Anthopoulos. All authors have read and agreed to the published version of the manuscript.
- **Use of AI:** No AI tool was used.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Al-kfairy, M., Alomari, A., Al-Bashayreh, M., Alfandi, O., & Tubishat, M. (2024). Unveiling the Metaverse: A survey of user perceptions and the impact of usability, social influence and interoperability. *Heliyon, 10*(10), e31413. https://doi.org/10.1016/j.heliyon.2024.e31413

Anthopoulos, L. (2017). *Understanding smart cities: A tool for smart government or an industrial trick?* Springer: New York.

Appio, F. P., Lima, M., & Paroutis, S. (2019). Understanding smart cities: Innovation ecosystems, technological advancements, and societal challenges. *Technological Forecasting and Social Change, 142*, 1–14. https://doi.org/10.1016/j.techfore.2018.12.018

Baker, J., Nam, K., & Dutt, C. S. (2023). A user experience perspective on heritage tourism in the metaverse: Empirical evidence and design dilemmas for VR. *Information Technology & Tourism, 25*, 265–306. https://doi.org/10.1007/s40558-023-00256-x

Barrutia, J. M., Echebarria, C., Aguado-Moralejo, I., Apaolaza-Ibáñez, V., & Hartmann, P. (2022). Leading smart city projects: Government dynamic capabilities and public value creation. *Technological Forecasting and Social Change, 179*, 121679. https://doi.org/10.1016/j.techfore.2022.121679

Bibri, S. E., Allam, Z., & Krogstie, J. (2022). The Metaverse as a virtual form of data-driven smart urbanism: Platformization and its underlying processes, institutional dimensions, and disruptive impacts. *Computational Urban Science, 2*(1), 24. https://doi.org/10.1007/s43762-022-00051-0

Bilgihan, A., Leong, A. M. W., Okumus, F., & Bai, J. (2024). Proposing a metaverse engagement model for brand development. *Journal of Retailing and Consumer Services, 78*, 103781. https://doi.org/10.1016/j.jretconser.2024.103781

Bruhn, J. (2009). The concept of social cohesion. In *The Group Effect* (pp. 31–48). Arizona: Springer.

Camboim, G. F., Zawislak, P. A., & Pufal, N. A. (2019). Driving elements to make cities smarter: Evidences from European projects. *Technological Forecasting and Social Change, 142*, 154–167. https://doi.org/10.1016/j.techfore.2018.09.014

Cosgrave, E., Tryfonas, T., & Crick, T. (2014). The smart city from a public value perspective. In *Proceedings of the 2014 Conference ICT for Sustainability* (pp. 369–377). https://doi.org/10.2991/ict4s-14.2014.45

Council of Europe. (2005). *Concerted development of social cohesion indicators: Methodological guide*. Strasbourg: Council of Europe Publishing.

Díaz-Díaz, R., Muñoz, L., & Pérez-González, D. (2017). Business model analysis of public services operating in the smart city ecosystem: The case of SmartSantander. *Future Generation Computer Systems, 76*, 198–214. https://doi.org/10.1016/j.future.2017.01.032

Din, I. U., & Almogren, A. (2023). Exploring the psychological effects of Metaverse on mental health and well-being. *Information Technology & Tourism, 25*, 367–389. https://doi.org/10.1007/s40558-023-00259-8

Donvito, R., Acuti, D., & Song, S. (2024). Fashion and the metaverse: Implications for consumers and firms. *Journal of Global Fashion Marketing, 15*(1), 1–5. https://doi.org/10.1080/20932685.2023.2293290

Durkheim, E. (1897). *Le suicide: étude de sociologie*. New York, NY: F. Alcan

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M. K., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D. P., Gustafsson, A., Hinsch, C., Jebabli, I., Janssen, M., Kim, Y.-G., Kim, J., Koos, S., Kreps, D., Kshetri, N., Kumar, V., Ooi, K.-B., Papagiannidis, S., Pappas, I. O., Polyviou, A., Park, S.-M., Pandey, N., Queiroz, M. M., Raman, R., Rauschnabel, P. A., Shirish, A., Sigala, M., Spanaki, K., Tan, G. W.-H., Tiwari, M. K., Viglia, G., & Fosso Wamba, S. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management, 66*, 102542. https://doi.org/10.1016/j.ijinfomgt.2022.102542

Dwivedi, Y. K., Kshetri, N., Hughes, L., Rana, N. P., Baabdullah, A. M., Kar, A. K., Koohang, A., Ribeiro-Navarrete, S., Belei, N., Balakrishnan, J., Basu, S., Behl, A., Davies, G. H., Dutot, V., Dwivedi, R., Evans, L., Felix, R., Foster-Fletcher, R., Giannakis, M., ... Yan, M. (2023). Exploring the darkverse: A multi-perspective analysis of the negative societal impacts of the metaverse. *Information Systems Frontiers, 25*(6), 2071–2114. https://doi.org/10.1007/s10796-023-10400-x

Fonseca, X., Lukosch, S., & Brazier, F. (2019). Social cohesion revisited: A new definition and how to characterize it. *Innovation: The European Journal of Social Science Research, 32*(2), 231–253. https://doi.org/10.1080/13511610.2018.1497480

Grossi, G., & Trunova, O. (2021). Are UN SDGs useful for capturing multiple values of smart city? *Cities, 114*, 103193. https://doi.org/10.1016/j.cities.2021.103193

Han, Z., Tu, Y., & Huang, C. (2023). A framework for constructing a technology-enhanced education metaverse: Learner engagement with human-machine collaboration. *IEEE Transactions on Learning Technologies, 16*(6), 1179–1189. https://doi.org/10.1109/TLT.2023.3257511

International Telecommunication Union (ITU). (2023). *Definition of metaverse*. ITU Focus Group on Metaverse Technical Specification FGMV-20. Retrieved, Jan. 14, 2025 from https://www.itu.int/pub/T-FG-MV-2023-20

International Telecommunication Union (ITU). (2023b). *Building a people-centred CitiVerse*. ITU Focus Group on Metaverse Technical Report. Retrieved, Jan. 14, 2025 from https://www.itu.int/pub/T-FG-MV-2024-35

International Telecommunication Union (ITU). (2024). *Definitions of CitiVerse*. ITU Focus Group on Metaverse Technical Report. Retrieved, Jan. 14, 2025 from https://www.itu.int/pub/T-FG-MV-2023-20

Jung, T., Cho, J., Han, D.-I. D., Ahn, S. J. (G.), Gupta, M., Das, G., Heo, C. Y., Loureiro, S. M. C., Sigala, M., Trunfio, M., Taylor, A., & tom Dieck, M. C. (2024). Metaverse for service industries: Future applications, opportunities, challenges and research directions. *Computers in Human Behavior, 151*, 108039. https://doi.org/10.1016/j.chb.2023.108039

Kitchenham, B. (2004). Procedures for performing systematic reviews. Keele, UK: Keele University.

Kontogianni, E., & Anthopoulos, L. (2024). Preliminary research results on exploring the business ecosystem and the value sources of metaverse. *Sustainability, 16*, 3134. https://doi.org/10.3390/su16083134

Lee, L.-H., Braud, T., Zhou, P., Wang, L., Xu, D., Lin, Z., Kumar, A., Bermejo, C., & Hui, P. (2021). All one needs to know about metaverse: A complete survey on technological singularity, virtual ecosystem, and research agenda. Retrieved from https://doi.org/10.48550/arXiv.2110.05352

Lim, W. M., Kumar, S., & Donthu, N. (2024). How to combine and clean bibliometric data and use bibliometric tools synergistically: Guidelines using metaverse research. *Journal of Business Research, 182*, 114760. https://doi.org/10.1016/j.jbusres.2024.114760

Metz, D., & Gurău, M.-M. (2023). Emerging and disruptive technologies: The Metaverse. Implications on global security. *Land Forces Academy Review, 27*(4), 411–422. https://doi.org/10.2478/raft-2022-0050

NCP Flanders. (2023). Info day on developing Citiverse. Retrieved September 10, 2023, from https://ncpflanders.be/activities/info-day-on-developing-citiverse

Parsons, T. (2013). *Social System*. London: Routledge.

Pellegrino, A., Wang, R., & Stasi, A. (2023). Exploring the intersection of sustainable consumption and the Metaverse: A review of current literature and future research directions. *Heliyon, 9*(9), e19190. https://doi.org/10.1016/j.heliyon.2023.e19190

Pentangelo, V., Di Dario, D., Lambiase, S., Ferrucci, F., Gravino, C., & Palomba, F. (2024). SENEM: A software engineering-enabled educational metaverse. *Information and Software Technology, 174*, 107512. https://doi.org/10.1016/j.infsof.2024.107512

Salvetti, F., Gardner, R., Rudolph, J., Minehart, R., Bertagni, B., & Contardo, I. (2023). Extended reality and medical simulation: Cooperation into the Metaverse to boost diversity and inclusion. In Guralnick, D., Auer, M. E., & Poce, A. (Eds.), *Creative approaches to technology-enhanced learning for the workplace and higher education* (pp. 451–462). Lecture Notes in Networks and Systems (Vol. 767). Cham: Springer. https://doi.org/10.1007/978-3-031-41637-8_37

Schiefer, D., & van der Noll, J. (2017). The essentials of social cohesion: A literature review. *Social Indicators Research*, *132*, 579–603. https://doi.org/10.1007/s11205-016-1314-5

Schmitt, M. (2023). Metaverse: Implications for business, politics, and society. Available at SSRN: https://ssrn.com/abstract=4168458 or http://dx.doi.org/10.2139/ssrn.4168458

Seoul Metropolitan Government. (2023, January 25). *Official release of Metaverse Seoul*. The Official Website of the Seoul Metropolitan Government. Retrieved September 20, 2023, from https://english.seoul.go.kr/official-release-of-metaverse-seoul/

Stephenson, N. (1992). *Snow Crash*. London, UK: ROC.

Suanpang, P., Niamsorn, C., Pothipassa, P., Chunhapataragul, T., Netwong, T., & Jermsittiparsert, K. (2022). Extensible Metaverse implication for a smart tourism city. *Sustainability*, *14*, 14027. https://doi.org/10.3390/su142114027

UAE Government. (2023, November 7). *Dubai Metaverse Strategy*. The Official Portal of the UAE Government. Retrieved December 3, 2023, from https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/government-services-and-digital-transformation/dubai-metaverse-strategy

Vanderhorst, H., Heesom, D., & Yenneti, K. (2024). Technological advancements and the vision of a meta smart twin city. *Technology in Society*, *79*, 102731. https://doi.org/10.1016/j.techsoc.2024.102731

Yaqoob, I., Salah, K., Jayaraman, R., & Omar, M. (2023). Metaverse applications in smart cities: Enabling technologies, opportunities, challenges, and future directions. *Internet of Things*, *23*, 100884. https://doi.org/10.1016/j.iot.2023.100884

Zhao, Y., Jiang, J., Chen, Y., Liu, R., Yang, Y., Xue, X., & Chen, S. (2022). Metaverse: Perspectives from graphics, interactions and visualization. *Visual Informatics*, *6*(1), 56–67. https://doi.org/10.1016/j.visinf.2022.03.002

Context-sensitive measurement: Addressing the local context in smart city assessment

Manuella Maia Ribeiro [a*], *Erico Przeybilovicz* [b], *Delfina Soares* [c]

[a] Regional Center for Studies on the Development of the Information Society (Cetic.br), Brazilian Network Information Center (NIC.br), São Paulo, Brazil, manuella@nic.br, https://orcid.org/0000-0002-5420-1348

[b] Center for Technology in Government, University at Albany – State University of New York (CTG UAlbany), Albany, United States, eprzeybilovicz@albany.edu, https://orcid.org/0000-0002-1363-0306

[c] United Nations University Operating Unit on Policy-Driven Electronic Governance (UNU-EGOV), Guimarães, Portugal, soares@unu.edu, https://orcid.org/0000-0002-2835-4789

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Various organizations and researchers have developed Smart Cities Measurements (SCM) to monitor the advance of Smart Cities (SC) initiatives worldwide, yet there is no consensus about their impact on local governments. Local managers implement SC and SCM projects differently depending on their contexts, but few studies have analysed these measurement initiatives from local governments' perspective. To address this gap, this paper aims to identify how municipalities use SCM and adopt indicators according to local context. Data were collected by in-depth semi-structured interviews with representatives from seventeen Brazilian cities, including different regions and population sizes. The results describe how local governments adopt measurement frameworks, expanding the literature on SCM.

Keywords. Smart cities, Measurement, Context-sensitive indicators.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.984

1. Introduction

Smart Cities (SC) initiatives aim to improve people's quality of life by adopting multidimensional strategies and using digital technologies to mitigate various complex urban challenges. In this context, Smart City Measurements (SCM) have been developed to monitor and assess the implementation of such projects. The literature shows the importance of measurement in verifying the advance and progress of SC initiatives (Caird et al., 2016; Fachinelli et al., 2023; Hajek et al., 2022). Besides the ultimate goal of improving the quality of life in cities (Sharifi, 2019), being smarter can attract resources, such as investments and talent (Hajek et al., 2022). Other benefits were listed by Huovila et al. (2019), which include easy language to show the development of SC, transparency for citizens about the benefits provided by SC, and support for government decisions.

However, most SCM frameworks are designed to cover many cities, leading to the lack of context-specific indicators that allow to capture the complexity of SC initiatives (Backhouse, 2020). While SCM aim to measure progress, facilitate comparisons, and guide decision-making for local and national governments, they often fail to account for the diverse contexts, priorities, and challenges of individual cities, imposing universal models instead (Backhouse & Dhaou, 2020; Skargren, 2020). Universal measurements can also pose difficulties in understanding the local context, particularly in countries where the diversity of cities' conditions can lead to different needs and issues. In addition, local governments can also adopt different SC perspectives and dimensions. This variety of frameworks is also true for adopting SCM (Albino et al., 2015).

Besides the lack of context-sensitive indicators in measurement frameworks, an additional gap is the need to understand the use of SCM by local governments, particularly in different contexts (Albino et al., 2015; Hajek et al., 2022). Despite the increasing number of papers focusing on defining SCM (Hajek et al., 2022; Huovila et al., 2019; Sharifi, 2019, 2020), just a few studies analyze smart city indicators from the perspective of local governments and local managers (Caird et al., 2016), showing the need for more studies regarding the usefulness of SCM for cities (Sharifi, 2020).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This paper takes a unique approach by focusing on how local governments adopt and use SCM in their smart city initiatives, which leads to developing an understanding of context-sensitive measurement frameworks. To achieve this objective, data were collected by in-depth semi-structured interviews with representatives from seventeen cities in Brazil, including different regions and population sizes. The respondents were top-level managers involved or in charge of measuring indicators related to SC projects. Brazil was chosen because of the complexity and diversity of conditions among more than 5,500 municipalities, providing a fruitful environment to analyse the inclusion of SCM in monitoring SC initiatives.

The theoretical contribution relies on context-sensitive frameworks for local governments and enhances discussions on SCM and SC (Albino et al., 2015; Hajek et al., 2022; Huovila et al., 2019; Sharifi, 2019, 2020). External indicators can help local governments monitor SC projects, especially with limited resources. However, literature suggests that local managers should critically adopt SCM based on their specific contexts, choosing relevant indicators (Sharifi, 2019). Additionally, this paper can provide insights for local governments and policymakers on effectively utilizing SCM frameworks and selecting appropriate indicators for their SC initiatives.

2. Context-sensitive measurement of Smart Cities

The concept of SC focuses on improving urban quality of life through multidimensional strategies and technologies addressing challenges in areas like the environment, mobility, and housing (Albino et al., 2015; Cunha et al., 2016; Nam & Pardo, 2011). However, the lack of consensus on SC dimensions affects the creation of monitoring frameworks and indicators (Hajek et al., 2022; Sharifi, 2019, 2020).The diversity of concepts has led to multiple interpretations and numerous methods and frameworks to measure and monitor SC (Metwally et al., 2023). In this context, SCM has gained interest among SC scholars and practitioners, with different measurement approaches emerging globally (Sharifi, 2020).

SCM frameworks commonly focus on developing indicators, metrics, or standards for SC, including assessment tools, indexes and rankings (Hajek et al., 2022). Literature has been analysing the existing SCM or defining the best indicators and measurements (Sharifi, 2019), such as Bosch et al. (2017) and Huovila et al. (2019) studies. In addition, there is an increasing recognition of the need for context-specific approaches to SC initiatives, given the diverse cultural, social, political, and technological environments of cities (Albino et al., 2015; Alcaide Muñoz & Rodríguez Bolívar, 2021; Esposito et al., 2021). In this sense, Lopes (2017) and Tomor et al. (2019) emphasize how these contextual factors significantly affect SC governance.

De Oliveira et al. (2024) found that the variety of measurement frameworks reflect these contextual influences and highlight the inadequacy of a single definition for SC. Previous studies also advocate for tailored measurement approaches rather than a universal framework (Angelidou, 2014; Albino et al., 2015; Hajek et al., 2022). However, most SCM initiatives did not consider the local contextual conditions (Backhouse, 2020; Ependi et al., 2022; Patrão et al., 2020; Sharifi, 2019). Backhouse and Dhaou (2020) also highlighted that SCM frameworks reflect the priorities and concerns of their creators (whether individual researchers or organizations) and not necessarily the city's needs, and rarely reflect the nuances of the local context, making complex for cities to adopt them considering their needs and challenges (Backhouse & Dhaou, 2020; Backhouse, 2020; Giffinger et al., 2007; Patrão et al., 2020). In this sense, it is fundamental that cities understand possible applications of measurement frameworks in their realities, including adopted dimensions, purposes of measurement, and how the indicators' results impact their goals (Backhouse, 2020).

One way to guarantee the local context is to include context-sensitive indicators aligned with local goals, enabling governments to tailor their actions based on specific needs (Backhouse, 2020; Sharifi, 2019, 2020). However, there is no consensus on defining these indicators. Although many studies have highlighted the importance of context and specific conditions, they do not specify the meaning of context sensitivity or factors that contribute to contextualizing SC indicators (Fernandez-Anez et al., 2020; Hajek et al., 2022; Huovila et al., 2019; Patrão et al., 2020). An exception is Lai and Cole (2023), who argue SCM should measure and compare cities in equal conditions based on a given parameter, such as population size. They also highlighted the importance of weighting for a fair assessment, evaluating cities in a common basis characteristic. For instance, a context-sensitive measure might assign a higher weight to environmental sustainability in a city with a high pollution level. In contrast, measurements might prioritize public safety initiatives in a city with a high crime rate (Lai & Cole, 2023).

To identify the characteristics of context-sensitive frameworks, we conducted a literature review about SC and context-sensitive indicators. Our findings, summarized in Table 1, identify three macro dimensions and their characteristics associated with context-sensitive SCM. First, most authors emphasizes the importance of indicators related to local conditions, including economic, geographic, territorial, and social characteristics. The second dimension focuses on local needs, highlighting areas for local government actions to enhance quality of life, participation and collaboration with local stakeholders. The last dimension incorporates flexible methodologies, proposing different strategies to ensure proper comparability and customization for the cities.

Table 1. Characteristics of context-sensitive frameworks based on the literature

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Dimensions	Characteristics	Sources
Local conditions	• Socioeconomic conditions • Natural and geographic conditions • Territorial conditions • Cultural and political conditions	de Oliveira et al. (2024), Gracias et al. (2023), Wang et al. (2022), Esposito et al. (2021), Alcaide Muñoz & Rodríguez Bolívar (2021), Desdemoustier et al. (2019), Sharifi (2019), Visvizi & Lytras (2018), Caird et al. (2016), Miller et al. (2013)
Local needs	• Citizen and local stakeholders' needs • Participation and collaboration • Priority areas (i.e. mobility, health, education, economy, environment, and others)	Miller et al. (2013), Malek et al. (2021), Sharifi (2019)
Methodological flexibility	• Qualitative and quantitative approaches • Indicator weights • Core and additional indicators	Lai & Cole (2023), Khatibi et al. (2022), Sharifi (2020), Sharifi (2019), Shi and Shi (2023), Lee & Lee (2014), Przeybilovicz et al. (2020)

Source: Elaborated by the authors.

Among local conditions characteristics, population size is a contextual data of cities appearing frequently to analyze SC (Desemoustier et al., 2019; Esposito et al., 2021; Wang et al., 2022). Regarding geographical characteristics, context can be related to a country (Fachinelli et al., 2023; Masik et al., 2021; Shen et al., 2018; Yadav et al., 2019), a world region (Fernandez-Anez et al., 2020; Peter et al., 2023; Marchetti et al., 2019) or smaller territories (Arief et al., 2020), such as villages, or neighborhoods (Maja et al., 2020; Visvizi & Lytras, 2018). For instance, Anand (2021), Marchetti et al. (2019), and Sharifi (2019) pointed out the lack of SCM adapted to the Global South or specific regions in the world, such as Latin America, highlighting the need for adapting or developing measurements that include their specific contexts and issues. Economic and social characteristics, such as developed or developing countries, as well as political and cultural aspects, can also be included as a contextual variable (Alcaide Muñoz & Rodríguez Bolívar, 2021). These contextual characteristics play a crucial role in shaping the governance and measurement of SC, highlighting the relevance of researching SCM according to the cities' specificities.

Another way to adhere to a context-sensitive approach is to include indicators considering local needs (Fachinelli et al., 2023; Malek et al., 2021; Miller et al., 2013; Sharifi, 2019). According to Huovila et al. (2019), a "standard indicator set should be considered as a starting point. Individual cities should thus always select and adapt indicators corresponding to their needs" (p. 150). Thus, SCM should compare cities with similar characteristics, avoiding evaluating cities together that have different needs (Sharifi, 2020). This approach can include measurements related to citizens' needs and participation as well as sectors of investments and priority areas necessary to improve people's lives, such as mobility, public safety, and housing. In this sense, Hajek et al. (2022) and Sharifi (2020) observed that most SCM did not include stakeholders participation among their indicators or in the process of measurement definition.

Some authors suggest that SCM should include a flexible methodology, for example, suggesting a combination of quantitative and qualitative approachess (Khatibi et al., 2022; Lee & Lee, 2014; Sharifi, 2020, 2019) and the inclusion of core and additional indicators (Sharifi, 2020). Methodological flexibility can also include weighting indicators to reflect their importance within an assessment scheme (Sharifi, 2020). This allows cities to differentiate indicators according to the context's importance or have an alternative to customize the SCM (Sharifi, 2020). Sharifi (2019) suggested the adoption of adjusted weights to fit different city contexts with assessment frameworks and bespoke indicators. In this sense, an example is the International Telecommunication Union's maturity model for Smart Sustainable Cities (SSC) adaptation by Przeybilovicz et al. (2020), which showed the need for customization to reflect Brazil's diverse contexts and include more context-related indicators.

While existing studies, like Caird et al. (2016), highlight the alignment of indicators with city strategy, local governments' practical use of SCM also remains underexplored. This paper specifically examines Brazilian municipalities and their implementation of SCM. Considering the need to incorporate more context-sensitive frameworks based on local conditions, needs, and methodological flexibility, this paper focuses on understanding

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

SCM adoption from the local government's perspective, leading to developing an understanding of context-sensitive frameworks. Therefore, considering this gap, this paper analyzes how Brazilian municipalities adopt such measurements in their SC initiatives.

3. Methodology

This paper is anchored in a qualitative approach through in-depth online interviews with representatives from Brazilian cities via a semi-structured protocol. This method allows for detailed exploration of context-sensitive SCM frameworks, providing insights from the data that can inform and enrich theoretical understanding (Gregor, 2006; Walsham, 1995). Based on the literature review, the interview script addressed five key topics: 1) respondent's background and involvement in SC initiatives; 2) city SC initiatives; 3) city measurement strategies; 4) SCM frameworks and local adaptations; and 5) external SCM frameworks influencing SC public policies.

In the last two decades, many SC initiatives have been implemented in Brazil (Cunha et al., 2016). The country is also characterized by 5,570 municipalities with different conditions, such as economic activities, geographic features, and population size (Ribeiro et al., 2020). It is also one of the most unequal countries in the world (Brazilian Institute of Geography and Statistics [IBGE], 2020), with significant regional and local disparities among socioeconomic indicators, such as access to education and healthcare, and people's income (Przeybilovicz et al., 2020). These inequalities pose challenges that can affect the development of SC in specific contexts. In this sense, Brazilian cities offer a rich source for understanding contextual factors that can make difficult or facilitate SC initiatives, including indicators about city characteristics in SCM frameworks.

Between December 2023 and February 2024, twenty-seven local government managers involved in SC initiatives were interviewed across 17 Brazilian cities, representing diverse socioeconomic and demographic conditions. This included cities from four of the five geographical regions and four state capitals. Population size was a key selection criterion, as this city characteristic is frequently presented in the literature as a fundamental contextual variable (Wang et al., 2022; Esposito et al., 2021; Desemoustier et al., 2019), categorizing analyzed cities into three groups: five with populations up to 100,000, eight between 100,000 and 500,000, and four with over 500,000 inhabitants. All cities had implemented SC initiatives and adopted SCM frameworks. Most respondents were top-level local managers responsible for SCM definition, implementation, or monitoring in their cities, including seven who were municipal secretaries mainly related to innovation, science and technology development, and urban planning or had positions in the mayor's office, and a deputy mayor. Interviews with information technology directors or those in similar positions were conducted in four cities. In other cases, the interviews included coordination positions in municipal autonomous agencies related to technology, innovation, and data offices or observatories.

The interviews were transcribed utilizing the Happy Scribe application. Data from interviews were analyzed through a deductive-inductive content analysis technique that categorized how cities adopt and use SCM in their activities according to context-sensitive dimensions found in the literature, along with additional codes that emerged during the process. One author coded the interviews, with results discussed in meetings with the other authors. Microsoft Excel was used to organize data related to the observed dimensions and to create matrices for analyzing how local governments implement SCM in their SC initiatives. Table 2 summarizes the interviews and the main characteristics of the cities.

Table 2. Characteristics of cities and respondents

Region	Interview code	Population size	Location	Number of interviewees	Interviewees positions
North	North_1	Up to 100,000 inhabitants	Non-capital city	1	Project Coordinator
	North_2	More than 100,000 up to 500,000 inhabitants	Non-capital city	1	IT Director
	North_3	More than 100,000 up to 500,000 inhabitants	Capital city	1	IT Superintendent
Northeast	Northeast_1	More than 500,000 inhabitants	Capital city	2	Director and analyst from a municipal technology and/or innovation agency
	Northeast_2	Up to 100,000 inhabitants	Non-capital city	2	Municipal Secretary in the area of public security and technical

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

					advisor at the Mayor's Office
South	South_1	Up to 100,000 inhabitants	Non-capital city	1	Municipal Secretary in the area of Science, Technology and/or Innovation
	South_2	Up to 100,000 inhabitants	Non-capital city	1	Director from a municipal technology and/or innovation agency
	South_3	More than 500,000 inhabitants	Capital city	1	Coordinator from a municipal technology and/or innovation agency
	South_4	More than 100,000 up to 500,000 inhabitants	Non-capital city	1	IT Director
	South_5	More than 100,000 up to 500,000 inhabitants	Non-capital city	2	Deputy Mayor and Data Office Director
	South_6	More than 100,000 up to 500,000 inhabitants	Non-capital city	2	Managers from a municipal technology and/or innovation agency
	South_7	More than 500,000 inhabitants	Non-capital city	1	Municipal Secretary in the area of Urban Planning
Southeast	Southeast_1	Up to 100,000 inhabitants	Non-capital city	1	IT Director
	Southeast_2	More than 100,000 up to 500,000 inhabitants	Non-capital city	1	Municipal Deputy Secretary in the area of Finance
	Southeast_3	More than 100,000 up to 500,000 inhabitants	Non-capital city	4	Municipal Secretary in the area of Science, Technology and/or Innovation, Municipal Secretary in the area of Management and Digital Government, Municipal Deputy Secretary in the area of Management Modernization, and Digital Services Director
	Southeast_4	More than 500,000 inhabitants	Non-capital city	1	Municipal Secretary in the area of Economic Development
	Southeast_5	More than 100,000 up to 500,000 inhabitants	Capital city	4	Undersecretary of Planning and technical analysts

Source: Elaborated by the authors.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4. Findings

This section presents the results of the content analysis of the interviews. First, we present the adoption of SCM in Brazilian cities, followed by the challenges and benefits, and finally, context-sensitive approaches adopted by the cities.

4.1 Adoption of SCM

Firstly, all representatives confirmed their knowledge of at least one SCM, collectively mentioning over 30 measurements. Local managers typically monitor results from multiple frameworks, primarily citing national SCM, with some international standards as exceptions. International standards followed by Brazilian cities included the Sustainable Development Goals (SDG) indicators, the ITU maturity model for Smart Sustainable Cities (SSC), and SC indicators from the International Organization for Standardization (ISO). Among national measurements, the Connected Smart Cities index and the Bright Cities platform were most frequently mentioned. The first ranks cities with over 50,000 inhabitants based on 70 indicators (Fachinelli et al., 2023; Fariniuk, 2020), while the Bright Cities platform assesses cities using 160 indicators across governance, education, health, urbanism, and environment dimensions (Bright Cities, n.d.). Both are supported by Brazilian consulting enterprises that providing indicators and offering services to develop SC initiatives.

The initial categorization of Brazilian cities identifies two SCM user types: observers and participants. While observers merely follow some SCM for Brazilian cities to check the results, participants play a more active role. They provide, collect, and analyze the data and results for the city and actively seek to be part of SCM proposed by external organizations. This includes sending information or registration for rankings, awards, or other ways of monitoring the SC projects and adopting recognized national and international frameworks like the SC indicators proposed by the ISO. Some of these cities have already received certification from the Brazilian Association of Technical Standards (ABNT), which ISO accredits to translate SC standards in the country, and others are in the process of certification.

Some cities frequently update data for national SCM indicators, guaranteeing that the data used is the most current and accurate one. One example was detailed by the interviewee from Southeast_3: "*One that we follow very closely is the Connected Smart Cities index. (...) we monitor how these indicators are being measured within the city government*". These indicators can also influence the actions of local governments, as pointed out by the South_6 interviewee: "*We use (…) Connected Smart Cities ranking as a means of monitoring [the city], which is divided into thematic axes. Within these axes, we can see which indicators are monitored, which criteria they use, and which data source they use. (...) based on these indicators, (...) we have meetings with the municipal departments once a year, when the indicators are released, and we plan next steps*".

Generally, they combine different external and internal indicators, showing that Brazilian local managers looked for using different sources of data according to the city context. For example, South_1 not only uses external measurement frameworks but also developed its own public relevance index, focusing on contextualized SC indicators as a small city: "*When you start looking at these manuals, you realize that you are always following the big cities. It is as if small cities are a shadow because everything is first tested in the bigger cities and, if it works there, replicated to the small cities. But, in innovation, it does not work, because you create a parameter of: You are a smart city, if you have X startups, if you have X incubators, X accelerators, and we start to question ourselves: But I will never get there. I will never have this ecosystem (...) What, in fact, considers us as a smart city*?".

Another local manager highlighted that cities should adapt the indicators to their context, not incorporating methodologies that do not include local issues: "*The ranking is not the only thing that will tell us whether we are doing well or not. Many times, it will show other cities advancing, not necessarily yours. That is why I think it is essential to have data and to have a purpose and indicators established by the policy (...) because I will look at my context. So, there are indicators and data which are often not mapped in rankings, but they are essential*" (Southeast_3). Therefore, regarding the adoption of external SCM, Brazilian municipalities not only demonstrate awareness of these models but also actively engage in monitoring and incorporating them according to their context: "*Indicators serve as a map, a guiding tool, but it is essential to consider the context of each city. This approach makes it easier to develop and implement strategies effectively*." (South_2)

4.2 SCM challenges and benefits

According to local managers, incorporating external SCM to monitor the cities' SC projects has numerous benefits. The benefits include comparisons with other Brazilian cities, enhancing the visibility and transparency of municipal actions, and attracting investment. SCM indicators also drive the engagement of public managers in SC, as it prompts government officials to respond to the reported results or take action to improve their results.

Furthermore, these frameworks enable the municipality to starting points for measurement initiatives, offer guidance on various indicators, and foster accountability by informing citizens about local government actions. In their opinion, adopting SCM also save resources and enhance city marketing and competitiveness. The following quotations highlight some advantages considered by Brazilian local managers:

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

"*The ranking actually publicizes how cities are doing, and this generates engagement from public managers because they want to be well-placed, showcase their city's progress, and so on.*" (South_5)

"*The key aspect (...) is having at least a minimally comparable basis to assess whether the path being followed [by the city] is indeed one that leads to improvements in public policy (...). There is also another important advantage (...) which is mobilization. Every time a ranking is released, it mobilizes the city.*" (Southeast_3)

"*We strive to keep these numbers updated and available because this is also (...) a marketing strategy for the city, enhancing its competitiveness to attract investments*." (South_7)

On the other hand, challenges mentioned by SC managers in Brazil regarding SCM adoption include a focus on larger cities, lack of standardization among different SCM, and difficulties in adapting measurement models to the unique characteristics of certain regions or contexts, such as the North and Amazon regions. The interviewer from North_1 pointed out these difficulties: "(...) *The models we have read about, (...) have looked for in the literature, do not fit our reality. The closest city here is 100 kilometers away. Everything is different when compared with the Center-West region, the Southeast region*". Because of these disparities, they opted to develop their own regional indicators to measure SC initiatives: "A*bout 40% of the indicators are global at the Brazilian level, about 70% are regionalized indicators for the North region (...) I have other difficulties (...) like access to the cities. There are cities in Amazonas State, cities in Acre State, you cannot access by roads. So, these are indicators that we must take into consideration*".

Another example is related to specific dimensions, such as transportation and mobility: "*If we look at cities that have a subway and those that do not, it is completely different. So, there's no point in suddenly adopting a methodology that incorporates the subway, and we do not have one. These things are sometimes the disadvantages of taking something closed and trying to put it that way without really adapting it to the local context*" (South_3). The requirements to have an airport close to the city were also mentioned: "*The number of airports that are taken into consideration for you to say that I am a smart city. (...) So we question the indicators for some things, that's why we look at the indicator, the source, to really know if it applies to us. If it doesn't, we need to adapt it*" (South_6).

Another challenge includes the laborious nature of data analysis. Some interviews highlighted difficulties to collect or access some indicators: "*There are indicators that require data that are not within the municipality's jurisdiction, but rather the jurisdiction of the private entity or another public organization. So, this makes it very complex. And it is not because the city does not want to show itself, it is because (...) data curation process is complex*" (Northeast_1). There are also concerns about the lack of transparency, uniformity in data availability, and the weights given to indicators among different SCM. The promotion of excessive competition among cities, particularly through rankings or indexes, was also mentioned as a challenge: "*We talk a lot about (...) not looking at rankings, because each city has its own peculiarities. (...) It is nice to be first, but there's a whole trajectory of why we are not in the first position*." (South_5). Table 3 summarizes the main benefits and challenges pointed out by Brazilian local managers.

Table 3. Benefits and challenges for adopting SCM according to the Brazilian local managers

Benefits of SCM	**Challenges of SCM**
Internal to the government • Recognition and legitimacy of the municipality's actions • Data for decision-making and management improvement • Comparison with other cities • Establishment of a baseline for indicators • Mobilization of public managers • Saving local government resources related to the creation and collection of indicators	**Lack of context-sensitive approaches** • Focus on the context of larger municipalities • Lack of in-depth analysis for specific contexts • Measurement models are not very useful for the context of some Brazilian regions, such as the North and Amazon regions • Comparison with municipalities that have different contexts • General results without segmentation according to the city's main characteristics, such as size
External to the government • Recognition and legitimacy of the municipality's actions • Attracting investments to the city • Transparency of SC initiatives • Mobilization of citizens	**SCM methodology** • Lack of transparency of SCM • Lack of standardization among indicators and weights of different SCM • Lack of in-depth indicators

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

• Reliability of information for society as it is provided by an external organization	**Other** • It is laborious to collect and analyze the data • Promoting excessive competitiveness to maintain position in rankings or indexes

Source: Elaborated by the authors.

4.3 Context-sensitive approaches adopted by the cities

This section presents findings from the content analysis of interviews, using the three dimensions of context-sensitive frameworks identified in the literature section. The analysis revealed new characteristics for measurement studies that could be expanded for the debates related to SCM and the local context. Among the novelties, interviews demonstrated the importance of including digital infrastructure and historical conditions in SCM frameworks, as well as the need for SCM transparency and data source flexibility.

Following the literature (Caird et al., 2016; de Oliveira et al., 2024; Esposito et al., 2021; Sharifi, 2019; Visvizi & Lytras, 2018; Wang et al., 2022), **local conditions** were emphasized by local managers, particularly the lack of context-sensitive indicators or approaches. Local managers noted the absence of indicators for small municipalities, specific regions of the country, and cultural and historical characteristics. For instance, the Connected Smart Cities Index, evaluating only cities with over 50,000 inhabitants, i.e., only 12% of Brazilian cities in 2023. Despite this limitation, the city of South_1, a small municipality, follows this index to gain insights into their SC projects and learn about other initiatives. Another example is the difficulty of finding SCM considering regional specificities, such as the municipalities in the North and Amazon regions. This region in Brazil has many natural and geographic challenges, including difficulties with Internet access. The IT manager from North_3 mentioned that there are only two fiber internet providers along the BR-364 road, and they face interruptions due to weather conditions like rain or fire. This affects critical services, making the Amazon region highly sensitive to ensuring the continuity of technology services, such as technologies highly dependent on fiber optic connection. The main adaptations to local conditions challenges pointed out by the local managers were choosing only appropriate indicators for their contexts or even creating locally relevant indicators for their specific contexts and needs, mixing external and internal measurements.

Regarding **local needs** initiatives to include citizens and local stakeholders in SC projects and measurement, some cities adopted participative approaches, particularly in developing medium or long-term goals. Some cities have official plans that received contributions from society to establish achievements for 2030 or 2040. Shorter-term goals were also mentioned, such as government plans for four-year terms. However, most cities did not involve society in the measurement process, a situation reinforced by literature highlighting the lack of SC indicators focused on citizen participation or the inclusion of the local stakeholders in SCM decisions (Malek et al., 2021; Miller et al., 2013; Sharifi, 2020). The main initiatives were related to the transparency of SC indicators: Half of the cities adopted data observatories and portals to share data related to their SC projects (Northeast_1; South_2; South_3; South_4; South_5; South_7; Southeast_2; Southeast_3; Southeast_5). According to the local manager from Southeast_2, citizens can monitor the same indicators that local managers can access internally, including ISO 37120 indicators for sustainable and resilient cities: "*We created an observatory here in the city to monitor this data and for citizens to be able to follow it with us. The same data that I monitor here as an internal manager, citizens can also follow (...). All these approximately 400 indicators are available on a web portal (...) and it is possible to monitor each one of them to keep track of the progress*". These findings echo the observations of Huovila et al. (2019) that cities are developing strategies to increase indicators transparency, including adopting dashboards. Sharifi (2019) has underscored the crucial role of SCM in enhancing governance transparency. Managers also cited priority areas for developing indicators on SC. Ten cities had initiatives to monitor the SDG in their contexts, including, in some cases, the integration and adaptation with the local government goals and policies. This link of SC-related indicators was also presented by the literature through studies that linked SCM with themes, such as sustainability and resilience (Ependi et al., 2022; Samarakkody et al., 2022; Wang et al., 2022). In some cases, the cities also prioritized SC indicators related to the most prominent social issues in the local context. For instance, a city won many prizes and awards for public safety monitoring, including technology initiatives to decrease violence against women (Northeast_2).

About **methodological flexibility**, generally, cities avoid changing SCM-defined indicators to maintain comparability and certifications, such as ISO framework or rankings: "*Adaptation is not an option. At times, we simply do not provide the data. An indicator is an indicator—it has a specific calculation and a defined data composition. (...). For the indicators we follow, either we have the necessary data, ensuring its reliability, or we do not present it*" (Northeast_1). In some cases, local managers propose different data sources according to the information available for the city, as exemplified by Southeast_4, which commissioned a survey to measure English-speaking women due to a lack of structured data. Sharifi (2019) mentioned this type of customization and considered allowing proxy data to be the main flexibility criterion proposed by SCM. Still, cities depend on the approval of the SCM organizers to include a different source for one or more indicators. Another approach is to consider missing data for indicators that are difficult to measure or not applicable to the city's context. When they do not follow officially an SCM, some cities adapt indicators to their specific characteristics, such as segmentation

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

by population size.

The findings suggest a lack of SCM frameworks that consider smaller cities as well as those that address the unique geographical, cultural, historical, and digital characteristics of different regions. Regarding local needs, the results emphasize the importance of measuring relevant indicators and ensuring their transparency through observatories and online dashboards. Finally, the analysis reveals that city managers hesitate to change methods to maintain comparability, though adaptations to data sources may be necessary.

5. Discussion

SCM frameworks are designed to cover many cities. This leads to the lack of context-specific indicators that capture the complexity of SC initiatives focused on cities' needs and issues (Ependi et al., 2022; Patrão et al., 2020; Sharifi, 2019; Backhouse, 2020), particularly in countries where the diversity of cities' conditions can lead to different challenges and needs. Previous studies indicated that different characteristics and levels of inequalities among Brazilian cities could affect the development of SC and the adoption of technologies by local governments (Brazilian Internet Steering Committee [CGI.br], 2022; Przeybilovicz et al., 2018; Ribeiro et al., 2020).

In this sense, the results evidenced that a single SMC framework cannot capture a Brazilian city's diversity. Among interviews with representatives from 17 cities, more than 30 SCM frameworks were mentioned, demonstrating that the city managers combine different frameworks to cover their needs to understand their SC initiatives' progress in different contexts. In contrast to the observations of Backhouse and Dhao (2020) related to the lack of SCM criticism by the cities, these municipalities did not adopt such frameworks uncritically; rather, in general, they contextualized and evaluated them from a critical perspective by combining indicators from different sources and even incorporating internal municipal indicators to monitor their SC policies.

According to local managers, the advantages of incorporating external SCM are various, verifying the advance and progress of smart city initiatives (Caird et al., 2016; Fachinelli et al., 2023; Hajek et al., 2022), attracting resources, such as investments and talent (Hajek et al., 2022), transparency for citizens about the benefits provided by SC (Huovila et al., 2019) corroborating the literature perspective on the importance of measurements covering many cities. Another crucial aspect is the possibility of comparing cities' results, an advantage mentioned by most cities. However, some challenges mentioned in balancing external comparison and context-sensitive approaches are related to focusing on the local conditions of larger cities that do not fit the context of smaller cities. Historical and cultural differences should also be considered when adapting the SCM frameworks, as well as geographic and territorial differences.

In terms of context-sensitive indicators, besides adopting external SCM, all local managers emphasized that they also have internal indicators for smart city projects, complementing external standards for monitoring their SC initiatives. For example, this includes local relevant indicators for municipal public policies in education and health sectors and according to local conditions like population size and geographic characteristics. Regarding local needs, there are more initiatives related to the transparency of SC-related indicators than those that involve the participation of society or other local stakeholders in these initiatives. Thus, there is room for improving citizens and local stakeholders' participation in both SC and SCM initiatives, as outlined by Miller et al. (2013) and Malek et al. (2021).

There is less room for adaptation in terms of methodological flexibility. From the perspective of local managers, the comparison between cities must be maintained using the same methodology. However, one recurring adaptation is the data source, which is based on the information available in the city (Sharif, 2019, 2020).

6. Conclusion

This article explores how local governments adopt and utilize SCM frameworks in their smart city initiatives. It was conducted 27 interviews with local government managers from 17 Brazilian cities and analyzed literature to identify characteristics of context-sensitive SCM frameworks. Results indicate that local conditions—such as socioeconomic, geographic, cultural, and digital infrastructure—are key for adapting SCM frameworks. Additionally, local needs including citizen and stakeholder participation, priority areas (e.g., mobility, health, education), and SCM transparency must be considered. Methodological flexibility, involving qualitative and quantitative approaches, indicator weights, and the distinction between core and supplementary data, can also enhance adaptability.

Another conclusion is that a single SCM framework is inadequate for capturing a city's complexity and measuring its SC development. Measurement models often simplify reality, making it difficult to assess the specific context. Interviews revealed that managers often use multiple models to evaluate their SC initiatives. Additionally, a dichotomy exists between addressing local context and maintaining comparability. While managers prioritize their city's specific conditions and needs, they tend to avoid flexible methodologies to prevent losing comparability.

The interview analysis shows that cities often use multiple frameworks, incorporating local indicators for internal monitoring and external ones for benchmarking. The interviews indicate that the context-sensitivity of SCM is not inherently tied to the model itself but rather to how it is appropriated, adapted, and implemented by each city. For

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

academia, future studies may investigate how local governments in other contexts, countries, and regions adopt and use SCM in their SC initiatives and whether this tendency to use multiple frameworks, add local indicators, and maintain comparability is also how managers appropriate and "contextualize" the models. For SC managers, the recommendation is to employ multiple frameworks, integrate local indicators, and maintain comparability.

The paper's limitations include its focus on local government officials in Brazil, potentially restricting the generalizability of findings to other countries. Additionally, the sample size may not fully represent Brazil's diversity in SC initiatives. Future studies could include comparative analysis across different countries to understand the variations in implementation, contextual factors, and other stakeholders' perspectives, such as citizens and the organizations that develop the SCM frameworks.

Acknowledgement

- **Contributor Statement***: Manuella Maia Ribeiro was responsible for conceptualization, data curation, investigation, methodology and writing - original draft. Erico Przeybilovicz was responsible for supervision and writing - original draft. Delfina Soares was responsible for supervision and writing - review and editing.
- **Use of AI***: During the preparation of this work, the authors used Grammarly in order to correct grammatical errors. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology*, *22*(1), 3-21. https://doi.org/10.1080/10630732.2014.942092

Alcaide Muñoz, L., & Rodríguez Bolívar, M. P. (2021). Different levels of smart and sustainable cities construction using e-participation tools in European and Central Asian countries. *Sustainability*, *13*(6), 3561.

Anand, P. B. (2021). Assessing smart city projects and their implications for public policy in the Global South. *Contemporary Social Science*, *16*(2), 199-212.

Angelidou, M. (2014). Smart city policies: A spatial approach. *Cities*, *41*, S3-S11.

Arief, A., Abbas, M. Y., Wahab, I. H. A., Latif, L. A., Abdullah, S. D., & Sensuse, D. I. (2020, July). The smart islands vision: Towards smart city readiness in local government of Archipelagos. In *Journal of Physics: Conference Series* (Vol. 1569, No. 4, p. 042006). IOP Publishing.

Backhouse, J. (2020, September). A taxonomy of measures for smart cities. In *Proceedings of the 13th International Conference on Theory and Practice of Electronic Governance* (pp. 609-619).

Backhouse, J.; Dhaou, S. B. (2020). Medidas de cidades sustentáveis e inteligentes: partindo do âmbito global para o local. In *Tecnologias de informação e comunicação na gestão urbana: desafios para a medição de cidades inteligentes* (pp. 76-108). NIC.br.

Bosch, P., Jongeneel, S., Rovers, V., Neumann, H. M., Airaksinen, M., & Huovila, A. (2017). CITYkeys indicators for smart city projects and smart cities. *CITYkeys report*, 10.

Brazilian Institute of Geography and Statistics. (2020). *Síntese de Indicadores sociais 2019*. https://www.ibge.gov.br/estatisticas/sociais/trabalho/9221-sintese-de-indicadores-sociais.html?edicao=25875

Brazilian Internet Steering Committee. (2022). *Survey on the use of information and communication technologies in the Brazilian public sector – ICT Electronic Government 2021*. https://cetic.br/media/docs/publicacoes/2/20220725170710/tic_governo_eletronico_2021_livro_eletronico.pdf

Bright cities. (n.d.). Bright Cities. https://www.brightcities.city/cities-diagnosis

Caird, S. with Hudson, L., & Kortuem, G. (2016). *A Tale of Evaluation and Reporting in UK Smart Cities*. 53pp. The Open University, UK.

Cunha, M. A., Przeybilovicz, E., Macaya, J. F. M., & Santos, F. B. P. D. (2016). *Smart cities: transformação digital de cidades*. https://repositorio.fgv.br/server/api/core/bitstreams/8f7749f0-0f4e-4411-92dd-373afe1638f2/content

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Desdemoustier, J., Crutzen, N., & Giffinger, R. (2019). Municipalities' understanding of the Smart City concept: An exploratory analysis in Belgium. *Technological Forecasting and Social Change*, 142, 129-141.

de Oliveira, J. C., Mazieri, M. R., & Kniess, C. T. (2024). Smart Cities Indicators: How Regional Context and Its Stakeholders Are Essential to Name "The" Smart City. *Journal of Urban Technology*, 1-24.

Ependi, U., Rochim, A. F., & Wibowo, A. (2022, March). Smart city assessment for sustainable city development on smart governance: A systematic literature review. In *2022 International Conference on Decision Aid Sciences and Applications (DASA)* (pp. 1088-1097). IEEE.

Esposito, G., Clement, J., Mora, L., & Crutzen, N. (2021). One size does not fit all: Framing smart city policy narratives within regional socio-economic contexts in Brussels and Wallonia. *Cities*, 118, 103329.

Fachinelli, A. C., Yigitcanlar, T., Sabatini-Marques, J., Cortese, T. T. P., Sotto, D., & Libardi, B. (2023). Urban smartness and city performance: identifying Brazilian smart cities through a novel approach. *Sustainability*, *15*(13), 10323.

Fariniuk, T. M. D. (2020). Smart cities and the pandemic: digital technologies on the urban management of Brazilian cities. *Revista de Administração Pública*, 54, 860-873.

Fernandez-Anez, V., Velazquez, G., Perez-Prada, F., & Monzón, A. (2020). Smart city projects assessment matrix: Connecting challenges and actions in the Mediterranean region. *Journal of Urban Technology*, *27*(4), 79-103.

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. J. (2007). *Smart cities. Ranking of European medium-sized cities*. Final Report.

Gracias, J. S., Parnell, G. S., Specking, E., Pohl, E. A., & Buchanan, R. (2023). Smart Cities—A Structured Literature Review. *Smart Cities*, *6*(4), 1719-1743.

Gregor, S. (2006). The nature of theory in information systems. *MIS quarterly*, 611-642.

Hajek, P., Youssef, A., & Hajkova, V. (2022). Recent developments in smart city assessment: A bibliometric and content analysis-based literature review. *Cities*, 126, 103709.

Huovila, A., Bosch, P., & Airaksinen, M. (2019). Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when? *Cities*, 89, 141-153.

Karal, F. S., & Soyer, A. (2024). A systematic literature review: Setting a basis for smart and sustainable city performance measurement. *Sustainable Development*, *32*(1), 555-573.

Khatibi, H., Wilkinson, S., Eriwata, G., Sweya, L. N., Baghersad, M., Dianat, H., ... & Javanmardi, A. (2022). An integrated framework for assessment of smart city resilience. *Environment and Planning B: Urban Analytics and City Science*, *49*(5), 1556-1577.

Lai, C. M. T., & Cole, A. (2023). Measuring progress of smart cities: Indexing the smart city indices. *Urban governance*, *3*(1), 45-57.

Lee, M. J., & Lee, D. E. (2014). Questioning beliefs surrounding urban sustainability: the need for a contextual urban model. *Journal of Asian Architecture and Building Engineering*, *13*(1), 163-170

Lopes, N. V. (2017, July). Smart governance: A key factor for smart cities implementation. In *2017 IEEE international conference on smart grid and smart cities (ICSGSC)* (pp. 277-282). IEEE.

Maja, P. W., Meyer, J., & Von Solms, S. (2020). Development of smart rural village indicators in line with industry 4.0. *IEEE Access*, 8, 152017-152033.

Malek, J. A., Lim, S. B., & Yigitcanlar, T. (2021). Social inclusion indicators for building citizen-centric smart cities: A systematic literature review. *Sustainability*, *13*(1), 376.

Marchetti, D., Oliveira, R., & Figueira, A. R. (2019). Are global north smart city models capable to assess Latin American cities? A model and indicators for a new context. *Cities*, 92, 197-207.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Masik, G., Sagan, I., & Scott, J. W. (2021). Smart City strategies and new urban development policies in the Polish context. *Cities*, 108, 102970.

Metwally, E., Samir, E., & Ayman, M. (2023). The indicators of the smartness to assess Egypt's New Administrative Capital as a smart city. *Mansoura Engineering Journal*, *48*(6), 12.

Miller, H. J., Witlox, F., & Tribby, C. P. (2013). Developing context-sensitive livability indicators for transportation planning: a measurement framework. *Journal of Transport Geography*, 26, 51-64.

Nam, T., & Pardo, T. A. (2011, June). Conceptualizing smart city with dimensions of technology, people, and institutions. In *Proceedings of the 12th annual international digital government research conference: digital government innovation in challenging times* (pp. 282-291).

Patrão, C., Moura, P., & Almeida, A. D. (2020). Review of Smart City Assessment Tools. *Smart Cities, 3* (4), 1117–1132.

Peter, C., & Meyer, C. (2023). Organizing for the Smart African City: Leveraging the urban commons for exerting the right to the city. *Organization Studies*, 44, 1725–1746.

Przeybilovicz, E., Cunha, M. A., & Meirelles, F. D. S. (2018). The use of information and communication technology to characterize municipalities: who they are and what they need to develop e-government and smart city initiatives. *Revista de Administração Pública*, 52, 630-649.

Przeybilovicz, E., Fernandes, V. B., Lima, C. F. C., Loureiro, Martinez. M. R. M., & Paseto, L. (2020). A experiência de ampliação de modelo de maturidade e indicadores de cidade inteligente para um país emergente. In *Tecnologias de informação e comunicação na gestão urbana: desafios para a medição de cidades inteligentes* (pp. 110-153). NIC.br.

Ribeiro, M. M., Macaya, J., dos Santos, M. P. R., Cunha, M. A., & Pitta, M. T. (2020, April). ICT usage in Contexts of Regional Inequalities. In *2020 Seventh International Conference on eDemocracy & eGovernment (ICEDEG)* (pp. 231-236). IEEE.

Samarakkody, A., Amaratunga, D., & Haigh, R. (2022). Characterising smartness to make smart cities resilient. *Sustainability*, *14*(19), 12716.

Sharifi, A. (2019). A critical review of selected smart city assessment tools and indicator sets. *Journal of cleaner production*, 233, 1269-1283.

Sharifi, A. (2020). A typology of smart city assessment tools and indicator sets. *Sustainable cities and society*, 53, 101936.

Shen, L., Huang, Z., Wong, S. W., Liao, S., & Lou, Y. (2018). A holistic evaluation of smart city performance in the context of China. *Journal of Cleaner Production*, 200, 667-679.

Shi, F., & Shi, W. (2023). A Critical Review of Smart City Frameworks: New Criteria to Consider When Building Smart City Framework. *ISPRS International Journal of Geo-Information*, 12(9), 364.

Skargren, F. (2020). What is the point of benchmarking e-government? An integrative and critical literature review on the phenomenon of benchmarking e-government. *Information Polity*, *25*(1), 67-89.

Tomor, Z., Meijer, A., Michels, A., & Geertman, S. (2019). Smart governance for sustainable cities: Findings from a systematic literature review. *Journal of urban technology*, *26*(4), 3-27.

Visvizi, A., & Lytras, M. D. (2018). It's not a fad: Smart cities and smart villages research in European and global contexts. *Sustainability*, *10*(8), 2727.

Walsham, G. (1995). Interpretive case studies in IS research: nature and method. *European Journal of information systems*, *4*(2), 74-81.

Wang, X., Hopeward, J., Yi, I., McElroy, M. W., & Sutton, P. C. (2022). Supporting the Sustainable Development Goals: A context sensitive indicator for sustainable use of water at the facility level. *Sustainable Development*,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

30(5), 1184-1199.

Yadav, G., Mangla, S. K., Luthra, S., & Rai, D. P. (2019). Developing a sustainable smart city framework for developing economies: An Indian context. *Sustainable Cities and Society*, 47, 101462.

Zhao, F., Fashola, O. I., Olarewaju, T. I., & Onwumere, I. (2021). Smart city research: A holistic and state-of-the-art literature review. *Cities*, 119, 103406.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital Inclusion and Social Cohesion in Smart Cities: Overcoming Barriers in the Digital Age

Christos Karelis [a*], *Zoi* Lachana[b], *Irina* Gorelova[c], *Charalampos* Alexopoulos[d], *Nikoleta* Lavdaria[e], *Francesco* Bellini[f], *Yannis* Charalabidis[g]

[a] Department of Information and Communication Systems Engineering, University of the Aegean, Samos, Greece, ckarelis@aegean.gr, 0009-0006-7708-1162 .

[b] Department of Information and Communication Systems Engineering, University of the Aegean, Samos, Greece, zoi@aegean.gr, 0000-0001-7356-8041.

[c] Department of Management, Sapienza University of Rome, Rome, Italy, irina.gorelova@uniroma1.it, 0000-0002-1205-3658.

[d] Department of Information and Communication Systems Engineering, University of the Aegean, Samos, Greece, alexop@aegean.gr, 0000-0002-6610-0675.

[e] Hellenic Open University, Patra, Greece, nilavdaria@gmail.com, 0009-0004-9557-0897.

[f] Department of Management, Sapienza University of Rome, Rome, Italy, francesco.bellini@uniroma1.i, 0000-0002-0609-8796.

[g] Department of Information and Communication Systems Engineering, University of the Aegean, Samos, Greece, yannisx@aegean.gr, 0000-0003-3760-5495.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. In the era of smart cities and digital transformation, ensuring digital inclusion has become a critical factor in fostering social cohesion and equitable urban development. While digital technology brings unprecedented opportunities for development, education, and civic engagement, barriers such as limited infrastructure, financial constraints, digital literacy gaps, and social exclusion continue to hinder full digital inclusion. This article explores the complex challenges of the digital divide and its impact on marginalized groups, including older adults, low-income households, migrants, and rural communities. Through a critical review of literature and policy analysis, this study examines key obstacles to digital inclusion in smart cities and evaluates the European Union's response to these challenges through policy interventions, broadband expansion, digital skills programs, accessibility standards, and affordability measures. Additionally, the paper highlights strategies to enhance digital participation, such as citizen engagement, inclusive urban planning, and public-private partnerships. Through the analysis of EU initiatives and emerging policy approaches, this research contributes to the discourse on digital equity and provides insights into building smart, sustainable, and inclusive urban environments. The findings emphasize the need for integrated, cross-sectoral strategies to bridge the digital divide, ensuring that all citizens can access and benefit from the digital economy and society.

Keywords. Social Cohesion, Digital Inclusion Barriers, Smart Cities, Digital Divide, Social exclusion
Research paper, DOI: https://doi.org/10.59490/dgo.2025.987

1. Introduction

Digital inclusion is a crucial factor for social and economic development in the modern era, as access to and use of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

digital technologies have become an integral part of everyday life, education, work and social participation. In a world that is changing rapidly due to the digital revolution, inequality in access to technological capabilities can intensify already existing social and economic discrimination (Helsper, 2008). The European Union (EU) and international organizations, such as the United Nations (UN), have adopted policies and programs that aim to reduce these inequalities, through the expansion of digital infrastructure, education and the promotion of digital access (European Commission, 2021).

Digital inclusion includes both access to the internet and or/any devices along with the capability of people to use technologies in order to equally participate in the information society. Losing this ability drives in digital exclusion which in turn affects mostly elderly people, people with low income, migrants and rural communities (Correa & Pavez, 2016, Gorelova et al, 2023). Usually, the reasons for digital exclusion concern economic, social, cultural and academic inequalities that discourage equal participation in a society. In addition, social exclusion and digital divide are two important factors that need to be understood so we can clarify the importance of digital inclusion. Social exclusion refers to the inability of people to participate in social, economic and cultural activities, a situation that can be caused by many factors such as lack of access to basic services and inadequate social networking (Sanders, 2020, Karelis et al., 2024). At the same time, the digital divide describes inequalities in access to and use of digital technologies among different social groups or geographical areas. Factors that contribute to the digital divide include lack of digital skills, the technologies' cost and geographical isolation (Damodaran et al., 2015). Since technological developments evolve over time, the digital divide constitutes a dynamic phenomenon. Even today, regardless of improvements in the deployment of high-speed networks, there are many people who do not have access to reliable internet connections (or cannot afford them), particularly those from rural and remote areas (Mervyn, Simon, & Allen, 2014). Moreover, age and educational levels can create such gaps, with elderly people and those with low educational levels facing such challenges (Tomczyk et al., 2023).

Addressing the challenges of digital divide and social exclusion requires a multifaceted strategy that involves technological infrastructure, fostering digital literacy, and implementing policies that ensure inclusivity and equitable access to technology. In the context of this research, the main obstacles to achieving digital inclusion will be examined, as well as strategies that can contribute to mitigating inequalities and promoting a more inclusive digital environment. This research contributes towards this purpose, to systematically identify the key barriers to digital inclusion and examine the extent to which the European Union's policies and initiatives address each of these challenges. In this context, both barriers and the EU-specific strategies are examined, while assessing the effectiveness of these initiatives in promoting a more inclusive digital environment.

The rest of this study is structured as follows: In section 2 background information is provided, necessary for landscaping the field we examine. Section 3 reveals our methodology which underlies our research. Section 4 presents barriers to digital inclusion while section 5 highlights EU efforts in addressing these barriers. In section 6 an analysis of means of mitigation is presented, followed by conclusions and directions for future research steps in Section 7.

2. Research Methods

The study adopted a qualitative approach with secondary data (scientific literature and policy documents) analysis and further data triangulation.

Data Collection: The research began by making queries for publications relevant to the topic on Google Scholar using the keywords "Digital inclusion in smart cities", "Barriers to digital inclusion", and "Smart city equity challenges" conducted in September 2024. The criteria to include the publications in the study were that they had to be published in 2008 and later, they were focusing on smart cities and urban digital inclusion, and addressing citizen-centric approaches. We deliberately omitted the exclusion criteria in order to explore the broader range of topical academic literature.

Data Selection and Analysis: The selected literature was analysed using a thematic analysis approach. During the "Data Selection and Analysis" step we identified the most common barriers to digital inclusion in the scientific literature. Specifically, the analysis resulted in six primary barriers which are *infrastructure, economic, educational, social and cultural, policy and regulatory, and psychological and perceptual challenges.* Following the identification of barriers, during the next step of our research we retrieved key strategies for countering digital disadvantage presented in the literature, with a focus placed on policy initiatives, infrastructure development, digital literacy, accessibility, and affordability. In addition, real-life examples of effective practices were included to enrich the research with authentic field experiences.

Focus on the European Union: We explored EU initiatives (policies and frameworks) to provide evidence on the ways to tackle digital inclusion barriers in Europe. This included an in-depth review of policies, frameworks, and strategic documents from the European Union, such as the 2030 Digital Compass and NextGenerationEU. The aim was to assess how these initiatives address the identified barriers and to evaluate their effectiveness in promoting digital inclusion across diverse member states. The findings were then thoroughly analysed to gain an extensive

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

comprehension of the dynamics of the studied field both on scientific and political levels.

Mapping: Finally, we conducted a systematic mapping of the identified barriers against the identified EU initiatives, policies and frameworks. In a few words, we aligned each barrier with specific EU initiatives, policies, and frameworks to evaluate the degree of alignment between the barriers and the EU responses and highlight gaps, overlaps, and areas of strong intervention. This approach provided deeper insights into the effectiveness and comprehensiveness of the EU's strategies in promoting digital inclusion.

During this phase, a qualitative stance was conducted with secondary analysis of scientific literature and policy documents. To seek out relevant EU initiatives, policies, and frameworks for dealing with digital inclusion in a systemic manner, a focused research methodology was adopted, with a thorough and stringent selection process in place.

The research began with a critical review of policy and literature, with a specific focus placed on formal documents of the EU, strategic documents, and regulating policies. European Commission and European Parliament reports and documents, together with other European Union agencies such as the Digital Economy and Society Index (DESI) and 2030 Digital Compass, were key sources involved. All these sources provided key information about the ongoing digital transformation agenda in the EU and its commitment towards lessening digital inequalities.

To further restrict selection, a specific keyword search was performed via Google and academic databases, including Google Scholar, and Scopus, and via official databases of the European Union, including EUR-Lex, European Commission Publications, and the EU Open Data Portal. Search keywords included "Digital inclusion policies EU," "Smart cities && EU digital equity," "EU frameworks && digital transformation," "EU barriers && digital inclusion && strategies," and "European actions && digital divide." Criteria for selection involved relevant and updated policies and programs for access, literacy, infrastructure, and inclusion.

Following the selection of resulted policies, a comparative mapping and classification exercise was performed in an attempt to map each initiative in a systematic manner in relation to the six most important digital inclusion barriers: infrastructure, economic, educational, social and cultural, policy and regulatory, and psychological and perceptual barriers. Mapping revealed in detail how such policies contribute towards lessening digital inequalities, even when not explicitly under social cohesion and digital inclusion programs. Most of the shortlisted initiatives address key structural barriers through augmented digital infrastructure, enhancing digital competencies and workforce capabilities, augmented access for disadvantaged groups, and cybersecurity and trust in cyberspace. Cross-referral with academic studies and case studies, in addition to critical analysis, examined the effectiveness and impact of such EU actions.

While some of the identified EU policies and initiatives are not explicitly framed under digital inclusion or social cohesion, they were selected based on their direct and indirect contributions to bridging digital inequalities and fostering a more inclusive digital society. These initiatives collectively address key structural challenges by ensuring equal access to digital infrastructure, enhancing digital literacy and skills, and promoting inclusive and secure digital participation.

3. Barriers to Digital Inclusion

Digital inclusion is of major importance to ensure that people and communities have access to and can effectively use digital technologies to improve their quality of life. However, there are many barriers that hinder this goal creating a digital divide that leads to disadvantaged groups.

Despite the rapid evolvement of technology, especially if we consider the expansion of broadband networks, many rural regions lack reliable internet access, which in turn limits opportunities for economic development, education and social engagement. The urban-rural divide remains a persistent issue, as cities enjoy high-speed connections and advanced digital services, while rural communities struggle with slow, unreliable, and costly internet options (Sanders, R., 2020; Helsper, E., 2008; Correa, T., & Pavez, I., 2016). A typical example can be considered the deployment of 5G which, despite its promise to tackle such challenges, is progressing unevenly in smaller and remote areas with delays in its adoption.

Economic barriers is another critical barrier, part of digital inclusion, especially for low-income families and marginalised groups. Regardless of the European Union's efforts to reduce internet services' cost, financial difficulties prevent many individuals from accessing any possible online resources (Sanders, R., 2020; Mervyn, K., Simon, A., & Allen, D. K., 2014; Samodaran, L. et al, 2015). Economically disadvantaged groups, such as unemployed or migrants are unable to afford high monthly subscriptions or the cost of purchasing digital devices (Mervyn, K., et al., 2014; Samodaran, L. et al, 2015). In addition, economic inequalities can be found among the EU member states that worsen the issue (Helsper, E., 2008; Mervyn, K., et al., 2014), e.g., Germany and Sweden achieve high levels of digital inclusion in comparison to Bulgaria and Romania.

A significant part of the population, especially the elderly and those with low levels of formal education, lack the necessary digital literacy skills to effectively engage with digital technologies. The European Commission's Digital

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Economy and Society Index (DESI) reveals that a high level of citizens in the EU have poor basic digital competencies, holding them back from accessing and taking part in online goods and services (Damodaran et al., 2015). Four out of ten adults lack poor basic digital competencies, and one in six professionals in ICT is female, (Virkkunen, H., 2024). Inequalities in access to training programs deepen, with rural and disadvantaged areas not having educational programs for developing competencies in a virtual environment (Sanders, 2020). Poor competencies in a digital environment hinder access to significant information, work and social contacts in an emerging virtual world (Helsper, 2008).

Social and Cultural Barriers also play a pivotal role in digital exclusion, with age inequalities being one of them. Elderly people across the EU countries face difficulties in adopting new technologies, a situation that leads to digital divide (Tomczyk et al., 2023). Many older individuals consider digital tools complex and intimidating, leading to their isolation from the benefits of the digital age we are living in. Furthermore, people with disabilities face accessibility challenges that make it difficult, or sometimes impossible, for them to use any digital devices. Although progress has been made in developing assistive technologies and accessible web design, barriers to the widespread implementation of inclusive digital solutions persist (Damodaran et al., 2015, Sanders, 2020).

Policy and Regulation, particularly those related to cybersecurity and privacy, constitute barriers to digital inclusion. Growing awareness of cyber threats, data breaches, and privacy violations has led some individuals to avoid online platforms altogether. Even though regulations such as the General Data Protection Regulation (GDPR) are important for personal information sharing, their complexity prevents smaller businesses and individuals from fully engaging with digital services (Sanders, 2020, Damodaran, L., 2015). Striking a balance between ensuring user privacy and promoting digital participation remains a challenge for policymakers.

Psychological and perceptual barriers further contribute to digital exclusion, especially among elderly people who often exhibit the known ‘fear of technology’. Distrust or anxiety about digital tools, security, privacy and usability limit their willingness to adopt digital tools (Damodaran, L., 2015, Tomczyk, Ł. et al., 2023). At the same time, many individuals lack confidence in using technologies effectively, a situation that leads to the avoidance of using them and the digital divide.

It is evident that the rapid expansion of internet usage over the past decade has profoundly transformed global communication, commerce, education, and daily life. In 2010, approximately 30% of the global population was online; by 2020, this figure had doubled to 60%, and as of October 2024, it reached 67.5% (A. Petrosyan, 2024). This surge has been driven by advancements in broadband infrastructure, affordability of mobile technology, and increasing reliance on digital services. However, access alone does not guarantee equal participation in the digital world. Long-standing barriers including financial constraints, access barriers, and computer illiteracy persistently exclude significant parts of society. For instance, financial inequality and unaffordability have been long-standing deterrents to computer access (Taylor, D., & Packham, G., 2016). Also, the lack of supporting infrastructure keeps many out of range of accessing the web, electricity, and connectivity, undermining even the best efforts at digital inclusion. That paradox compels full-fledged approaches to digital inclusion that go beyond connectivity in order to make everyone effective in participating in the web economy and society.

To make these trends concrete, the following two charts present a graphical depiction of worldwide expansion in terms of internet use over time in relation to ongoing obstacles to digital access. The first chart (Figure 1) plots overall expansion in terms of internet use and yet reveals that a considerable part of society continues to have difficulty accessing and utilizing digital technology. The second chart (Figure 2) continues to dissect these obstacles, defining them in terms of economic, access, and digital skill-related obstacles, and underlines the necessity for focused interventions.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

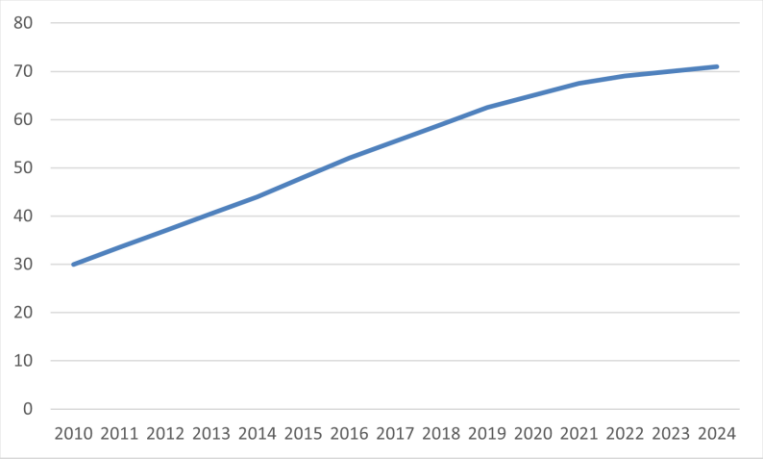


***Fig. 1**: Global Internet Penetration*

Figure 1 reflects the global expansion in internet use between 2010 and 2024. According to statistics compiled by the International Telecommunication Union (ITU, 2023) and Statista, 30% of 2010's population had access to the Internet, rising to 67.5% in 2024 (ITU, 2023; Statista, 2024). This sustained expansion is an indication of significant improvement in technology infrastructure, a fall in price for mobile devices, and an overall rise in the use of digital services in industries such as education, medical care, and business.

However, increased access to the web alone will not necessarily enhance fair digital inclusion. There are a variety of regions, most prominently developing countries and rural communities, with persistent barriers in terms of financial restrictions, infrastructure, and low digital capabilities. All these barriers arise even when connectivity keeps growing. Observations of the OECD and the World Bank point out that access, significant as it is, must accompany investments in digital capabilities and price-affordable alternatives in order to allow everyone to make an effective contribution to the digital economy (World Bank, 2016; OECD, 2021).

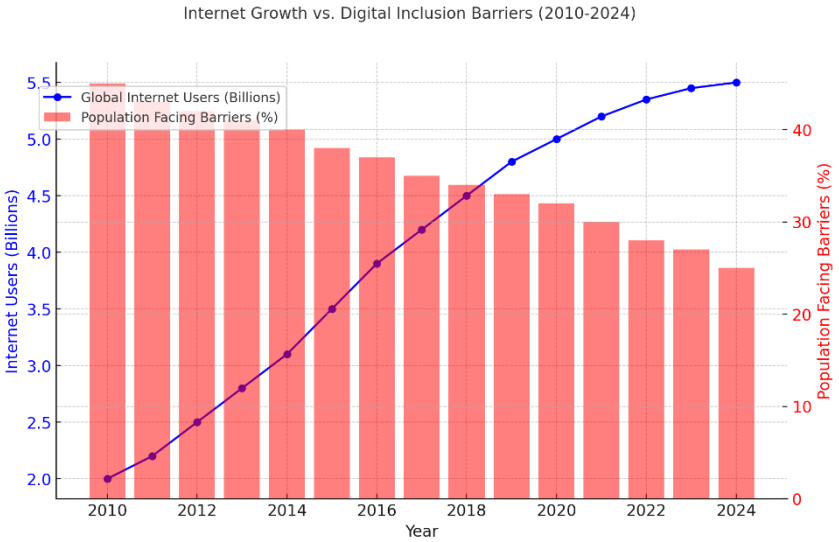


***Fig. 2**: Global Internet Growth vs. Digital Inclusion Barriers*

Figure 2 reveals the steady rise in global internet users from 2 billion in 2010 to approximately 5.5 billion in 2024, demonstrating the increasing digital connectivity worldwide. However, the chart also highlights that despite this growth, a significant portion of the population continues to face digital inclusion barriers, with 45% experiencing challenges in 2010 and 25% still affected in 2024. The trend, even in its demonstration of a decline in barriers over a period, identifies that access to the web alone cannot secure fair access and use of the information society and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

economy. Long-standing barriers, including financial constraints, access barriers, and computer and information skills lack, expose a demand for proactive interventions and policies in closing down the digital divide.

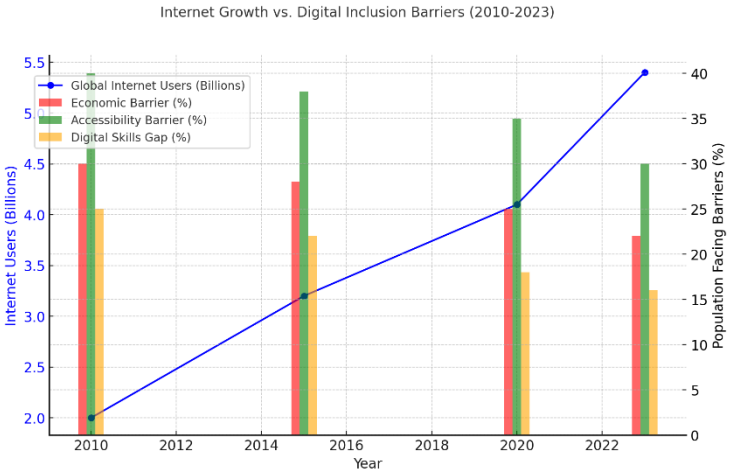


Fig. 3 *Internet Growth vs. Specific Digital Inclusion Barriers*

Figure 3 embarks on a deeper examination of barriers to full digital inclusion and organises them under three general categories: access, economic, and digital skill gaps. As per information, despite a drop in economic barriers over the years, beginning at 30% in 2010 and decreasing to 22% in 2023, lack of affordability continues to hinder access for poor segments of society. Accessibility barriers, which impacted 40% of the population in 2010, remain a significant challenge at 30% in 2023, reflecting the need for more inclusive digital infrastructure and services. Similarly, the digital skills gap has narrowed from 25% in 2010 to 16% in 2023, yet a considerable portion of the population still lacks the necessary competencies to fully participate in the digital world. These findings reinforce the importance of not just expanding internet access but also addressing the socioeconomic and educational factors that influence digital inclusion.

4. EU efforts to address and mitigate these barriers

The EU recognises there is an increasing digital divide and a pressing need, therefore, to promote digital inclusion for all citizens to enable them to participate in a digital economy and society. As digital technologies transform industries, education and everyday life, anyone lacking access to the infrastructure needed to use technology or lacking basic digital skills or affordable internet services, risks falling behind. Recognizing these challenges, the EU has implemented a series of policy initiatives, infrastructure investments, digital literacy programs, accessibility regulations, and affordability measures to create a more inclusive digital ecosystem. These efforts contribute to the goals of the 2030 Digital Compass towards a digitally empowered and technology sovereign European Union with connectivity, skill, cybersecurity, and innovation driving social and economic development.

The European Union has developed policy frameworks to make digital transformation work for everyone in society. Policies have been designed to give direction to member countries, companies, and public sectors for enhancing access, developing capabilities, and closing gaps in terms of digital engagement. The European Union long-term blueprint for digital transformation is the Digital Compass 2030. One of its most important objectives is to enable at least 80% of citizens to have minimum digital skills in 2030 and for all European homes to have access to gigabit connectivity. Having specific objectives, it creates a specific direction for enhancing digital inclusion and for having Europe competitive in a growing changing digital environment. The ESF+ (Social Fund Plus) scheme continues concentrated funding for training and work programmes for developing digital competences in disadvantaged groups, including low-income groups, immigrants, and jobseekers. ESF+ main objective is to reduce skill gaps and increase employability in an emerging digital jobs economy.

The Digital Skills and Jobs Coalition unites governments, employers, educational providers, and civil society in an attempt to bridge technology skills gaps. By developing collaboration, the coalition sees to it that workers and citizens have competencies in a position to join and contribute to the jobs marketplace and digital economy. Coding for All Initiatives supports coding education in schools and communities, preparing

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

students, job seekers, and professionals for future technological careers. It enhances Europe's digital workforce by equipping individuals with essential programming skills. The Upskilling Pathways Initiative empowers adults with low digital skills, offering them individualized training in computer literacy, web use, and problem-solving in a virtual environment. The Digital Europe Program addresses educational and financial barriers through financing for high-level digital competencies and technological capabilities through projects. By focusing on sectors such as supercomputing, artificial intelligence, and cybersecurity, it enables citizens and businesses to thrive in a digital economy, filling gaps in digital competency and spurring innovation in member nations. The European Digital Skills Awards respond to educational barriers through a recognition and motivation of successful programs that have successfully developed citizens' digital competencies in the European Union. By offering such incentives, such awards promote best practice in digital training, challenging educational institutions to apply effective training programs for closing gaps in digital literacy.

To address the urban-rural digital divide, the EU invests in broadband expansion and connectivity projects to ensure that underserved communities can access high-speed internet and digital services. These initiatives are particularly crucial in rural, remote, and economically disadvantaged areas. The Connecting Europe Facility (CEF) programme provides funding for rural and disadvantaged areas in Europe for connectivity improvement. CEF aims at closing geographical gaps in access to connectivity through financing for high-speed infrastructure development, fiber-optic connectivity, and 5G rollout. WiFi4EU scheme brings free public WiFi hotspots to parks, libraries, public spaces, and community spaces in EU nations. In other words, it provides free and secure access for all, no matter geographical location, helping also in breaking down financial barriers to connectivity, especially for those who cannot afford a subscription at home. Both WiFI4EU & CEF support also the infrastructure development. The European Digital Innovation Hubs Network addresses infrastructure and educational barriers through access to technical expertise, training, and financial consultancy for companies and public administration entities. Hubs promote and enable use of digital technology and innovation, specifically in regions with a lack of development in terms of digital technology. The Digital Transformation Compass 2030 addresses infrastructure, educational, and financial barriers through ambitious citizen and business enablement through digital transformation objectives. It seeks to build digital competencies, infrastructure development, and stimulate economic development for assured access to the digital economy.

In parallel, the EU prioritized accessibility regulations to ensure that all individuals, including those with disabilities, can fully participate in the digital world. These regulations encourage accessibility by everyone web development, electronic goods and services, and electronic environments. The Web Accessibility Directive mandates compliance with accessibility for all public sector websites and mobile applications. It enables persons with disabilities to access, use, and enjoy electronic goods and services with no obstacles in between. EU Disability Strategy (2021-2030) deepens commitment towards electronic access through overcoming barriers to access for persons with disabilities in electronic technology. It promotes accessible technology, accessible electronic information, and access policies in private and public sectors.

Some EU countries have introduced subsidies, financial incentives, and tax rebates to make access to the digital economy more affordable. Specifically, in certain EU member states, governments provide financial aid to low-income households, helping them purchase laptops, tablets, and internet subscriptions. For example, Slovenia’s Digital Inclusion Act offers digital vouchers to specific population groups, enabling disadvantaged individuals to buy computer equipment. Additionally, the EU encourages businesses to invest in digital tools and workforce training by offering incentives and tax allowances. These policies support corporate investment in employee digital upskilling while also reducing the cost of personal technology investments.

The European Declaration of Digital Principles and Rights addresses social, cultural, and legislative barriers through an emphasis on protecting fundamental rights, developing digital competences, and granting access to digital technology for all in an equitable manner. It guides the EU’s journey towards an inclusive, citizen-centred digital transformation that considers citizens' diversity in terms of requirements. Mitigation of digital inequity will require a coordinated and overall approach. One of the most effective strategies for creating inclusive digital policies is through actively engaging citizens in developing them. Engaging communities in participatory design sessions enables one to make strategies specific to them. For instance, the European Commission’s 2030 Digital Compass incorporated feedback from a variety of stakeholders, including citizens, in creating its 2030 Digital Compass (Ginters E, 2022). Regional cooperation is yet another key one. Policies such as the European Union’s Digital Decade Policy Programme (Signorelli S, 2024) drive countries to work together, with best practice shared and common objectives harmonized. To ensure accountability, transparent reporting and regular audits have to be conducted. NextGenerationEU programs, for one, exhibit

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

such a practice through reporting twice a year regarding funding operations.

The development of digital infrastructure is most critical in closing the divide, particularly in disadvantaged communities. Public-private partnerships generate additional momentum, such as with WiFi4EU (Kaššaj, M., & Peráček, T., 2024), in funding free public-space installation of WiFi in city councils through private companies for delivery. The integration of technology in current infrastructure also enables digital transformation. Cities such as Barcelona have incorporated smart sensors in public infrastructure in an attempt to make urban services and connectivity better.

The establishment of digital competences and literacy is key in developing an environment of inclusion. Community training programs, designed in collaboration with community groups, address specific individual requirements for individual groups. Interactive and gamificated platforms for training make skill development in a virtual environment accessible and exciting. Mentorship programs extend digital capabilities even further. In MIT's D-Lab (Smith, A., & Adams, N., 2022), experienced learners mentor students to co-create technology, and in Australia's Digital Mentors Program (Dezuanni, M., 2019), volunteers are trained to mentor others in enhancing their digital capabilities, with a view to creating knowledge spillover in communities.

To make tools and services accessible universally, development must be guided through universal approaches to design. Public sector websites have to abide by such standards under the EU Web Accessibility Directive (Ferri, D., & Favalli, S., 2018). Collaborative spaces like community access labs have a critical role in developing accessible tools for all. Implementation of access standards through audits and tracking strengthens compliance.

Affordability is a significant barrier to access, and simplifying access to subsidies can have a significant impact. Sliding scales in pricing frameworks make it even less costly through pricing in relation to incomes.

Effective digital inclusion strategies involve cross-cutting approaches with a high level of community and data-driven decision-making orientation. By having a variety of demographics involved in planning and rollout, programs can best react to community requirements. Participatory design processes in use in MIT's D-Lab and in the case of the platform in Barcelona demonstrate how citizen engagement can produce meaningful and inclusive outcomes. Data analysis is yet another powerful tool for sharpening and acting on strategies. There is an EU Digital Economy and Society Index tracking digital transformation in member nations. Public awareness programs serve a complementary role in creating awareness regarding programs and options that exist out there. Citizens become sensitized about their digital rights through the European Declaration of Digital Rights and Principles.

Table 1. EU mitigation measures to address Digital inclusion barriers

EU Initiatives/Policies/Frameworks	**Barriers Addressed**	**Description**
Digital Compass 2030	Educational, Infrastructure, Economic	Aims for 80% of citizens to have minimum digital skills and universal gigabit connectivity by 2030.
NextGenerationEU	Infrastructure, Educational, Economic	Funding for digital transition, infrastructure, skills training, and connectivity in disadvantaged regions.
ESF+ (Social Fund Plus)	Educational, Economic	Focused funding for digital competences development in disadvantaged groups.
Connecting Europe Facility (CEF)	Infrastructure, Geographical	Funding for broadband expansion and high-speed connectivity in rural and remote areas.
WiFi4EU	Infrastructure, Economic	Free public WiFi hotspots in parks, libraries, and public spaces across EU countries.
Digital Skills and Jobs Coalition	Educational	Collaboration to bridge technology skills gaps across governments, employers, and educators.
Coding for All Initiatives	Educational	Prepares students and professionals for future tech careers through coding education.
Upskilling Pathways Initiative	Educational	Individualized training for adults with low digital skills to improve competencies.
Web Accessibility Directive	Accessibility, Social and Cultural	Mandates accessibility compliance for public sector websites and mobile applications.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

EU Disability Strategy (2021-2030)	Accessibility, Social and Cultural	Promotes accessible technology and policies for persons with disabilities.
Digital Inclusion Act (Slovenia)	Economic	Provides digital vouchers for low-income groups to purchase computer equipment.
Digital Decade Policy Programme	Infrastructure, Educational, Policy and Regulatory	Sets goals for digital skills, infrastructure, business transformation, and digital public services by 2030.
Digital Services Act (DSA)	Policy and Regulatory, Psychological and Perceptual	Creates safer digital spaces by regulating online platforms and enhancing user protections.
Digital Education Action Plan (2021-2027)	Educational	Promotes high-quality, inclusive, and accessible digital education across Europe.
European Digital Identity (EUDI)	Policy and Regulatory, Accessibility	Provides secure digital wallets for citizens to access services across EU member states.
Cyber Resilience Act	Policy and Regulatory, Psychological and Perceptual	Enforces cybersecurity standards for internet-connected products to enhance digital trust.
Digital Agenda for Europe	Infrastructure, Educational, Economic	Maximizes the benefits of digital technologies for all EU citizens through improved access and digital literacy.
Horizon 2020	Educational, Infrastructure, Policy and Regulatory	Funds research and innovation projects, including those promoting digital inclusion and technological development.
European Regional Development Fund (ERDF)	Infrastructure, Geographical, Economic	Invests in ICT infrastructure in less developed regions to reduce the digital divide.
European Accessibility Act	Accessibility, Social and Cultural, Policy and Regulatory	Requires accessible design for products and services like computers and e-commerce to ensure inclusion of persons with disabilities.
Digital Europe Programme	Infrastructure, Educational, Economic	Funds projects in supercomputing, AI, cybersecurity, and advanced digital skills to accelerate Europe's digital transformation.
All Digital	Educational, Social and Cultural	Brings together organizations to empower citizens with digital skills, focusing on basic competencies, coding, and digital literacy.
European Digital Skills Awards	Educational	Recognizes initiatives that improve digital skills of EU citizens, promoting best practices in digital education.
European Digital Innovation Hubs Network	Infrastructure, Educational, Policy and Regulatory	Supports digital transformation by providing services and resources to governments and businesses through digital platforms.
Digital Transformation Compass 2030	Infrastructure, Educational, Economic	Sets ambitious goals for empowering citizens and businesses via digital transformation by 2030.
European Declaration on Digital Rights and Principles	Social and Cultural, Policy and Regulatory	Promotes principles for a digital transformation that respects European values and citizens' rights.

The EU's policies and initiatives to address digital inclusion barriers reflect a structured, multi-dimensional approach aimed at creating a more equitable digital society. By tackling key issues—such as infrastructure deficits, economic limitations, digital literacy gaps, social and cultural obstacles, and regulatory complexities—the EU reaffirms its strong commitment to closing the digital divide. These efforts align with broader strategies like the Digital Compass 2030, NextGenerationEU, and the Digital Decade Policy Programme, all designed to promote universal connectivity, enhance digital skills, and ensure accessible technology for all citizens.

Despite advancements in technology and policy interventions, significant challenges persist. Rural and underserved areas continue to struggle with infrastructure gaps, affordability remains a barrier for many low-income households, and marginalized groups still face digital exclusion due to limited skills or accessibility constraints. Additionally, the fast-paced evolution of digital technologies necessitates continuous policy adaptation to keep inclusion strategies effective and relevant in an ever-changing digital

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

landscape.

Moving forward, future research should focus on assessing the long-term impact of the EU's digital inclusion initiatives, evaluating their sustainability, scalability, and ability to adapt to emerging technological, economic, and social challenges. Comparative studies across EU member states could also offer valuable insights into best practices, policy effectiveness, and areas that require further intervention. As the digital landscape continues to evolve, ongoing assessment and targeted efforts will be crucial in ensuring that no one is left behind in Europe's journey toward full digital inclusion.

5. Conclusions

The EU is taking a well-rounded approach to breaking down barriers to digital inclusion, ensuring that everyone has the opportunity to benefit from technology. By addressing challenges like limited infrastructure, economic hardship, gaps in digital skills, and regulatory hurdles, the EU is making a strong push to close the digital divide. Initiatives such as the Digital Compass 2030, NextGenerationEU, and the Digital Decade Policy Programme all reflect a shared commitment to expanding internet access, improving digital literacy, and making technology more accessible to all.

However, despite these efforts, significant challenges remain. Many rural and underserved communities still struggle with poor connectivity, while affordability continues to be a major hurdle for low-income households. Marginalized groups often face exclusion due to limited digital skills or accessibility barriers, and the rapid pace of technological change means policies must constantly evolve to stay effective.

Looking ahead, it's crucial to assess the long-term impact of these initiatives—are they truly sustainable, scalable, and adaptable to future challenges? Comparative studies across EU member states could shed light on what's working and what still needs improvement. As the digital world continues to evolve, ongoing evaluation and targeted action will be essential to ensure that no one is left behind in Europe's journey toward full digital inclusion.

References

1. A. Petrosyan, Ed. (2024, November 5). Worldwide internet user penetration from 2014 to October 2024 [Review of Worldwide internet user penetration from 2014 to October 2024]. Statista. https://www.statista.com/statistics/325706/global-internet-user-penetration/
2. Correa, T., & Pavez, I. (2016). Digital inclusion in rural areas: A qualitative exploration of challenges faced by people from isolated communities. Journal of Computer-Mediated Communication, 21(3), 247-263.
3. Damodaran, L., Gilbertson, T., Olphert, W., Sandhu, J., & Craig, M. (2015). Digital inclusion-the vision, the challenges and the way forward. International Journal on Advances in Internet Technology, 8(3/4), 78-92.
4. DeHart, J. (2022). Understanding equity and diversity in smart city infrastructures: Chicago, IL, USA. XRDS: Crossroads, The ACM Magazine for Students, 28(3), 60-61.
5. Dezuanni, M., Marshall, A., Cross, A., Burgess, J., & Mitchell, P. (2019). Digital mentoring in Australian communities - A report prepared for Australia Post. https://eprints.qut.edu.au/239868/
6. European Commission. (2021). 2030 Digital Compass: The European way for the Digital Decade. https://ec.europa.eu/digital-strategy
7. Ferri, D., & Favalli, S. (2018). Web accessibility for people with disabilities in the European Union: Paving the road to social inclusion. Societies, 8(2), 40.
8. Ginters, E. (2022). Cutting-edge technologies sustainability assessment towards EC Digital Decade 2030 Compass objectives. WSEAS Transactions on Systems and Control, 17, 153-158.
9. Helsper, E. (2008). Digital inclusion: An analysis of social disadvantage and the information society. Department for Communities and Local Government.
10. Colding, J., Nilsson, C., & Sjöberg, S. (2024). Smart Cities for All? Bridging Digital Divides for Socially Sustainable and Inclusive Cities. Smart Cities, 7(3), 1044-1059. https://doi.org/10.3390/smartcities7030044
11. Itoh, N., & Sagawa, K. (2019). Accessibility and Standards in Japan—Historical Overview and the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Future—. In Proceedings of the 20th Congress of the International Ergonomics Association (IEA 2018) Volume VII: Ergonomics in Design, Design for All, Activity Theories for Work Analysis and Design, Affective Design 20 (pp. 1498-1505). Springer International Publishing.
12. Kaššaj, M., & Peráček, T. (2024). Sustainable connectivity—integration of mobile roaming, WiFi4EU and smart city concept in the European union. Sustainability, 16(2), 788.
13. Kolotouchkina, O., Ripoll González, L., & Belabas, W. (2024). Smart Cities, Digital Inequalities, and the Challenge of Inclusion. Smart Cities, 7(6), 3355-3370. https://doi.org/10.3390/smartcities7060130
14. Mervyn, K., Simon, A., & Allen, D. K. (2014). Digital inclusion and social inclusion: A tale of two cities. Information, Communication & Society, 17(9), 1086-1104. https://doi.org/10.1080/1369118X.2014.889148
15. Nunez, I. J. (2022). Essays on the FCC's Rural Digital Opportunity Fund (Doctoral dissertation). https://repositories.lib.utexas.edu/items/45fa8765-baa9-4cb8-a0b6-dbbc35bbb819
16. Kolotouchkina, O., Llorente Barroso, C., & Manfredi Sánchez, J. L. (2022). Smart cities, the digital divide, and people with disabilities. Cities, 123, 103613. https://doi.org/10.1016/j.cities.2022.103613
17. Signorelli, S., Torrecillas Jodar, J., Papazoglou, M., & López Cobo, M. (2024). Mapping EU level funding instruments 2021-2027 to Digital Decade targets.
18. Smith, A., & Adams, N. (2022). MIT D-Lab: designing for a more equitable world. In Handbook of Innovation & Appropriate Technologies for International Development (pp. 7-21). Edward Elgar Publishing.
19. Karelis, C., Lachana, Z., Kontos, G., & Charalabidis, Y. (2024, October). A Comprehensive Review of Citizen Science Projects for behavioral change towards Sustainable Urban Environments. In Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance (pp. 309-317).
20. Smith, R. M., Pathak, P. A., & Agrawal, G. (2019). India's "smart" cities mission: A preliminary examination into India's newest urban development policy. Journal of Urban Affairs, 41(4), 518-534.
21. Taylor, D., & Packham, G. (2016). Social inclusion through ICT: Identifying and overcoming barriers to ICT use. Strategic Change, 25(1), 45-60.
22. Tomczyk, Ł., Mascia, M. L., Gierszewski, D., & Walker, C. (2023). Barriers to digital inclusion among older people : a intergenerational reflection on the need to develop digital competences for the group with the highest level of digital exclusion. Innoeduca, 9(1), 5–26. https://doi.org/10.24310/innoeduca.2023.v9i1.16433
23. Virkkunen, H. (2024, April 5). Better digital skills for a better Europe. The Parliament Magazine. https://www.theparliamentmagazine.eu/news/article/better-digital-skills-for-a-better-europe
24. Gorelova, I., Lachana, Z., Loutsaris, M. A., Bellini, F., Charalabidis, Y., & D'Ascenzo, F. (2023). The e-government initiatives in the smart cities. Insights from the European Commission's Intelligent Cities Challenge.
25. Zhang, L., Zhang, C., Dang, S., & Shihada, B. (2022). Lessons From the Commercial Failure of Project Loon for 6G Research Roadmap Design. Frontiers in Communications and Networks, 3, 867581.
26. Zhao, P., Yen, Y., Bailey, E., & Sohail, M. T. (2019). Analysis of urban drivable and walkable street networks of the ASEAN Smart Cities Network. ISPRS International Journal of Geo-Information, 8(10), 459.
27. International Telecommunication Union. (2023). Global ICT developments. Retrieved from https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx
28. Statista. (2024). Internet usage worldwide - Statistics & Facts. Retrieved from https://www.statista.com
29. Organisation for Economic Co-operation and Development. (2021). Bridging the Digital Divide: Skills for the Digital Economy. Paris: OECD Publishing.
30. European Commission. (2023). Digital Economy and Society Index (DESI) 2023. Retrieved from https://digital-strategy.ec.europa.eu/en/policies/desi
31. Sanders, R. (2020). Digital inclusion, exclusion and participation. Glasgow: Iriss.
32. Damodaran, L., Sandhu, J., & De Angeli, A. (2015). Digital inclusion: The role of user-centered design. International Journal of Digital Society, 6(2), 102-112.
33. El País. (2024, January 31). Más del 40% de los europeos carece de habilidades digitales para gestiones online. El País. Retrieved from https://elpais.com
34. International Social Security Association (ISSA). (2023). Leaving no one behind: Experiences in digital inclusion in Europe. Retrieved from https://www.issa.int
35. Organisation for Economic Co-operation and Development. (2020). OECD Digital Economy Outlook 2020. Paris: OECD Publishing. Retrieved from https://espas.secure.europarl.europa.eu
36. Sanders, R. (2020). Digital inclusion and accessibility: A European perspective. European Journal of Digital Policy, 12(1), 45-60.
37. World Bank. (2016). World Development Report 2016: Digital dividends. Washington, DC: World Bank Group. Retrieved from https://espas.secure.europarl.europa.eu
38. IEEE CTU. (2023). Barriers to digital inclusion: The role of infrastructure and affordability. IEEE Technical Blog. Retrieved from https://ctu.ieee.org

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

European urban strategic initiatives involving emerging technologies for addressing climate change

Manuel Pedro Rodríguez Bolívar [a*], *Cristina* Alcaide Muñoz[b], *Laura* Alcaide Muñoz[c], *Rocío* de la Torre Martínez[d]

[a] Department of Accounting and Finance, University of Granada, Granada, Spain, manuelp@ugr.es, https://orcid.org/0000-0001-8959-7664

[b] Department of Accounting and Finance, University of Granada, Granada Spain, c.alcaide@ugr.es, https://orcid.org/0000-0001-6910-202X

[c] Department of Accounting and Finance, University of Granada, Granada, Spain, lauraam@ugr.es, https://orcid.org/0000-0003-3885-0660

[d] Department of Business Administration, Polytechnic University of Valencia, Valencia, Spain, mrtormar@omp.upv.es, https://orcid.org/0000-0002-8662-8901

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. In the contemporary era, climate change (CC) has become a defining challenge and a wicked problem for society, particularly in urban areas, due to their direct experience of the impacts of climate variability and extreme events. This has led to a heightened focus on the strategic planning processes, which are now under pressure to develop long-term strategies and investments for CC adaptation at the local level. This includes the implementation of effective measures and smart initiatives to address CC. In this context, smart cities (SCs) are progressively adopting emerging technologies (ETs) that hold the promise of enhancing urban resilience. Nonetheless, this implementation should be grounded in the strategic smart initiatives previously delineated in the strategic document of these cities, a domain that has remained largely unexplored. Thus, the present study aims to examine how a sample of European SCs are planning strategic actions to address the CC challenge through the design and execution of smart initiatives. Particularly, we focus on the analysis of governance issues -the leadership of the smart initiatives (RQ1) and the departments involved (RQ2)-, the smart dimensions involved in the strategic actions (RQ3) and, finally, the use of ETs (RQ4) in the different CC adaptation actions planned. The findings indicate fragmented governance, weak interdepartmental coordination, and minimal involvement. While some municipalities have dedicated sustainability departments, many initiatives lack centralized management. Although big data and AI play a key role in decision-making, the adoption of advanced technologies remains limited.

Keywords. Climate Change, Emerging Technologies, Strategic Planning, Smart Cities.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.986

1. Introduction

In the contemporary era, climate change (CC) has become a defining challenge and a wicked problem for society, characterised by its multidimensional and substantial impacts on environmental, social and economic spheres at different spatial scales (international, national, regional and local contexts) -OECD, 2024a-. However, despite intense discussions on CC in the global arena and the urgent measures designed by governments and international bodies to address this challenge, no tangible results have yet been achieved in terms of mitigation and adaptation

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

mechanisms to address CC (OECD, 2024a).

International organisations point out that effective policymaking for CC adaptation requires measurable objectives, whole-of-government coordination, stakeholder engagement, sufficient funding and robust mechanisms to monitor progress and evaluate the effectiveness of policies (OECD, 2024a). Previous research has also highlighted that the ability to implement CC goals and policies in practice is largely determined by the robustness of institutions -e.g. strategic plans, policies- and systems -e.g. infrastructure, ecosystems- (Birchall and Bonnet, 2021). This has put considerable pressure on strategic planning processes to develop long-term strategies and investments for CC adaptation at the local level, including effective measures and smart initiatives to address CC (Bera and Lewicki, 2023).

Although it is acknowledged both that confronting CC necessitates the coordination and alignment of public policies across different administration levels and the important constraints faced by local government in their efforts to enhance climate resilience -including technical, financial and legal capacity issues (OECD, 2023a)-, the impacts of climate stressors manifest at local scales, underscoring the imperative for effective adaptation strategies to be tailored to the specific characteristics of the local context (IPCC, 2018). Indeed, local governments are critical for CC adaptation implementation (OECD, 2024a) and bear primary responsibility for important adaptation policy areas such as the delivery and operation of key infrastructure (OECD, 2024b) or the setting of regulatory functions (such as land-use planning, project permitting and standard setting) that can build climate resilience -OECD, 2024b-).

Local-level governments thus become central actors in fostering resilience through effective CC adaptation (Shi, 2019; Bonnett and Birchall, 2023), given their unique position to lead on CC adaptation actions due to their direct experience with the impacts of climate variability and climate extreme events as well as their understanding of the needs for locally tailored solutions (OECD, 2023a). So, a "place-based" approach to understanding and addressing local differences is essential for developing effective adaptation strategies that can mitigate climate change impacts and enhance resilience in communities (OECD, 2023a; OECD, 2023b).

In this regard, the available evidence suggests that strategies for cities should be developed at the metropolitan (functional urban area) level (OECD, 2024a). However, recent research has revealed that Australian and European cities usually have a low-quality adaptation plan for CC (Reckien et al., 2023) and limited number and low integration of CC adaptation and mitigation actions in urban planning documents (Hurlimann et al., 2021). This evidence could be the result of the limited financial resources that cities own, particularly in the most vulnerable communities and regions, which has compounded disparities in CC adaptation efforts (OECD, 2023a; OECD, 2023b).

As larger local authorities possess greater financial resources and technical infrastructure, they have developed dedicated adaptation plans and strategies to mainstream climate resilience across all locally led functions, often complemented by targeted plans to address specific risks (OECD, 2023a). Furthermore, it can be argued that the 'shock' of CC and its local and regional impacts is creating the conditions for greater innovation at urban and regional scales (Sancino et al., 2022). In this context, the rapid advancement of information and communication technologies (ICTs) has led to the increasing application of technologies in the urban context for the development of forward-looking plans for reducing vulnerability and disaster threats (Kuo and Li, 2022) particularly in the so-called 'smart cities' (SCs) due to their intense use of ICTs in the urban space, advanced governance models and the pursuit of sustainability goals (Su and Fan, 2023). Special attention should be paid to emerging technologies (ETs) in SC which have the potential to assist these cities in achieving resilience (Grovert et al., 2022). The aforementioned reasons provide a robust foundation for the focus on SCs as a fertile ground for research, despite the fact that they have been extensively explored (Butler et al., 2021).

Therefore, the present study aims to examine how a sample of European SCs are planning strategic actions to address the CC challenge through the design and execution of smart initiatives. Particularly, we focus on the analysis of governance issues -the leadership of the smart initiatives (RQ1) and the departments involved (RQ2)-, the smart dimensions involved in the strategic actions (RQ3) and, finally, the use of ETs (RQ4) in the different CC adaptation actions planned.

Recent research has indicated that sufficient resources do not guarantee effective adaptation planning in practice, because governments also face distinct adaptation barriers resulting from governance structure (Birchall et al., 2023). Consequently, within the domain of contemporary urban governance literature, there is an increasing focus on the leadership of smart initiatives and the role of city climate leadership (Rapoport et al., 2019) within the broader urban governance framework (Beer et al., 2021; Sotarauta and Beer, 2021; McPherson and Clarke, 2024). Although leadership in Europe is characterised by its multidimensional and collaborative nature (Hofstad et al., 2022; Sancino et al., 2022), political and administrative leaders play a crucial role in the vision and strategy for CC adaptation, the horizontal and vertical coordination and in leveraging resources from local, regional, and national actors within a multilevel governance system (Meijerink and Stiller, 2013; Hanssen and Tønnesen, 2022). This is

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

also relevant at the implementation stage in order to better coordinate actions and ensure long-term commitment to allocate resources to sustain actions (Vignola et al., 2017). Therefore, administrative leadership plays a pivotal role in steering climate policy initiatives (McPherson and Clarke, 2024).

Nonetheless, while sustainability appears to be evident in the SC fabric, it is influenced by both institutionalised and non-institutionalised factors, with perhaps most noteworthy factor being the unpredictability of the people and departments that eventually assume leadership in the smart initiatives (Haarstad and Wathne, 2019). Nonetheless, whether local governments are being structured for leading CC smart initiatives, as delineated in strategic documents, and the areas which lead these initiatives is an important and under-explored question. Therefore, the following research question is derived: RQ1. Do SCs have a department to lead all the smart city initiatives on sustainability or resilience or are they led by different departments according to the goals pursuit by the smart initiatives?

On another hand, the management of CC impacts constitutes a multifaceted and interdisciplinary domain, necessitating the integration of CC initiatives across various sectors and collaboration between diverse actors and departments within the strategic planning process (Theodora and Stratigea, 2021) to enhance preparedness for climate-related challenges (Bera and Lewicki, 2023). Furthermore, the organisational facet of the SC agenda entails the promotion of an integrated approach towards urban planning, the dissolution of silos, the transcendence of barriers, and the adoption of dynamic and reflexive methodologies to address various urban challenges. The interconnection of services, management and organisation is therefore a vital aspect of the SC agenda (Haarstad and Wathne, 2019).

Nonetheless, empirical evidence has revealed that many smart initiatives were designed to solve a specific problem handled by a specific department and current problems resulting in the development of short-sighted plans and initiatives (Kuo and Li, 2022). This approach hinders the capacity of cities to undergo CC adaptation in an effective manner. Consequently, the second research question of our study is as follows: RQ2. Which departments of the city are involved in the strategic planning processes of the smart initiatives related to CC strategic actions?

In addition, the interaction between technology and nature can be enhanced when a SC approach promotes the integration of climate strategies. Recent research has revealed that smart initiatives promoted by governments have been addressed to multiple smart dimensions (Kuo and Li, 2022), with those addressing the enhancement of smart living being the most prevalent, followed by smart mobility and smart data (Masrur and Sharifi, 2022). However, despite the relevance claimed by prior research concerning the implementation of ET for urban resilience in SCs, the sustainability aspect is not always prioritised in these initiatives. Indeed, the initiatives addressed to the smart environment dimension which takes a wider approach and relates more to climate action in the form of adaptation to CC are not always in the equation (García Fernández and Peek, 2020).

Conversely, when smart initiatives are spearheaded by experts or vendors in the private sector, their primary focus is on economic outcomes, leading to initiatives in domains such as mobility, energy, and heating (Fekete, 2022). While sustainability is often a central tenet of these initiatives, its role in adaptation also remains marginal (Fekete, 2022). In light of these observations, the third research question is thus posed to ascertain the smart dimensions that are present in the smart initiatives related to CC strategic actions in the sample cities of this research. The following question is thus derived: RQ3. In which smart dimensions are European SCs performing strategic actions to face CC?

Finally, local governments must adopt innovative technologies to facilitate the planning and management of activities aimed at CC mitigation and adaptation. This is necessary to enable adaptation solutions and provide a foundation for their implementation (Pancewicz, 2021). In this regard, the advancement of ETs and SCs are bringing new opportunities for innovation in climate mitigation at both the local and global levels, even when projects address only a small number of resilience characteristics (Grovert et al., 2022; McPherson and Clarke, 2024).

Nonetheless, prior research indicates that sustainability measures in SCs are seldom driven by advanced technology, despite the SC agenda being centred on such innovations (Haarstad and Wathne, 2019; Kuo and Li, 2022). Only recent research has detected a change in this trend, thereby identifying intensive efforts aimed at addressing the CC with the integration of innovative solutions based on AI, IoT, and Big Data (Bibri et al., 2023). Consequently, environmentally sustainable SCs have emerged as a rapidly expanding trend, exhibiting a marked escalation from 2016 to 2021, largely attributable to the advent of the pandemic and the rapid advancement of data-driven technologies (Bibri et al., 2023). Within this context, the fourth research question guiding this study is as follows: RQ4. Which ETs are being used for facing the CC challenge into the urban context? And how are the ETs used in the different smart dimensions?

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2. Data and Research Methods

Citizens are increasingly concerned about the effects their actions have on the environment, as these impacts directly affect their quality of life. As awareness grows, the need to address climate changes becomes even more pressing (Wang and Zhou, 2023; Masrur and Sharifi, 2022). The implementation of new technologies is no longer sufficient to improve citizens' lives, emerging technologies are increasingly gaining more presence. In fact, they are explicitly playing a crucial role in the fight against climate change, as the integration of these technologies not only optimizes urban resources but also fosters the creation of more sustainable urban environments (Theodora and Stratigea, 2021; Kuo and Li, 2022; Yukhno, 2024; Zhen et al., 2024). So, it is essential to understand how smart cities are incorporating these technological innovations into their strategies and how these initiatives contribute to mitigating the impact of climate change.

With this objective in mind, this study focuses on analysing how the leading European smart cities develop environmental strategies to reduce the effects of climate change, leveraging the potential of emerging technologies. The process of data collection occurred in two phases. The first phase involved identifying the European cities recognized as "smart cities" across a series of prominent international rankings such as: Euro Smart Cities 2024/2025, Cities in Motion 2022, Easy Park IMD and Innovation Cities. These rankings are considered global benchmarks in assessing cities' ability to integrate emerging technologies, manage urban resources efficiently, and promote sustainability (Toh, 2022). To ensure a representative sample, cities that appeared in all these rankings were chosen, reflecting their established leadership in the field of smart cities.

In total, 25 European cities meeting these criteria were selected: Vienna, Brussels, Tallin, Helsinki, Lyon, Paris, Berlin, Hamburg, Munich, Dublin, Milan, Amsterdam, Rotterdam, Bratislava, Madrid, Barcelona, Bilbao, Gothenburg, Stockholm, Geneva, Zurich, Prague, Copenhagen, Rome, and Manchester. These cities were selected for their prominent position in the aforementioned rankings and their focus on strategic projects aimed at mitigating climate change.

Once the European cities were identified, the authors defined criteria for selecting the resilience and climate change strategy documents of these cities, drawing upon the framework proposed by Yigicanlar (2018). In this sense, the selection of these documents was: (1) the document must be officially issued or endorsed by the local government of the selected city; (2) it must explicitly address CC adaptation and/or urban resilience as a key strategic objective; (3) it must refer to the integration of emerging technologies within their strategic actions; (4) the document must be publicly available through the official website of the city; and (5) the strategy document must be a full report rather than an executive summary or highlights; (6) the publication date must fall within the period from 2015-2024 to ensure currently and relevance to the contemporary planning context. This initiated the second phases, which was further divided into two sub-phases. Firstly, between October and November 2024, these documents were accessed through the official websites of the cities, and the data was collected and reviewed for the purpose of identifying the key initiatives, stakeholders, and strategies used to address urban climate challenges. Afterwards, the strategies were thoroughly examined, leading to a total of 1,439 cases of smart initiatives. These initiatives were classified based on the department in charge of the initiative, the smart city domain, the stakeholders involved, and the vision, objectives and strategies for mitigating the impact of climate change.

3. Analysis of results

Climate change represents one of the most pressing challenges of the 21st century, particularly in urban context where cities must develop effective strategies to mitigate its effects and enhance resilience. In this regard, smart cities have emerged as hubs of innovation, leveraging emerging technologies (ETs) to improve sustainability and climate governance (Gil-García et al., 2014; Valle-Cruz, 2019). Such technologies enable local administrations to optimize decision-making, coordinate multiple stakeholders, and enhance the efficiency of environmental policy adoption (Kalampokis et al., 2023). However, the effectiveness of these approaches largely depends on the presence of specified organizational structures and interdepartmental collaborations (Rodríguez Bolívar et al., 2020).

Next, the obtained results will be analysed to answer each of the previous described research questions, aiming to provide a comprehensive perspective on the degree of institutionalization of sustainability in European Smart Cities, the cross-sectional nature of their climate policies, and the role of ETs in the transformation of urban governance.

3.1 RQ1: Do smart cities have dedicated departments for sustainability or resilience management?

To assess if the department of Climate and Sustainability Protection leads the initiatives concerning sustainability issues in each European Smart Cities, we first analyse the entity that leads each initiative. In figure 1, we can observe that just 2 percent of the analysed European initiatives are not directly led by the municipal council.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Although collaboration with private companies and academia is highly promoted in European initiative, it seems that only 1 percent of them are led by a private company and leadership by research institutions is practically non-existent (0.35%).

A significant portion of European initiatives (66.16%) do not specify the leading entity, indicating the lack of transparency in project governance. Among the identified leaders, almost 6 percent of initiatives are led by a dedicated municipal department for sustainability or resilience, while a considerably higher percentage (26.27%) are managed by other municipal departments not specially focused on resilience or sustainability. This suggests that, although European Smart Cities have established specialized governance structure for climate action, a significant portion of the initiative address more specific aspect such as a sustainable mobility, building efficiency, urban infrastructure improvements, support for vulnerable groups and so on, which require the assignment of departments better equipped to handle these challenges. As a result, instead of being centrally managed by sustainability or resilience departments, these initiatives are integrated into broader municipal strategies through the relevant sectoral departments. This aligns with prior research highlighting the uneven institutionalization of sustainability governance across smart cities.

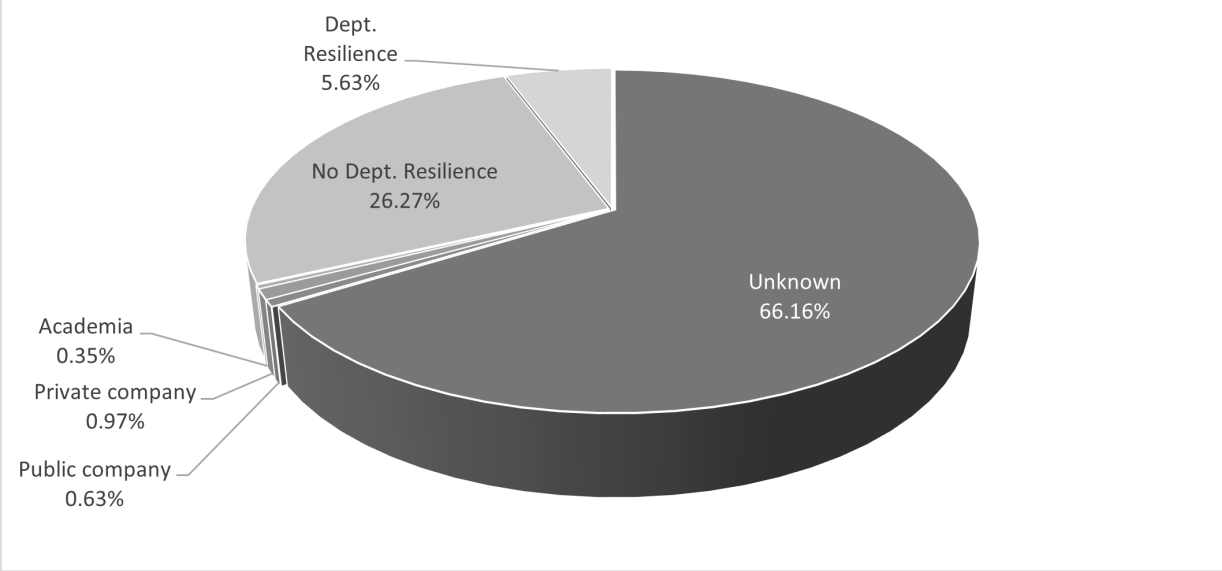


Fig 1 – Departments or Institutions leading European initiatives

Secondly, to further analyse the departments or institutions leading European initiatives, we will evaluate what happens in each of the smart dimensions. For this, the different initiatives have been categorized according to their specific goals based on the smart dimensions of Smart Cities established by Giffinger and Gudrun (2010). The results reveals that a significant portion of initiatives, particularly those related to living -quality life, cultural services, social cohesion and, safety and housing- lack specified leadership (almost 45 percent – see figure 2).

Regarding institutional leadership, public companies play a dominant role in mobility issues (87.5 percent). It may be due to the fact the public transport is generally not an attractive sector for private companies, as it is often not highly profitable. Nevertheless, their presence in other dimensions is minimal. In contrast, private companies emerge as main leaders in environmental initiatives (42.86 percent). It may suggest that these issues require the development and use of advanced technologies that are primarily created and managed by private companies, making their involvement essential in implementing innovative and technical solutions in this field.

Although research institutions play a limited role overall, their involvement in mobility issues (80%), highlighting their contribution to research, technological development, and innovation in transportation and ICT accessibility. However, their absence in other dimensions suggests that they are not primary actors in the direct governance of sustainable initiatives.

As for municipal leadership, sustainability or resilience department is predominant in environmental initiatives (39.51 percent), followed by governance and people initiatives (both 18.52 percent), likely due to their involvement in climate policies, transparency, citizen engagement, and education initiatives on sustainability. We can also observe that environmental initiatives (31.75%) are led by other departments (not sustainability or resilience), as well as living and mobility (both 18.52 percent), reinforcing the idea that each department oversees initiatives aligned with its area of expertise. Therefore, it confirms that European smart cities do not follow a unified governance model for sustainable initiatives.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

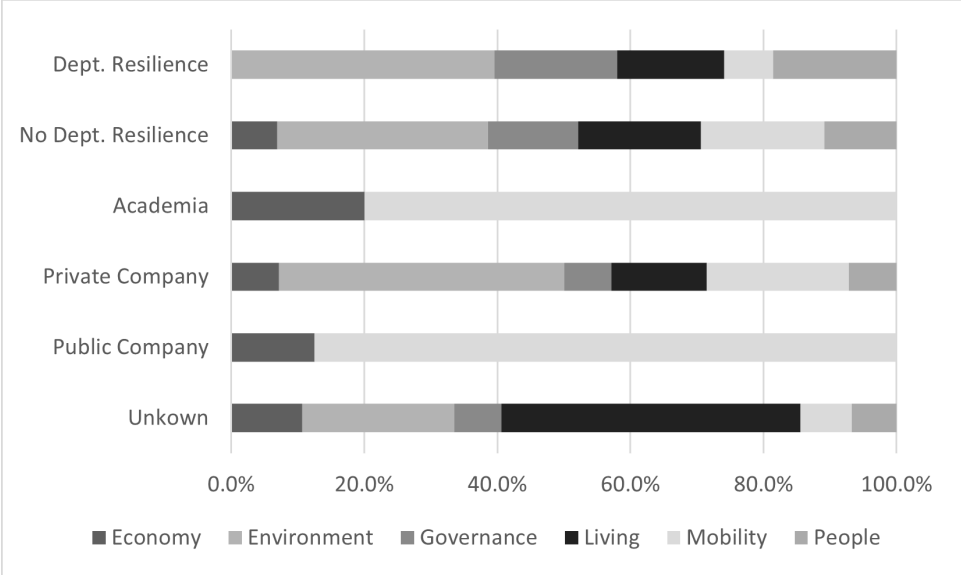


Fig 2 – Departments or Institutions leading European initiatives, depending to smart dimensions

3.2 RQ2. Which department of the city are involved into the strategic planning processes of the measure to protect sustainability and improve city resilience?

In figure 3, we can observe that the majority of European initiatives following a vertical approach, since 70.54 percent of projects being led by a single department. In contrast, just 29.7 percent of European initiative involve multiple departments (transversal approach). Although there is some level of interdepartmental coordination, it remains less common, despite its potential benefits in optimizing resources and creating synergies between different urban policies. The lower percentage of transversal collaboration may reflect structural challenges, such as the complexity of coordinating across departments, bureaucratic barriers, or the need for more integrated governance frameworks. These results align with previous literature, which highlight the difficulties cities face in establishing cross-departmental collaboration for smart initiatives, due to institutional silos, lack of communication channels, and the predominance of sectoral governance models (Liarte et al., 2024; Zhu et al., 2024; Alcaide Muñoz et al., 2023, Rodríguez Bolívar et al., 2023).

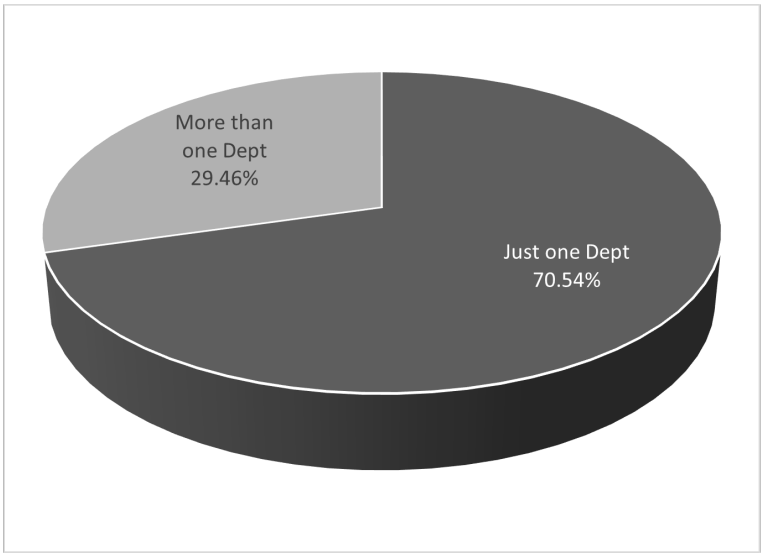


Fig 3 – Interdepartmental collaboration

The analysis provides further insight into how different smart dimensions are managed within vertical and transversal approaches in European smart cities. In this sense, the environment dimension is predominant managed through a vertical approach, that is, 30.35 percent of projects do not involve another department, while only 15.80 percent promote institutional collaboration. It reflects that environmental policies tend to be centralized within specialized municipal units, likely due to the technical expertise required for managing climate-related initiatives, sustainable resources use, and regulatory compliance. As a result, it can limit cross-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

departmental synergies and interdisciplinary collaboration.

The living dimension exhibits the highest level of transversal governance (47.64 percent). It suggests that initiative related to urban well-being require coordination between housing, social affairs, urban planning and environmental departments to ensure a holistic approach to urban sustainability. Additionally, governance dimension also has a greater degree of interdepartmental collaboration (13.68 percent). This is aligned with previous studies suggesting that governance improvements, particularly in areas like transparency, citizen participation, and decision-making processes, often require multi-stakeholder coordination (Alcaide Muñoz et al., 2023, Rodríguez Bolívar et al., 2023). Finally, mobility, people and economy-related initiatives display a more balanced distribution between vertical and transversal governance models, with no significant disparities between the two approaches.

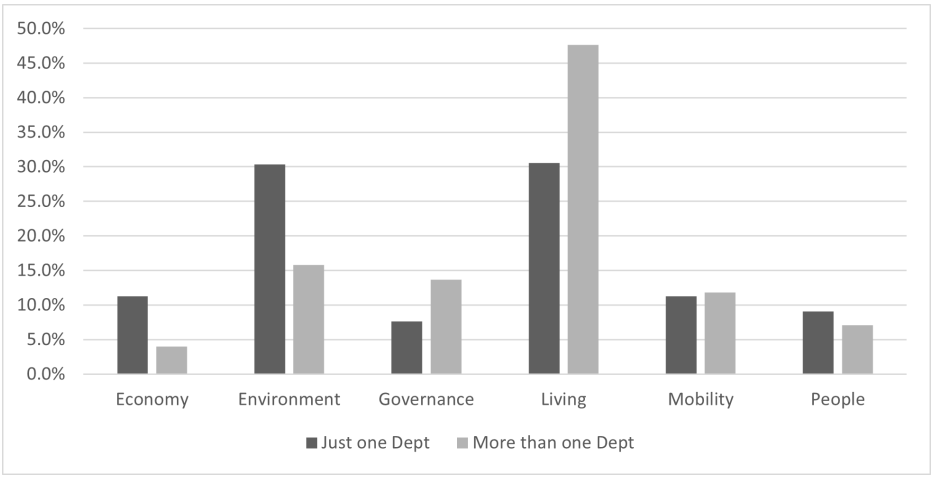


Fig 4 – Interdepartmental collaboration, depending to smart dimensions

To further explore the governance of sustainability initiatives, we will analyse the departments involved specifically in initiative directly focused on environmental issues (see figure 5). So, we can identify municipal departments that play a central role in environmental governance and how different sectors contribute to the implementation of sustainability policies within European smart cities. In this term, the department of Urban Planning and the department of Climate and Environmental Protection (28.18 percent and 23.02 percent, respectively) play the most significant roles, reflecting the importance of land use planning, infrastructure adaptation, and environmental regulation in addressing sustainability challenges. It suggests that urban planning initiatives are deeply integrated with environmental policies to ensure sustainable urban development.

Alongside these main departments, others contribute to environmental initiatives, revealing the interdisciplinary nature of sustainability efforts. There is a growing emphasis on technological solutions and digital engagement in environmental initiatives due to their involvement of the department of innovation and digital transformation and the department of digital governance and citizen participation (10.99 percent and 5.84 percent, respectively). This in line with previous research on the trend of cities to improve citizens' lives through the adoption of use of technology (Alcaide Muñoz et al., 2023; Wang and Zhou, 2023; Sari, 2023).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

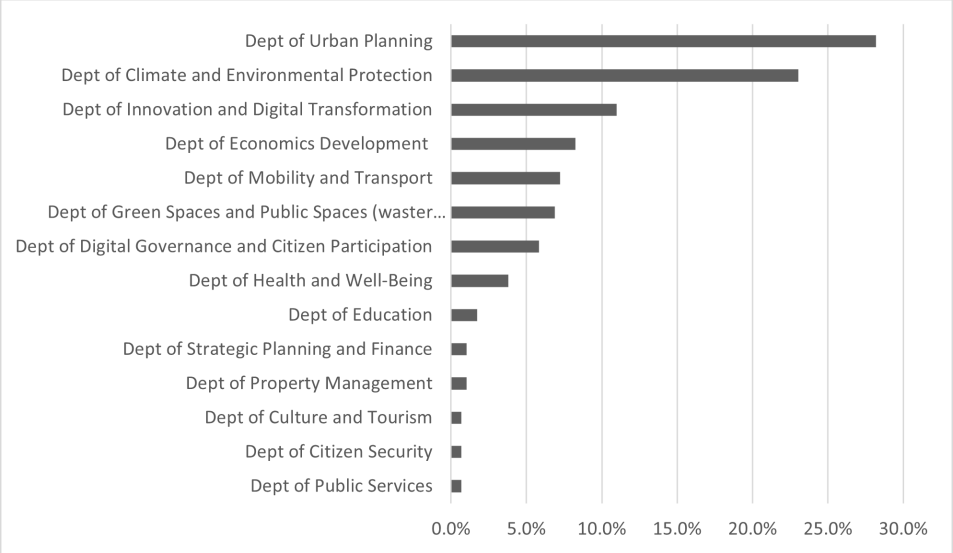


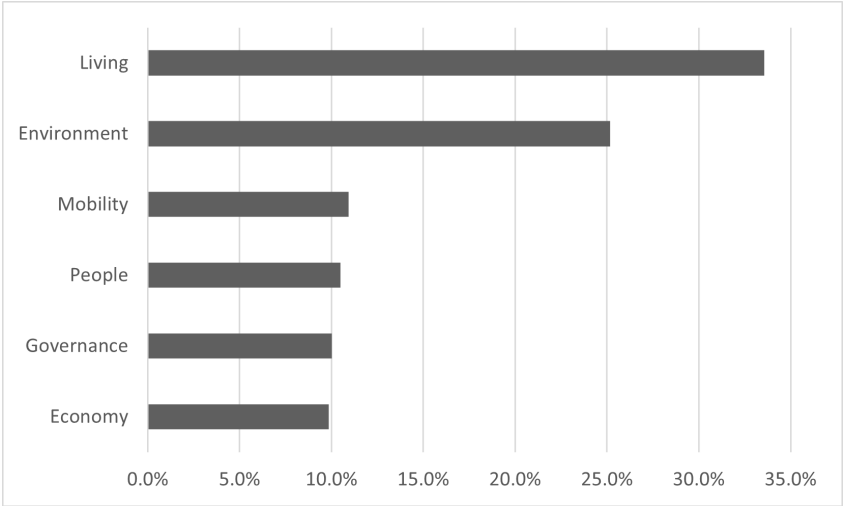
Fig 5 – Department involved in environmental initiatives

Another noteworthy aspect is the involvement of economics and mobility-related departments in environmental initiatives (8.25 percent and 7.21 percent, respectively), which reveals the significant link between environmental sustainability and both economic and mobility issues. Additionally, the existence of a broad scope of environmental initiatives in public health, green infrastructure and education programs issues is also revealed -the department of health and well-being with 3.78 percent, the department of green spaces and public services with 6.87 percent and the department of education with only 1.72 percent-. Nevertheless, the lower involvement of public services, culture and tourism, and citizen security departments (each below 1 percent) suggests their indirect role in climate change affairs.

3.3. RQ3. In which smart dimensions are European Smart Cities performing strategic actions to face climate change?

Figure 6 shows the key actions and thematic areas promoted by European smart cities in their efforts to tackle climate changes. So, we can determine which aspects of sustainability and resilience are being prioritized by such cities under study. It will provide insight into the specific themes and initiatives that are most significant to European smart cities, highlighting their approaches to creating sustainable and resilient urban environments and mitigating their impacts of climate changes.

The main priority of European smart cities is the improvement of quality of life, urban spaces, social cohesion, and safety and housing issues (living dimension-33.56 percent-), as well as the mitigation of climate change via the improvement of energy efficiency and green infrastructure, and the promotion and adoption of sustainable resources (environment dimension-25.16 percent-). Both dimensions involved actions aimed at creation more resilient urban environments and climate adaptation, which reinforces the commitment of cities to adopt eco-friendly initiatives.



Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Fig 6 – The main scope of European initiatives

The following themes that seem to concern European smart cities are those related to the sustainable mobility and economy (10.94 percent and 9.85 percent, respectively). This shows the great concern from both citizens and their policymakers regarding the high levels of pollution and congestion in European cities, motivating the acceleration of the transition to low-carbon transportation and sustainable mobility solutions in order to reduce their environmental impact. In addition, although at first glance economics factors are not as prominent as environmental or social factors, in the strategic actions against climate change, we can expect that the economy dimension to become more relevant as cities aim to integrate green business models and sustainable growth.

Lastly, the Government dimension, accounting for 10.02 percent, indicates the need for transparent decision-making, participatory governance, and collaboration across stakeholders, which underscores the importance of policy frameworks and institutional cooperation in adopting effective climate change initiatives.

3.4. RQ4. Which Emerging technologies are being used for facing the climate change challenge into the urban context? And how are the ETs used in the different smart dimensions?

Emerging technologies play a pivotal role in shaping the future of urban governance, particularly in the context of addressing the complex challenges posed by climate change and sustainability (Suprayitno et al., 2024). Technologies such as big data, artificial intelligence (AI), smart sensors or blockchain, offer unprecedented opportunities to enhance decision-making, optimize resources management, and foster transparency in public administration (Yukhno, 2024). These innovations enable governments to process vast amounts of data in real-time, allowing for more informed, agile responses to urban challenges (Gil-Garcia et al., 2014). However, despite their potential, the integration of emerging technologies into public sector operations presents several challenges. Public administration must contend with issues such as data privacy and security, bureaucratic resistance, skill gaps, and the need for interdepartmental coordination (Kankanhalli et al., 2023; Alcaide Muñoz et al, 2023; Zhu et al., 2024; Liarte et al., 2024). Furthermore, their successful adoption requires significant investment in infrastructure, capacity building, and the development of regulatory frameworks that ensure ethical and effective use (U.S. Government Accountability Office – GAO-, 2021; Merguel et al., 2024). As cities increasingly rely on these technologies to drive sustainability and resilience, it is essential for policymakers to address these challenges to fully leverage the transformative potential of emerging technologies for public governance (Kalampokis, et al., 2023; Rodríguez Bolívar et al., 2023).

As we can see in figure 7, emerging technologies such as big data and smart sensors are the most widely used, in fact 16.06 percent and 14.03 percent of European initiatives incorporating these solutions, respectively. Big data allows cities to process vast amounts of environmental, transportation and infrastructure data, facilitating informed decision-making that optimizes resources management and supports climate mitigation initiatives. Similarly, smart sensors, deployed throughout urban environments, provide real-time data on key metrics such as air quality, energy consumption, and even traffic flow, enabling cities to monitor and respond to environmental challenges more effectively.

Digital tools, encompassing a wide range of platforms and applications, emerge as a centra technology in 11.57 percent of initiatives. They play a crucial role in urban management by facilitating the integration of various systems, including smart grids and sustainable urban planning frameworks. By leveraging these tools, cities can enhance their operational efficiency and make more informed, data-driven decisions regarding climate resilience. In addition to these, artificial intelligence (AI) (9.48 percent) is a pivotal technology for developing predictive models and optimization algorithms. It plays a critical role in urban sustainability by enabling cities to anticipate environmental challenges, such as extreme weather events, and optimize energy consumption across systems. This technology contributes to enhanced climate adaptation initiatives, ensuring that urban areas can adjust to rapidly changing environmental conditions.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

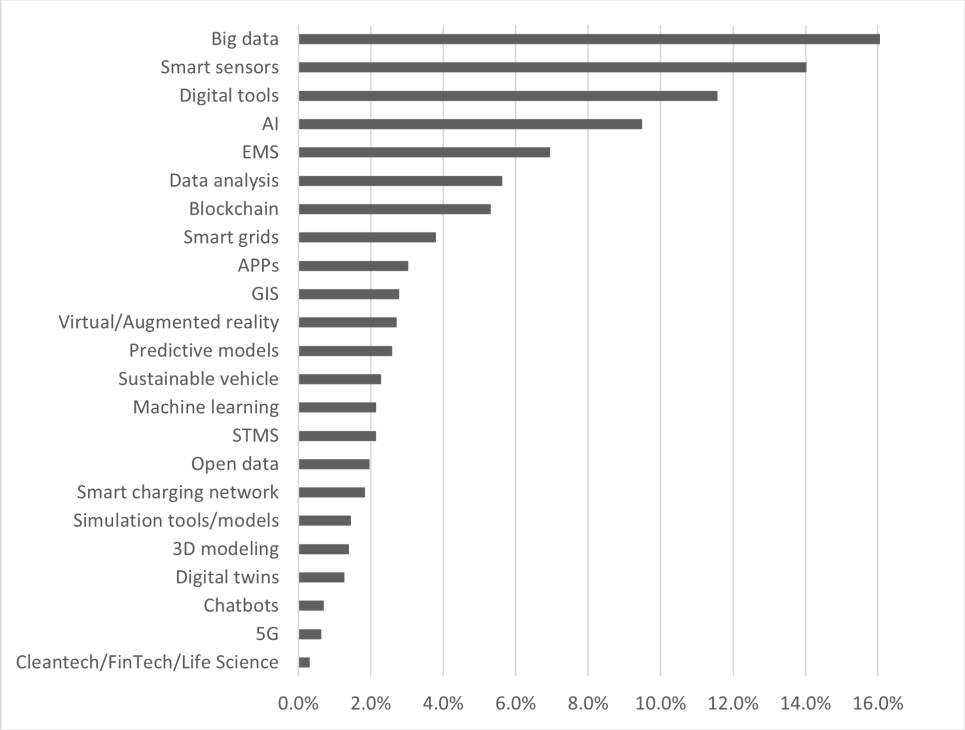


Fig 7 – The main emerging technology used in European initiatives

Energy Management System (EMS) appears in almost 7 percent of initiatives. This technology enables cities to monitor, control and optimize energy distribution and consumption in real-time, ensuring that energy use is both efficient and sustainable. By integrating renewable energy sources and improving the efficiency of urban energy systems. EMS technology significantly reduce cities' carbon footprint. Another important technology in environmental initiatives is blockchain (5.32 percent). Such technology improves transparency, security and efficiency in the management of environmental data. In fact, Blockchain is a great promise in sectors such as carbon credit trading, waste management, and the management of sustainable supply chains, providing secure, immutable records and environmental actions and facilitation accountability in urban sustainability efforts.

Figure 8 shown the representation of each emerging technologies depending on the specific goals of each initiative. In this sense, technologies as EMS and smart sensors and EMS (60.87 percent and 39.39 percent, respectively) play a central role, emphasizing the importance of environmental monitoring and efficiency energy management in European cities' sustainable initiatives. Moreover, big data, with a 21.26 percent of initiatives, and IA, with a 20. Percent of initiatives, are widely used, underscoring the growing reliance on data-driven decision-making to tackle environmental challenges and optimize urban systems.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

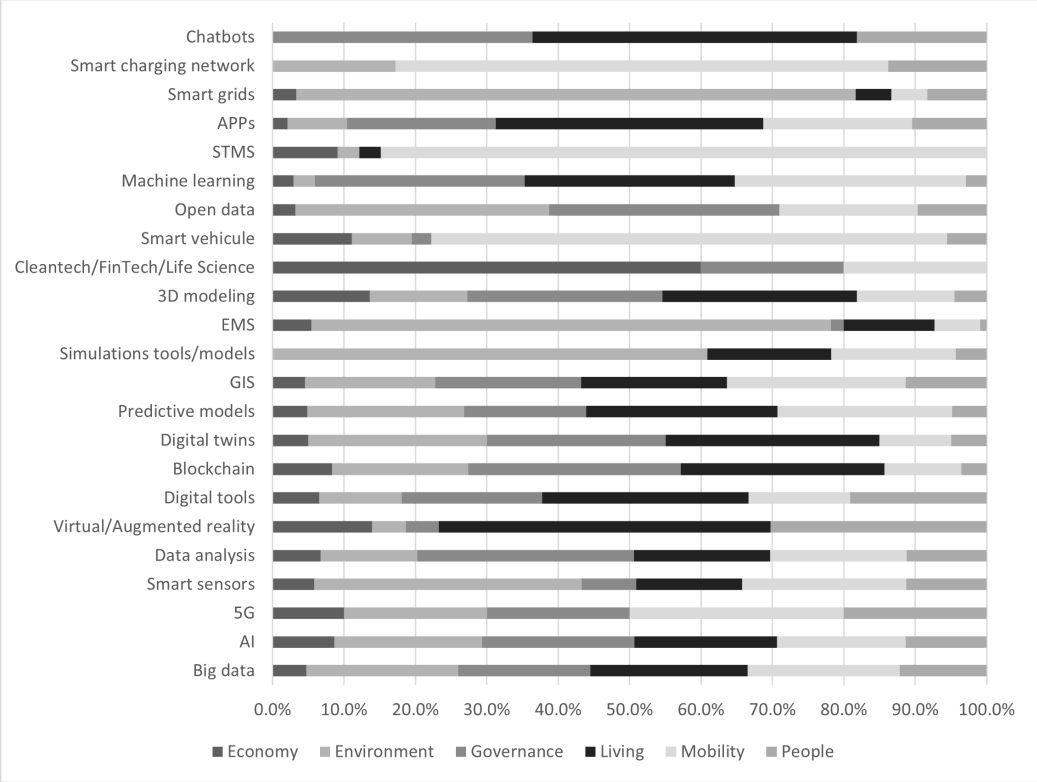


Fig 8 – The main emerging technology used in European initiatives, depending on smart dimensions

Initiatives focused on improving citizens' lives, social cohesion, safety and housing as well as promoting culture and tourism, show a greater presence of virtual/augmented reality and digital tools, with 46.51 percent and 28.96 percent, respectively. It suggests that such technologies are leveraged to enhance urban quality of life, public engagements, and the design of more interactive and sustainable urban spaces. They likely contribute to creating more resilient and adaptative environments that can respond effectively to climate change.

In the case of sustainable mobility issues, the use of smart grids (84.85 percent) and smart vehicles (72.22 percent) stand out. These technologies reflect the growing emphasis on sustainable transportation solutions, such as electric vehicle and intelligent transportation systems, designed to reduce carbon emissions and improve urban mobility. This trend aligns with the push for greener, more efficient cities with less reliance on fossil fuels (Inci et al., 2024; Zheng et al., 2024; Khaleel et al., 2024).

Furthermore, predictive models and digital tools (20.45 percent and 19.67 percent, respectively) are key to enhancing digital governance and transparency in city management (governance smart dimension). The use of these technologies enables municipalities to implement more efficient policymaking, predictive analytics for urban planning, and citizen engagement initiatives making them central to the development of smart government frameworks. Digital tools (19.13 percent), along with chatbots (18.18 percent), are commonly used to improve public services and citizen interaction (people smart dimension), as they not only facilitate better access to services, but also enhance public participation and help cities engage with their populations more effectively.

Lastly, in the economy dimension, CleanTech/FinTech is predominant, used in 60 percent of economic initiatives. This suggests that European cities are focusing on leveraging sustainable technologies and financial technologies to drive economic transformation, aiming to transition towards more eco-friendly and resilient economic structures. These initiatives align with the growing interest in circular economy models, seen as key to promoting long-term economic sustainability in urban environments. Other emerging technologies such as AI (8.57 percent), data analysis (5.86 percent), big data (4.72 percent), and AI are predominant, emphasizing the importance of data-driven decision-making in fostering sustainable economic practices and business models. Additionally, digital tools, with 6.56 percent, and smart sensors, with 5.86 percent, are employed to optimize resources allocation and urban economic planning, enabling smarter and more efficient economic initiatives.

Blockchain (5.31 percent) and predictive models (4.88 percent) also play a role in supporting financial innovation and enhancing the resilience of urban economies, ensuring that cities can adapt to shifting economic landscapes and incorporate green business models.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

To summarise, big data, AI and smart sensors are foundational to environmental and governance initiatives, while virtual/augmented reality, smart grids, and smart vehicles dominate in living and mobility initiatives. In addition, CleanTech/FinTech have a significant presence in economic initiatives. Therefore, European cities are increasingly integrating emerging technologies into their initiatives to address climate change and urban resilience in a comprehensive manner. By targeting specific goals, European cities are adopting a multifaceted approach to achieving sustainability and adapting to the challenges posed by climate change.

4. Conclusions and discussion

This study has analyzed how a set of European smart cities strategically plan actions to address the challenge of climate change through the implementation of smart initiatives. Specifically, four key aspects have been examined: the governance of these initiatives, including institutional leadership and the departments involved; the smart dimensions in which climate adaptation strategies are being developed; the role of emerging technologies in urban planning and climate resilience; and the integration of these technologies into the various smart dimensions of the city.

Unlike previous studies that have analyzed climate governance in smart cities in isolation (Hofstad et al., 2022) or focused solely on the role of emerging technologies in urban planning (Bibri et al., 2023; Su and Fan, 2023), this study offers an integrated perspective that combines both approaches. This allows for a deeper understanding of how governance structures influence the adoption and effectiveness of technological solutions in the context of climate action. While previous research has highlighted institutional fragmentation in smart city planning (Liarte et al., 2024; Zhu et al., 2024), this study advances by identifying the specific departments involved in the strategic planning of climate initiatives, highlighting the absence of efficient interdepartmental coordination structures.

The findings reveal that, although European smart cities have made progress in incorporating climate strategies into their urban plans, the governance of these initiatives does not follow a uniform model. While some municipalities have established dedicated departments for resilience and sustainability, a significant portion of initiatives remains managed by other municipal areas without a clear centralized structure. This aligns with previous studies indicating institutional fragmentation and the lack of coordinated leadership as barriers to the effectiveness of climate adaptation strategies (Birchall et al., 2023; Reckien et al., 2023).

Moreover, the analysis reveals that private sector involvement in the formulation and leadership of these initiatives is minimal. Similarly, the engagement of academic institutions and research centers in strategic planning is practically nonexistent. This finding is particularly relevant as it contrasts with trends observed in other regions, where public-private collaboration and the incorporation of scientific knowledge play a fundamental role in innovation and the formulation of urban sustainability strategies (OECD, 2024a; McPherson and Clarke, 2024). The limited presence of these key actors in the planning of European smart cities suggests a lack of articulation between technological and scientific advancements and their application in climate governance, potentially limiting the impact and effectiveness of implemented initiatives.

Regarding the dimension of urban initiatives, mobility is predominantly led by the public sector and primarily managed by municipal enterprises. This due to the strategic nature of transportation, the substantial investment in infrastructure it requires, and the strong governmental control and regulation in place. Private sector participation in this area is generally limited to complementary services. In contrast, environmental initiatives exhibit a high degree of private collaboration, as they largely rely on innovation and technological specialization. Meanwhile, initiatives aimed at enhancing quality of life face an unclear distribution of responsibilities, which could limit their overall impact. To improve governance in smart cities, it is essential to establish clearer structures and strengthen transparency in the management of urban initiatives, ensuring greater efficiency and sustainability in their implementation.

Moreover, the results highlight a lack of interdepartmental collaboration, as few initiatives involve multiple departments. This low incidence suggests the presence of structural and organizational barriers, such as the complexity of administrative coordination, bureaucratic rigidity, and the absence of more integrated governance frameworks. These findings reinforce prior evidence on the obstacles posed by institutional silos and the lack of interdepartmental communication, factors that continue to hinder the effectiveness of climate strategies in smart cities (Liarte et al., 2024; Zhu et al., 2024; Alcaide Muñoz et al., 2023; Rodríguez Bolívar et al., 2023).

The analysis of the smart dimensions involved in climate planning shows that initiatives related to environmental sustainability and urban quality of life are the most represented, reinforcing the idea that climate action is being integrated into key urban aspects (García Fernández and Peek, 2020; Bibri et al., 2023). However, the limited interconnection between these initiatives and other strategic dimensions, such as mobility and the economy, suggests that opportunities remain for greater cross-cutting integration of climate policies within smart urban planning.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

European smart cities are prioritizing quality of life and environmental sustainability in their strategic approaches, with a strong emphasis on sustainable mobility and the development or greener economies. This focus is largely driven by the existing regulatory framework and sustainability policies within the EU -particularly the European Green Deal 2050 (European Commission, 2024)- as sustainable mobility is considered a strategic priority due to its direct impact on emission reduction and public health improvement.

Furthermore, the study confirms that tools such as big data, AI, and smart sensors are playing a fundamental role in data-driven decision-making and the efficient management of urban resources. However, their implementation still faces significant challenges, including the lack of interdepartmental integration, the need for greater investment in infrastructure, and the regulation of data usage. In particular, the adoption of more advanced technologies, such as blockchain or AI predictive models, remains limited, raising questions about the barriers hindering their integration into urban climate governance (Kalampokis et al., 2023; Rodríguez Bolívar et al., 2023). To overcome these limitations and maximized their impact, a coordinated strategy between governments, businesses, and citizens is essential, ensuring that technological innovations are both accessible and sustainable in the long term.

Based on the results obtained, several lines of research are identified that can contribute to a more detailed understanding of the challenges and opportunities in the strategic planning of smart cities in response to climate change. First, the absence of a unified model and the predominance of sectoral approaches hinder interdepartmental coordination and limit the effectiveness of climate initiatives. Further research is needed to analyze collaborative governance models that promote greater articulation between municipal departments and levels of government, fostering more cross-cutting and adaptive decision-making structures. Future studies could examine successful cases where the integration of governmental actors has facilitated more efficient and coordinated planning.

Similarly, assessing the real impact of emerging technologies on climate adaptation and mitigation represents a priority research area. Although tools such as artificial intelligence, blockchain, and big data have demonstrated high potential for optimizing urban processes and enhancing climate resilience, their effectiveness remains insufficiently documented. Empirical studies are required to analyze the extent to which these technologies have contributed to reducing emissions, improving energy efficiency, or strengthening the capacity to respond to extreme climate events. Additionally, identifying the factors that facilitate or hinder their implementation in different urban contexts would allow for more precise recommendations for their integration into municipal planning.

In conclusion, this study contributes to the understanding of strategic planning in smart cities in response to climate change by providing an integrative perspective on the intersection of governance, technology, and the participation of strategic actors. The identification of shortcomings in interdepartmental collaboration, the limited involvement of the private and academic sectors, and the need to assess the impact of emerging technologies underscore the importance of advancing these research lines. The consolidation of more efficient and adaptive governance models will be crucial to ensuring that smart cities can respond more effectively and in a coordinated manner to future climate challenges.

Acknowledgement

- **Funding or Grant:** This research was funded by the Regional Government of Andalusia and the University of Granada, Spain (Research project number C-SEJ-325-UGR23).
- **Contributor Statement***: **Manuel Pedro Rodríguez Bolívar:** Conceptualization, Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Data Curation, Investigation. **Cristina Alcaide Muñoz:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Formal analysis, Data curation, Visualization; **Laura Alcaide Muñoz:** Writing – review & editing, Writing – original draft, Resources, Methodology, Data Curation, Investigation; **Rocío de la Torre Martínez**: Writing – review & editing, Writing – original draft, Resources, Methodology, Data Curation, Investigation.
- **Use of AI***: No use of AI.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Alcaide Muñoz, L., Rodríguez Bolívar, M.P., & Alcaide Muñoz, C. (2023). Political determinants in the strategic planning formulation of smart initiative. *Government Information Quarterly*, 40(1), 101776.

Beer, A., Sotarauta, M., & Ayles, K. (2021). Place, city, regional, rural leadership: A review. *Handbook on city and regional leadership*, 19-39.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Bera, M., & Lewicki, W. (2023). The Municipal Plan for Adaptation to Climate Change and Its Role in the Strategic Management of the Local Authority. *Scientific Papers of Silesian University of Technology. Organization & Management/Zeszyty Naukowe Politechniki Slaskiej. Seria Organizacji i Zarzadzanie*, (184).

Bibri, S. E., Alexandre, A., Sharifi, A., & Krogstie, J. (2023). Environmentally sustainable smart cities and their converging AI, IoT, and big data technologies and solutions: an integrated approach to an extensive literature review. *Energy Informatics*, *6*(1), 9.

Birchall, S. J., & Bonnett, N. (2021). Climate change adaptation policy and practice: The role of agents, institutions and systems. *Cities*, *108*, 103001.

Birchall, S. J., Bonnett, N., & Kehler, S. (2023). The influence of governance structure on local resilience: Enabling and constraining factors for climate change adaptation in practice. *Urban Climate*, *47*, 101348.

Bonnett, N. L., & Birchall, S. J. (2023). The influence of regional strategic policy on municipal climate adaptation planning. *Regional Studies*, *57*(1), 141-152.

Butler, W., Holmes, T., & Lange, Z. (2021). Mandated planning for climate change: responding to the peril of flood act for sea level rise adaptation in Florida. *Journal of the American Planning Association*, *87*(3), 370-382.

European Commission (2024). The European Green Deal 2050. Available at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/story-von-der-leyen-commission/european-green-deal_en?prefLang=es

Fekete, K. A. (2022). *Combating Climate Change through Smart Innovations-Examination of smart city concept in light of sustainability* (Doctoral dissertation, Budapesti Corvinus Egyetem).

García Fernández, C., & Peek, D. (2020). Smart and sustainable? Positioning adaptation to climate change in the European smart city. *Smart Cities*, *3*(2), 511-526.

Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: an effective instrument for the positioning of the cities?. *ACE: architecture, city and environment*, *4*(12), 7-26.

Grovert, A., Sambo, C., Meier, B., & Ko, Y. (2022). The Contributions of Smart City Initiatives to Urban Resilience: The Case of San Francisco, California, United States. In *Resilient Smart Cities: Theoretical and Empirical Insights* (pp. 303-322). Cham: Springer International Publishing.

Haarstad, H., & Wathne, M. W. (2019). Are smart city projects catalyzing urban energy sustainability?. *Energy policy*, *129*, 918-925.

Hanssen, G. S., & Tønnesen, A. (2022). Core-city climate leadership in metropolitan contractual management agreements. *European Planning Studies*, *30*(2), 269-291.

Hofstad, H., Sørensen, E., Torfing, J., & Vedeld, T. (2022). Designing and leading collaborative urban climate governance: Comparative experiences of co-creation from Copenhagen and Oslo. *Environmental Policy and Governance*, *32*(3), 203-216.

Hurlimann, A., Moosavi, S., & Browne, G. R. (2021). Urban planning policy must do more to integrate climate change adaptation and mitigation actions. *Land Use Policy*, *101*, 105188.

Inci, M., Çelik, Ö., Lashab, A., Bayındır, K. Ç., Vasquez, J. C., & Guerrero, J. M. (2024). Power system integration of electric vehicles: A review on impacts and contributions to the smart grid. *Applied Sciences*, *14*(6), 2246.

IPCC (Intergovernmental Panel on Climate Change) (2018). *Global Warming of 1.5° C. An IPCC Special Report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Geneva: ipcc.

Khaleel, M., Yusupov, Z., Alfalh, B., Guneser, M. T., Nassar, Y., & El-Khozondar, H. (2024). Impact of Smart Grid Technologies on Sustainable Urban Development. *International Journal of Electrical Engineering and Sustainability*, 62-82.

Kuo, N. W., & Li, C. E. (2022). Do Smart Cities Projects Contribute to Urban Resilience? A Case Study Based in Taipei City, Taiwan. In *Resilient Smart Cities: Theoretical and Empirical Insights* (pp. 189-212). Cham: Springer International Publishing.

Lai, C. M. T., & Cole, A. (2023). Measuring progress of smart cities: Indexing the smart city indices. *Urban governance*, *3*(1), 45-57.

Liarte, I., Criado, J. I., & Alcaide-Muñoz, L. (2024). Exploring Barriers to Innovation in Public Administration: An Empirical Study of the Local Layer of Government. *International Journal of Public Administration in the Digital Age (IJPADA)*, *11*(1), 1-23.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Masrur, H., & Sharifi, A. (2022). Contributions of Smart City Projects to Resilience: Lessons Learned from Case Studies. In *Resilient Smart Cities: Theoretical and Empirical Insights* (pp. 171-187). Cham: Springer International Publishing.

McPherson, C., & Clarke, A. (2024). Leadership and Climate Change Mitigation: A Systematic Literature Review. *Climate*, *12*(12), 207.

Meijerink, S., & Stiller, S. (2013). What kind of leadership do we need for climate adaptation? A framework for analyzing leadership objectives, functions, and tasks in climate change adaptation. *Environment and Planning C: Government and Policy*, *31*(2), 240-256

Mergel, I., Dickinson, H., Stenvall, J., & Gasco, M. (2024). Implementing AI in the public sector. *Public Management Review*, 1-14.

OECD (2023a). *Climate adaptation: Why local governments cannot do it alone*. OECD Environment Policy Papers, No. 38. Paris: OECD Publishing. Available at https://doi.org/10.1787/be90ac30-en.

OECD (2023b). *A Territorial Approach to Climate Action and Resilience*. OECD Regional Development Studies. Paris: OECD Publishing. Available at https://doi.org/10.1787/1ec42b0a-en.

OECD (2024a). *Climate change adaptation: Policies for a resilient future*. OECD Net Zero+ Policy Papers, No. 3. Paris: OECD Publishing. Available at https://doi.org/10.1787/8f29a387-en.

OECD (2024b). *Infrastructure for a Climate-Resilient Future*. Paris: OECD Publishing. Available at https://doi.org/10.1787/a74a45b0-en.

Pancewicz, A. (2021). Planning and strategic tools for adapting urban areas to climate change in Poland. *Architecture, Civil Engineering, Environment*, *14*(4), 31-44.

Parker, S., Hartley, J., Beashel, J., & Vo, Q. (2023). Leading for public value in multi-agency collaboration. *Public Policy and Administration*, *38*(1), 83-106.

Rapoport, E., Acuto, M., & Grcheva, L. (2019). *Leading cities: A global review of city leadership* (p. 140). Ucl Press.

Reckien, D., Buzasi, A., Olazabal, M., Spyridaki, N. A., Eckersley, P., Simoes, S. G., ... & Wejs, A. (2023). Quality of urban climate adaptation plans over time. *npj Urban sustainability*, 3(1), 13.

Rodríguez Bolívar, M.P., Alcaide Muñoz, L. & Alcaide Muñoz, C. (2023). Identifying patterns in samrt initiatives' planning in smart cities. An empirical analysis in Spanish smart cities. *Technological Forecasting and Social Change*, 196, 122781.

Sancino, A., Stafford, M., Braga, A., & Budd, L. (2022). What can city leaders do for climate change? Insights from the C40 Cities Climate Leadership Group network. *Regional Studies*, *56*(7), 1224-1233.

Sari, A. R. (2023). The Impact of Good Governance on the Quality of Public Management Decision Making. *Journal of Contemporary Administration and Management (ADMAN)*, *1*(2), 39-46.

Shi, L. (2019). Promise and paradox of metropolitan regional climate adaptation. *Environmental Science & Policy*, *92*, 262-274.

Sotarauta, M., & Beer, A. (2021). Introduction to city and regional leadership. In *Handbook on city and regional leadership* (pp. 2-18). Edward Elgar Publishing.

Su, Y., & Fan, D. (2023). Smart cities and sustainable development. *Regional Studies*, *57*(4), 722-738.

Suprayitno, D., Iskandar, S., Dahurandi, K., Hendarto, T., & Rumambi, F. J. (2024). Public Policy In The Era Of Climate Change: Adapting Strategies For Sustainable Futures. *Migration Letters*, *21*(S6), 945-958.

Theodora, Y., & Stratigea, A. (2021). Climate change and strategic adaptation planning in mediterranean insular territories: gathering methodological insights from greek experiences. In *Computational Science and Its Applications–ICCSA 2021: 21st International Conference, Cagliari, Italy, September 13–16, 2021, Proceedings, Part X 21* (pp. 100-115). Springer International Publishing.

Toh, C. K. (2022). Smart city indexes, criteria, indicators and rankings: An in-depth investigation and analysis. *IET Smart Cities*, *4*(3), 211-228.

U.S. Government Accountability Office (GAO). (2021). *Technology in the public sector: Ensuring that regulatory frameworks evolve with emerging technologies to safeguard public interests.* Retrieved from https://www.gao.gov/assets/d24106122.pdf

Vignola, R., Leclerc, G., Morales, M., & Gonzalez, J. (2017). Leadership for moving the climate change adaptation agenda from planning to action. *Current Opinion in Environmental Sustainability*, *26*, 84-89.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Wang, M., & Zhou, T. (2023). Does smart city implementation improve the subjective quality of life? Evidence from China. *Technology in Society*, *72*, 102161.

Yigitcanlar, T. (2018). Smart city policies revisited: Considerations for a truly smart and sustainable urbanism practice. *World Technopolis Reiew*, 7, 97-112.

Yukhno, A. (2024). Digital transformation: Exploring big data governance in public administration. *Public Organization Review*, *24*(1), 335-349.

Zheng, Z., Shafique, M., Luo, X., & Wang, S. (2024). A systematic review towards integrative energy management of smart grids and urban energy systems. *Renewable and Sustainable Energy Reviews*, *189*, 114023.

Zhu, J., Xiao, H., & Wu, B. (2024). From big data to higher bureaucratic capacity: Poverty alleviation in China. *Public Administration*, *102*(1), 61-78.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Opportunities and Challenges for Management and Governance in Smart Cities in Brazil.

Luísa Paseto [a*] *Márcia Regina Martins Martinez Corso* [b], *Andre Ponce de Leon Ferreira de Carvalho* [c].

[a*] CPA IARA USP – MCTI - Applied Research Center: Artificial Intelligence Reconstructing Environments/ São Carlos/Brasil. lu.paseto@usp.br. ORCID number 0000-0002-1810-2502

[b] CPA IARA USP – MCTI - Applied Research Center: Artificial Intelligence Reconstructing Environments/ São Carlos/Brasil. marcia.martinez@usp.br. ORCID number 0009-0004-8916-5457

[c] CPA IARA USP – MCTI - Applied Research Center: Artificial Intelligence Reconstructing Environments/São Carlos/Brasil, andre@icmc.usp.br, ORCID number 0000-0002-4765-6459

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. The inteli.gente platform is an adaptation and expansion of the Sustainable Smart City Maturity Model of the International Telecommunication Union – SSCMM-ITU and is the first step towards the formation of a Brazilian BIG DATA with customized information on the levels of maturity in digital transformation and sustainable development. The diagnoses and recommendations for the estimated maturity levels use AI and data science techniques for the analyses, predictions and estimates of the 5,570 municipalities, considering the diverse characteristics and specific needs of each Brazilian territory. The result presented on the Brazilian maturity level for digital transformation and development indicates a country between the planning level (3) and the alignment level (4) of its actions. For the sociocultural dimension, the diagnoses of the municipalities indicate the need for attention in their management and governance policies for digital inclusion and social inclusion in an equitable manner throughout their territory. For the economic dimension, the results indicate that Brazil already has a framework of management tools implemented that enable the development of digital transformation and a sustainable economy. The environmental dimension indicates that strong action is needed to improve basic infrastructure in sanitation, solid waste, among other topics for the resilience of future generations. The result of the Brazilian maturity level for the institutional capabilities dimension demonstrates that municipalities should be concerned with data governance, training leaders for digital transformation, planning and elaboration of goals and plans, among other topics. The availability and use of the inteli.gente platform by managers and public policy makers, using Artificial Intelligence (AI) tools, has made it possible to map and improve institutional public policies based on primary and secondary data from municipalities, promoting cooperation, exchange and the creation of innovative initiatives related to digital transformation and sustainable development in the public sector.

Keywords. Artificial intelligence, Smart cities, Governance systems, Public policies, inteli.gente, Management
Policy paper, DOI: https://doi.org/10.59490/dgo.2025.1014

1. Introduction

Planning and actions to become a smart city are increasingly present in sustainable development and digital transformation agendas around the world. The concepts of smart cities emerge from the development of information and communication technologies (ICT) and the need for their incorporation into the governance of public services, both in urban and rural environments.

According to Bibri, S. E., & Krogstie, J. (2017), smart city models were developed through standardization and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

assessments to define their maturity level and for comparisons and incentives to competitiveness. In this sense, the Brazilian Ministry of Science, Technology and Innovation (MCTI) adapted and expanded the inteli.gente platform, a Sustainable Smart Cities Maturity Model (SSCMM- ITU-T Y 4906, 2016), developed by the International Telecommunication Union (ITU), to Brazil. Used mainly in countries of the Global North, also called U4SSC, it is a flexible model that can be applied in different contexts for decision-making regarding the use of technological infrastructure for digital transformation and sustainable development, with the differential of focusing on quality of life for the population.

The National Center for Research in Applied Artificial Intelligence – IARA-USP, supported by MCTI, since November 2021, has remodeled the inteli.gente platform, with AI tools transforming it into a data lake for sustainable development and digital transformation with estimated diagnoses of maturity levels for all Brazilian municipalities.

Using Artificial Intelligence (AI) tools, it is possible to map and improve institutional public policies based on data provided by municipalities, promoting cooperation, exchange and the creation of innovative initiatives related to digital transformation and sustainable development in the public sector.

Inteli.gente is made available free of charge to 5,570 municipalities for the management and governance of data and knowledge in real time, as well as to public policy makers, academia, the general population, students, council bodies, among others. Other initiatives for smart cities are applied in Brazil, as well as some indicators and metrics for international comparability: ITU ICT Development Index (IDI), Cybersecurity: ITU Global Cybersecurity Index (GCI), E-Commerce: UNCTAD B2C E-commerce Index, E-Gov: UN E-Government Development Index (EGDI).

As an ITU Member State, Brazil has approved the inteli.gente platform as a Brazilian use case in the implementation of the SSCMM-ITU (Y-78 ITU-T, 2023).

1.1 inteli.gente platform

The methodology used in the expansion and adaptation of the SSCMM-ITU followed the studies reported in Yigitcanlar (2019), which consider that public participation in decision-making and collaboration between all stakeholders ensure progress towards sustainability.

In selecting the indicators, more than 1,000 indicators from various sources were analyzed, the most significant being (PCSI, 2018; ISO 37120, 2018; ISO 37122, 2019; ISO 37123, 2019; SEADE, 2023; ODS, 2023; CNM, 2023). From this evaluation, 113 indicators were selected. Due to its vast territorial extension, Brazil presents great regional and local differences. Although the laws stipulate that access to information and electronic services must be available on municipal websites, there are still varied realities between cities. In this diverse context, the inteli.gente platform is considered strategic, as it enables the understanding of these differences and realities, guiding the process of planning and building effective and efficient public policies for Brazilian cities.

The diagnoses and recommendations are divided into four dimensions: economic, environmental, sociocultural and institutional capacity, used for the management and governance of public policies. As in the SSCMM-ITU, the measurement of indicators in the inteli.gente platform adopts scoring levels based on the achievement of performance targets, defined based on the average Brazilian performance index, considering several thematic areas relevant to public policies for cities and the population.

The maturity levels provide a diagnosis for cities seeking their own development in the short, medium and long term. Each level has its objectives, indicators and expected practices organized by public policy themes, presenting an evolutionary diagnosis for sustainable smart cities.

The major change to the Brazilian model was the addition of two maturity levels at the bottom of the SSCMM-ITU. The other SSCMM-ITU maturity levels, known as planning, alignment, development, integration and optimization, were kept the same.

The two new Brazilian maturity levels were called "adherence" and "engagement" with the aim of covering Brazilian cities that are less advanced in terms of sustainable development and digital transformation. Thus, the creation of these two additional levels was necessary due to regional and local disparities between Brazilian cities, allowing all Brazilian cities to participate in the new model developed.

At the first level, called Adhesion, the city recognizes some of its main issues and understands the challenges for its digital transformation. This level is characterized by asymmetries in infrastructure, service provision and public facilities. The degree of digitalization related to services and processes is low. Cities at this level present the lowest results in terms of sustainable development and ICT indicators, indicating the need for improvements in economic, environmental and sociocultural aspects. The diagnoses provided by the inteli.gente platform at this level propose

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the development of public policies that promote the benefits of public management in people's lives and improve sociocultural, economic and environmental indicators.

At the second level, called Engagement, we can see the beginning of transformation actions in the city. Sectoral goals for the incorporation of technology emerge. There are actions to identify the areas most prioritized for investments in basic infrastructure. Among the priorities are the reduction of asymmetries, the standardization of processes and the digitalization of public services, in addition to capturing ideas for the monitoring and evaluation of public policies. The diagnoses provided by the inteli.gente platform at this level propose to offer tools and paths for cities to improve their sustainable urban development strategy and digital transformation.

The structure of the inteli.gente platform is presented in Fig. 1, containing the topics (thematic areas) related to each dimension. These topics are used to guide the indicators according to their purposes.

The knowledge base and information for each topic are obtained through metrics, statistical analyses and adaptations based on (Odum, 1996; IISD, 1997). The data sources come from official regulatory bodies (secondary sources) and/or municipal managers (primary sources).

Thus, the diagnosis of the maturity level of the indicators in the inteli.gente platform offers opportunities and challenges to improve the provision of services to the population in terms of digital transformation, transparency and quality. These diagnoses and recommendations encompass aspects ranging from the infrastructure required for digital transformation and urban development to the training and digital literacy required for solutions and services that improve the quality of life of citizens and city management.

With the experience of the IARA team and based on cities interested in digital transformation and sustainable development, projects and analyses are developed with large volumes of personalized urban data, expanding the range of diagnoses and recommendations for cities, using data science (prescriptive and predictive analyses) in their public policies.

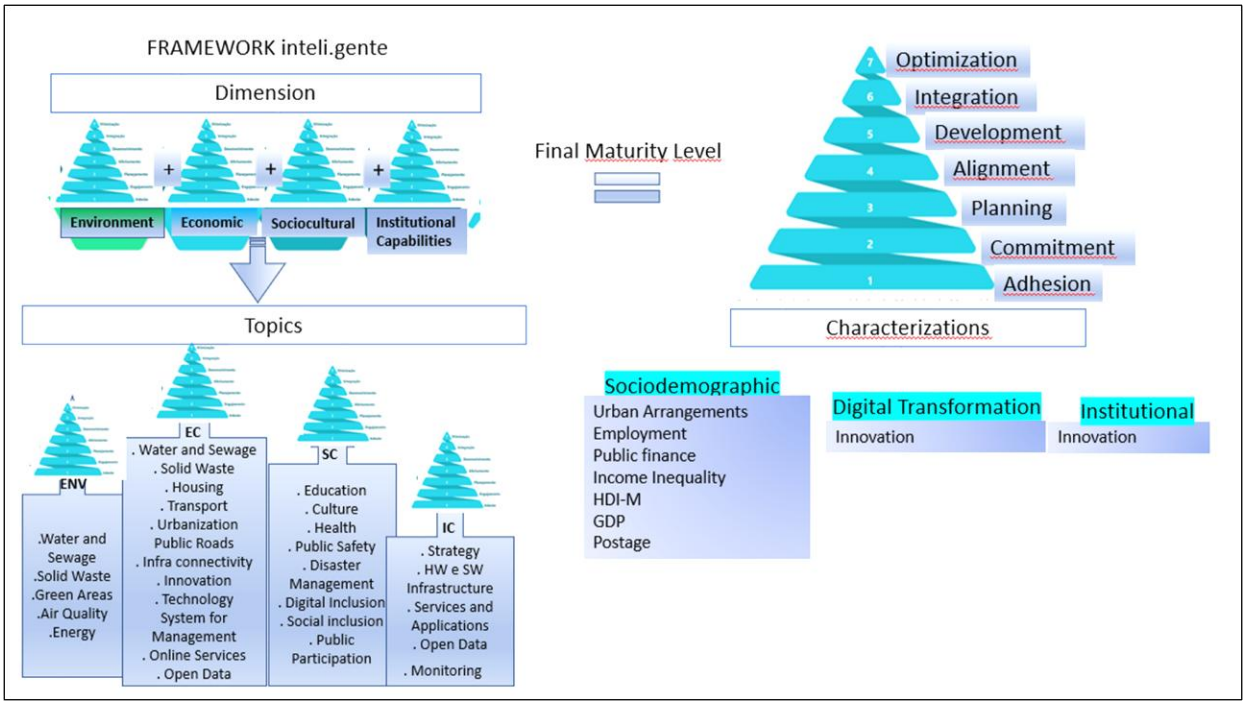


Figure 1 inteli.gente platform framework (Manual Reference, 2023)

2. Brazilian Results inteli.gente platform

The results presented in the inteli.gente analyses reflect the characteristics of a country in the global south, where municipal planning has not yet become a reality in local governance, although in some dimensional analyses the results indicate that the country has been implementing actions and programs for development.

The final maturity level in digital transformation and sustainable development estimated for Brazil, obtained by averaging the levels of Brazilian cities, was level 3 - Planning. This level obtained is equivalent to level 1 - Planning of the SSCMM-ITU.

The application of AI tools in the inteli.gente methodological model allowed cities to have their maturity level

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

estimated regardless of whether they provided their primary information in their own form.

The adaptations implemented in the inteli.gente platform for the Brazilian model were the use of four dimensions: Economic, Sociocultural, Environment and Institutional Capacity, which allowed the assignment of an estimated maturity level value to each dimension, indicator and public policy theme.

In this way, the final maturity level of the municipality is obtained by calculating the arithmetic mean of these four dimensions evaluated. The platform also used indicators to characterize the cities in terms of sociodemographics, digital transformation and institutional aspects.

The analysis of the indicators and themes of the economic dimension (Fig. 2) for Brazilian municipalities indicates that of the 5,570 municipalities, 152 still require greater efforts to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with basic infrastructure in sanitation, solid waste, housing, innovation and governance strategies, development of master plans, among other topics. The 2,357 cities at maturity level 4 (alignment) and 2,438 at maturity level 3 (planning) indicate that Brazil already has a framework of management tools implemented that enable the development of digital transformation and a sustainable economy.

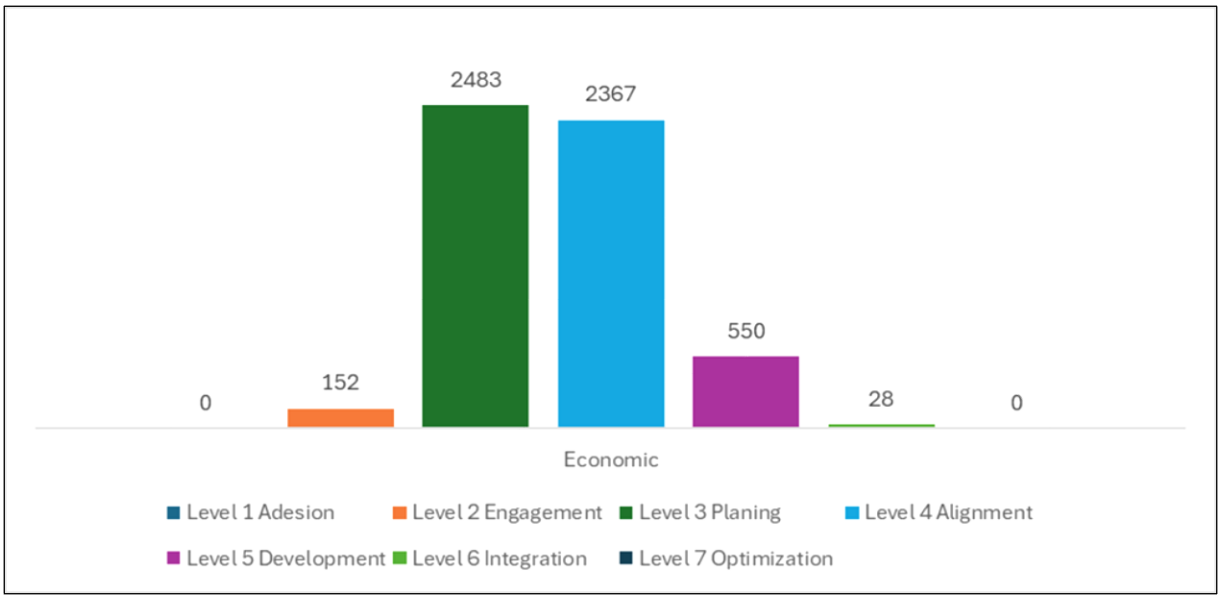


Figure 2 Maturity Level Economic Dimension All Brazilian cities

The analysis of indicators and themes of the environmental dimension (Fig. 3) for Brazilian municipalities indicates that of the 5,570 municipalities, 2,609 still need greater efforts to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with basic infrastructure in sanitation, solid waste and governance strategies, development of master plans, among other topics. The main demands on solid waste are the lack of selective collection in cities and of selection and recycling, as well as waste of treated water, between the treatment plant/capitation and domestic taps. The 957 cities at maturity level 4 (alignment) and 1,990 at maturity level 3 (planning) indicate that Brazil already has a framework of management tools implemented that enable the development of digital transformation and the preservation and sustainable use of its green areas.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

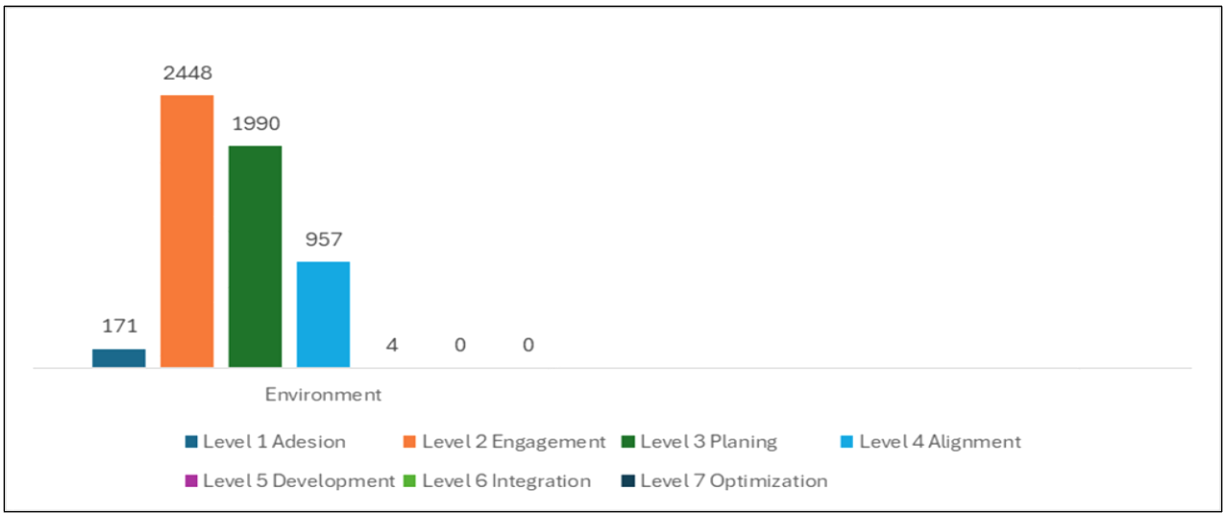


Figure 3 Maturity Level Environment Dimension All Brazilian cities

The analysis of the indicators and themes of the sociocultural dimension (Fig. 4) for Brazilian municipalities indicates that of the 5,570 municipalities, 171 still need greater efforts to be able to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with basic infrastructure in sanitation, solid waste, health, education, public safety, among other topics. The low number of cities that still require an effort in governance shows that social programs and inclusion efforts are on a positive path. The 29 cities at maturity level 4 (alignment) and 4,356 at maturity level 3 (planning) indicate that Brazil, despite the effort in social inclusion, still needs attention in its management policies to enable the development of digital transformation and social inclusion in an equitable manner throughout its territory.

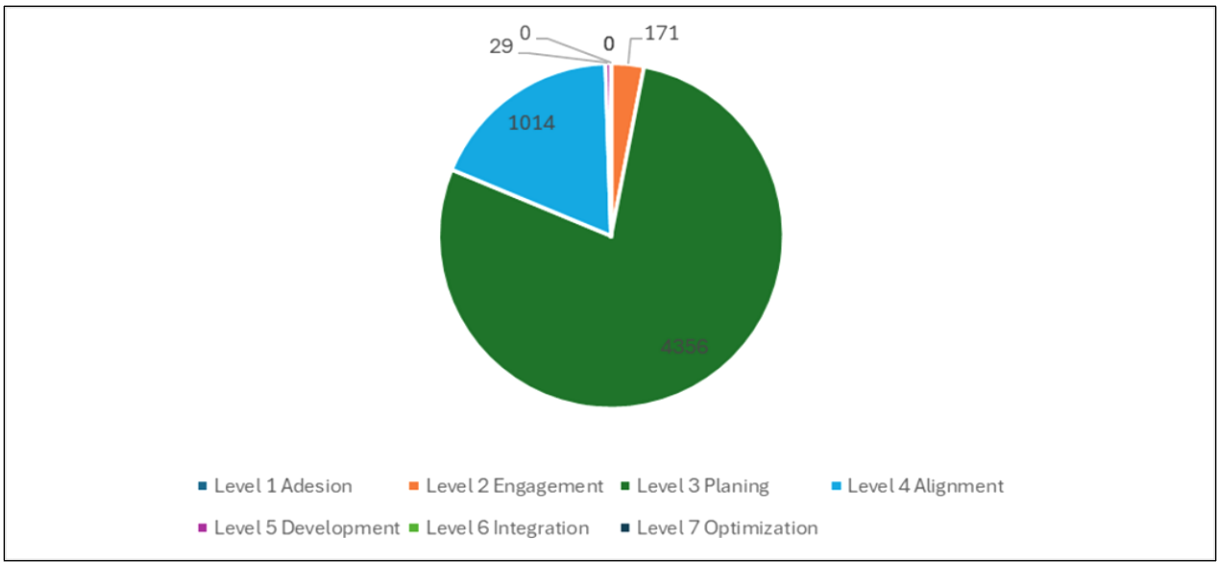


Figure 4 Maturity Level Socialculture Dimension All Brazilian cities

The analysis of the indicators and themes of the institutional capabilities dimension (Fig. 5) for Brazilian municipalities indicates that of the 5,570 municipalities, 5,026 still need greater efforts to be able to reach the level of maturity in digital transformation Planning. These are municipalities that still need to be concerned with data governance, training leaders for digital transformation, planning and developing goals and plans, among other topics. The 21 cities at maturity level 4 (alignment) and 514 at maturity level 3 (planning) indicate that Brazil, despite its efforts, still needs attention in its data management, transparency and public participation policies to enable the development of digital transformation and digital social inclusion in an equitable manner throughout its territory.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

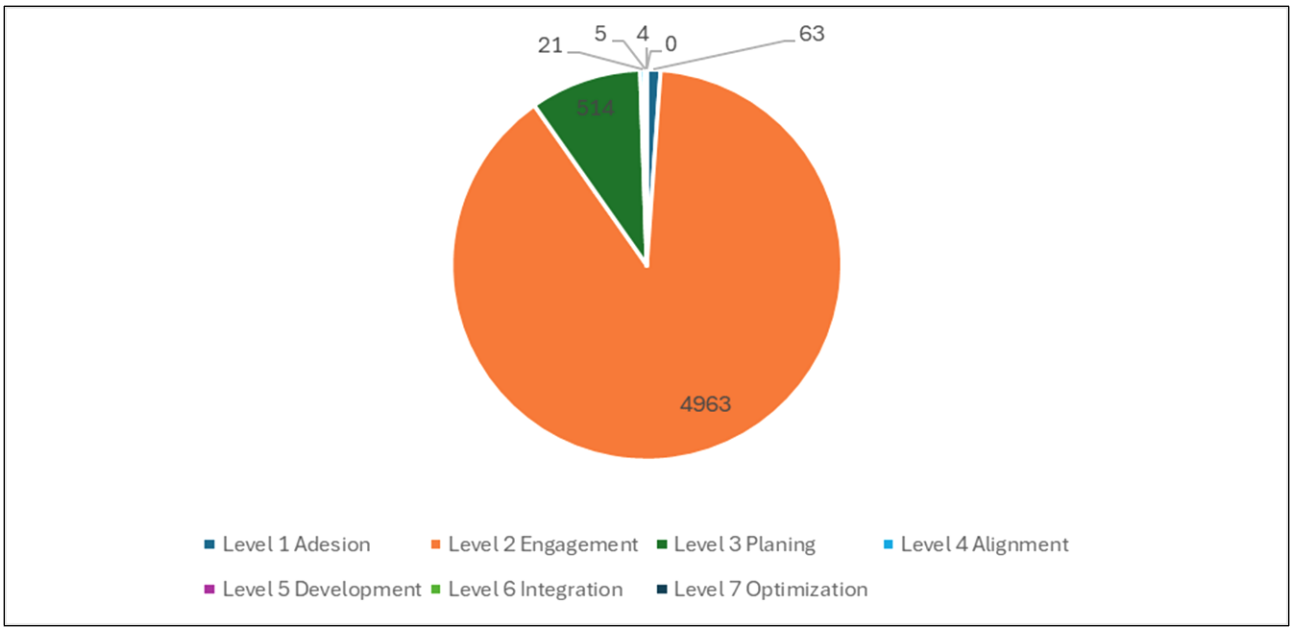


Figure 5 Maturity Level Institutional Capability Dimension All Brazilian cities

3. Conclusions

Diversity in Brazil has led to the need to contextualize recommendations regarding new maturity levels, with the main objective of covering the reality of Brazilian cities and their trajectories, as well as expanding the scope of analysis and diagnostics from the local to the global level of maturity of cities (Paseto, 2021:2020).

The new maturity levels implemented in inteli.gente have demonstrated asymmetries in infrastructure, service provision, public participation and public equipment made available to the population. The degree of digitalization related to services and processes in cities is still low, indicating the need to propose and develop public policies that promote the benefits of public management in people's lives and improve sociocultural, economic and environmental indicators.

The inteli.gente platform allows public policy makers to introduce and develop public policies with knowledge and in synergy with the needs of the population and also demonstrates that the level of maturity of digital transformation and sustainable development of a city does not depend on the size of the population, or even the influence of the municipal network, but rather on data management and governance where knowledge will be a feeding tool for decision-making.

Acknowledgement

We would like to thank MCTI for the research opportunity, CTI for initiating this work (2020-2021), IARA for continuing it (from November/2021:2025), RNP (2020:2023) for developing the digital platform and ANATEL for allowing us to disseminate and present new knowledge with SG 20 of SSCMM – ITU.

References

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: an extensive interdisciplinary literature review. Sustainable Cities and Society, 31, 183-212.

CNM (2023) - Confederação Nacional de Municípios,(2023). Available https://cnm.org.br

IESE Business School. (2018). Cities in Motion Index. Business School. Pamplona, ES: University of Navarra. Available: https://www.iese.edu/.

International Telecommunication Union (ITU). (2019). ITU-T Y.4906;04: Assessment framework for digital

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

transformation of sectors in smart cities SSCMM-ITU. Genebra, SWZ: ITU. Available: https://www.itu.int/rec/T-REC-Y.4906-201907-P

IISD- (1997)International Institute for Sustainable Development (IISD). (1997). Complete Bellagio Principles. Winnipeg, CA: IISD. Available: http://www.iisd.org/ measure/principles/progress/bellagio full.asp.

ISO 37120:2018(en). (2018). Sustainable Cities and Communities - Indicators for Urban Services and Quality of Life. Genebra, SWZ. Available: https://www.iso.org/standard/68498.html.

ISO 37122:2019(en). (2019). Sustainable Cities and Communities - Indicators for Smart Cities. Genebra, SWZ. Available: https://www.iso.org/standard/69050.html.

ISO 37123:2019(en). (2019). Sustainable Cities and Communities – Indicators for Resilient Cities. Genebra, SWZ. Available: https://www.iso.org/standard/70428.html.

Manual Reference (2023) Manual de referência para coleta e metrificação de dados para os indicadores da Plataforma inteli.gente: transformação digital para as cidades brasileiras versão 03 / Ministério da Ciência, Tecnologia e Inovação; Inteligência Artificial Recriando Ambientes – IARA – ICMC/USP. 1. ed. São Carlos: ICMC/USP, 2023. 171 p. ; pdf. ISBN 978-85-87837-41-7

ODS – SDG'S, (2023) – Objetivos de Desenvolvimento Sustentável . Available https://brasil.un.org.pt

Odum, H.T. (1996) Environmental Accounting: EMERGY and Environmental Decision Making. Wiley, New York.

Programa para Cidades Inteligentes e Sustentáveis (PCSI), 2018. Instituto Cidades Sustentáveis, ETHOS e Rede Cidades com Apoio CITinova. Available : https://citinova.mctic.gov.br/plataforma-do-conhecimento

Paseto, L, (2021) XI Seminário em TI do PCI/CTI – 2021 Infraestrutura: universalidade nas cidades brasileiras

Paseto,L; Martinez,M.R.M; Przeybilovicz,E.,(2020). Cidades Inteligentes e Indústria 4.0: A influência das tecnologias da informação e comunicação. 17ª edição da Revista E-Locução (ISSN 2238-1899), 2020.

Plataforma inteli.gente,(2021) – Ministério da Ciência, Tecnologia e Inovações - MCTI, (2021). Available: https://inteligente.mcti.gov.br

SEADE Fundação, (2023) Available: www.seade.gov.br

Y.Sup78, (2023) : Y-78 ITU- T : Use cases on implemented or evaluated smart sustainable city solutions based on ITU-T Y.4900 Recommendations series

Yigitcanlar, T. et al. (2019). Can cities become smart without being sustainable? A systematic review of the literature. Sustainable cities and society, 45, p. 348-365.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Towards social cohesion: understanding local migration governance's barriers in global south smart cities

Rosiane Alves Palacios [a*], *Edimara* Mezzomo Luciano [b], *Gabriela* Viale Pereira [c]

[a] Graduate Management Program, Pontifical Catholic University of Rio Grande do Sul Porto Alegre, Brazil, rosiane.palacios@edu.pucrs.br, ORCID 0000-0002-7588-6358

[b] Graduate Management Program, Pontifical Catholic University of Rio Grande do Sul Porto Alegre, Brazil, eluciano@pucrs.br, ORCID 0000-0002-2847-8845

[c] Center for E-Governance, University for Continuing Education Krems, Austria, gabriela.viale-pereira@donau-uni.ac.at, ORCID 0000-0002-7602-3052

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Smart cities (SC) are becoming increasingly popular around the world. Within the scope of SC studies is governance, which is directly related to the success of planned actions. Refugee migration is currently a challenge all over the world. But at the local level (cities) it can be better examined. The local migration governance network is one way for welcoming and integrating refugees in cities. However, there are barriers that can influence smart governance as well as migration governance. It is important that cities can be more inclusive and effective in welcoming migrants and refugees by promoting social cohesion. This study aimed to identify barriers of local migration governance in two smart cities in order to reflect on the possibility of increasing social cohesion for immigrants and refugees. A multiple case study was carried out on the local migration governance networks of two smart cities in the Global South: Porto Alegre-BRA and Cape Town-ZA. Twenty-five interviews were collected with migration experts and local migration governance actors, nine documents were analyzed, and observations were made in both cities. The data was analyzed through content analysis. The results of the research pointed to sixteen structural, social and political barriers. Social cohesion can be built through public policies that take diversity into account and where, once integrated, refugees can truly feel that they belong to the community. We propose a frame that summarize the actions that can promote social cohesion for immigrants and refugees in smart cities. We based the actions proposed on the barriers and the possibilities of interventions.

Keywords. Local Migration Governance, Smart Cities, Barriers, Refugees. Social Cohesion.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.985

1. Introduction

Smart city (SC) methodologies and initiatives are widespread today, bringing innovative possibilities to the urban challenges we face as a society (Popova & Popovs, 2023). SCs are, by definition, spaces that seek to promote quality of life for the people who live in the city and, to this end, use information and communication technologies (ICT) as tools for urban development (Echebarria, Barrutia, & Aguado-Moralejo, 2020; Ruijer et al., 2023). In order to achieve the objectives of SC, many studies consider that the interactions between governance stakeholders in the urban context are essential to make the necessary improvements and foster development (Mills, Izadgoshasb, & Pudney, 2021).

Within the scope of SC, Pereira, et al., (2018) consider the smart governance dimension to be strongly related to the decisions and strategies necessary for the planned urban actions and policies to be put into practice. It is within the framework of smart governance that policies and actions to build and/or transform an SC are planned and implemented (Bjørner, 2021). Przeybilovicz and Cunha (2024) ponder that in order to be sustainable, smart governance needs to be thought of and implemented as a dynamic process. The sustainability of planned actions is

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

paramount, as they provide the city with a response to a series of social problems (UN-Habitat, 2022). Smart governance has the potential to help transform the city (Mills et al., 2021) but this also implies including people, especially the most vulnerable, so that the proposed changes can happen and be meaningful for society as a whole. In this sense, Bolívar, Muñoz, & Muñoz (2022) say without practical strategies that really include vulnerable populations, paradoxically SC liable to increase inequalities instead of minimizing them.

UN-Habitat's Envisaging the Future of Cities report considers that, worldwide, growing waves of international migration are transforming urban areas into more culturally diverse spaces and bringing with them a variety of challenges and opportunities (UN-Habitat, 2022). We have seen that in addition to being more populous, the trend is for most cities to become increasingly diverse and for society to have to think progressively about the best ways to address the issues that arise from diversity and people's different needs (IOM, 2022b). Within the scope of migration, one of the groups of migrants who arrive in cities and who require sensitive attention are refugees, as they are a population who face human rights violations and who move to places that will welcome them safely (IOM, 2019). The places that receive this group of immigrants need to think about a series of strategies and reception structures that can be characterized as a governance structure or network (IOM Brazil, 2023). The United Nations Migration Agency (IOM) characterizes migration governance as the set of entities, policies and infrastructures that shape and regulate the processes related to the reception, integration or redistribution of immigrants in a nation-state, as well as the possibilities for cooperation and joint actions with organizations related to migration (IOM, 2022a).

Kvashnin's (2020) study points out that it is usually the national level that designs migration actions, but it is the regional level or even the local level (cities) that implements them, as they have no reference for how to deal with immigrants but end up planning and implementing migration policies. For Stürner (2020), the fact that cities deal directly with the reception and integration of immigrants and refugees on a daily basis, and often without the proper guidelines and resources, has led them to increasingly demand a place in the debates and decision-making spaces of migration governance. The gaps in the dialog between the local and national levels can push immigrants and refugees into spaces where access to information and the provision of public policies is precarious, affecting this population group's enjoyment of health, education and employability services, for example (Skodo & Zanzuchi, 2023).

Thus, there are several factors that can influence local migration governance negatively (barriers) in actions related to the effective reception and integration of immigrants (Caponio, Scholten, & Zapata-barrero, 2019; IOM, 2022). Bolívar, Muñoz, & Muñoz (2022) argue that integrating vulnerable population groups into strategic urban planning is essential to ensure that SC is not just technologically advanced but also socially equitable and inclusive promoting social cohesion. According to Valera, et al. (p.13, 2022) “the term ‘social cohesion’ has its origins in fundamental questions about the elements that connect people to each other and to society as a whole and that motivate them to be part of it”. In this sense, knowing the actors involved in local migratory governance and understanding the barriers of governance can contribute to promoting and/or expanding the quality of life, participation of the immigrant population in the life of the city and social cohesion. In countries classified as developing, the barriers may differ from countries classified as developed, which have more studies on local migration governance. In view of the above, this study aimed to identify the barriers experienced by local migration governance in two SCs located in the Global South and was conducted through a case study carried out in the cities of Porto Alegre-Brazil and Cape Town-South Africa.

This study is justified by the need to better understand the dynamics of migratory governance in the local context, as well as the arrangements and influences suffered in actions to welcome immigrants in SC, especially regarding to refugees. Popova and Popovs (2023) address the importance of looking at the barriers of intelligent governance in a broad way and Moolngearn and Kraiwanit (2024) conclude that there is still a lack of research focused on the scope of the barriers that prevent the effective development of SCs. In this paper, we propose associating SC concepts with the scope of migration, considering the potential that their combination can bring to both the field of action of local migratory governance networks and SC migration studies.

It should also be noted that there are no specific studies on governance and refugees using the concept of SC (Palacios, Luciano, & Pereira, 2024). However, concern about the agenda of political minorities in the SC research agenda is beginning to gain more prominence (Burns & Andrucki, 2021). From a managerial point of view, it is important that actions to welcome immigrants do not lead to their exclusion. In this sense, it is interesting to look at how SCs welcome refugees, also thinking about the possibilities of integrating them into the welcoming and decision-making processes. We argue that the lack of good local migration governance can impact the possibility of effective refugee integration and social cohesion. Cardullo and Kitchin (2019) see SCs as spaces with great potential for encouraging citizen participation in decision-making processes. As citizens, immigrants and refugees (both urban residents) can participate in local migration governance as stakeholders and contribute to initiatives and actions to welcome and integrate this population into the SCs. The UN's 2030 Agenda has included the refugee agenda in several of the Sustainable Development Goals (SDGs). This study is specifically aligned with two of the SDGs: SDG 11 and SDG 16. SDG 11 - Sustainable Cities and Communities - proposes making cities and human

settlements inclusive, safe, resilient and sustainable (UN, 2017). SDG 16 aims to achieve Peace, Justice and Strong Institutions, promoting peaceful and inclusive societies for sustainable development by providing access to justice for all, with an emphasis on building effective, accountable and inclusive institutions at all levels. In addition, target 10.7 in SDG 10 - Sustainable Development is closely linked to the migration agenda: "10.7 - Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies (UN, 2017).

2. Literature review

This session presents essential concepts that ground this study in terms of local migratory governance and barriers of migratory governance, as well as barriers of smart governance.

2.1 Local Migration Governance

The United Nations High Commissioner for Refugees (UNHCR, 2024) considers the protection (and subsequent reception and integration) of refugees as a shared task between public entities, private actors, NGOs, academia and international institutions, as only joint and synergistic approaches are capable of producing comprehensive responses to the needs of immigrants and refugees. With the need to look at the actions of the different levels of government, the scope of migration governance includes multilevel governance, which involves the alignment and joint action of nation-states, states and/or provinces and cities (Caponio & Pettrachin, 2023; Sabchev, 2022). Multilevel migratory governance is interesting when it interacts with and addresses the combined actions of the different levels of government. However, multi-level governance is not the reality in many cities around the world, especially cities in the Global South (Palacios et al., 2024) and the focus of migration governance is still strongly on securitization and protectionist policies at the national level (Elander, Granberg, & Montin, 2022).

Graauw's (2019) study, however, proposes that in Europe in particular, there has been a "Local Turn", in other words, a shift in perspective with more attention being paid to the local level of migration governance. Even though the local level is still a space for applying global (national and international) and multi-level actions, from this perspective, the local level ends up being the driving force behind migration governance. This paradigm shifts from an international and national focus to a local one can be seen in the literature, from the emergence of the terms "City Governance of Migration" or "Local Governance of immigrants or migration" (Zapata-Barrero & Cantle, 2019) and "*modes of city network mobilization"* (Caponio & Pettrachin, 2023), for example.

Tab.1 - Framework for a welcoming governance agenda for refugees/immigrants.

Approach	Definition
A deliberate approach, based on values and rights	city governance, by definition, must be welcoming, inclusive and explicitly announced in formal city policy
Services for all	universal and equal access for migrants and refugees to basic human and social services, without discrimination on any grounds
Promoting integration and social cohesion	equal treatment and opportunities and the prohibition of discrimination as essential components of city legislation, planning, policy and practice
Broad and committed campaign against discrimination, racism and xenophobia	promoting equal opportunities and outcomes for all migrants and refugees. An integral part of this campaign would be the integration of gender equality perspectives into local policies and practices
Ensuring the "right to the city"	deliberate and comprehensive inclusion and integration measures, recognizing migrants and refugees as inhabitants, social actors and political agents engaged in creating opportunities and achieving solutions
Celebrating culture and diversity	recognize cities as genuine places of diversity, taking into account their dynamism and offering the best prospects for future development
Incorporate seven key components for effective city governance	extensive knowledge base, rights-based and gender-specific legislation, deliberate policy, interdepartmental coordination, focal points, urban planning and evaluation
Involving all stakeholders	in consultative, decision-making and implementation bodies of city governance, especially economic actors, social partners, migrants and refugees, civil society organizations and social service actors
Multi-level governance	governance, dialogue and cooperation on various levels, national and local, to obtain the political "space" and support for cities that welcome and integrate migrants and refugees
Financing services for all	social cohesion and maintenance of the workforce should be reflected in allocations for programs, targeted outreach, trained personnel and specialized administrative departments, as well as the necessary infrastructure
Media work and public relations	deliberate strategy on migration and migrants as a key strategy to shore up public attitudes and gain voter support
Accountability on all levels	at all levels, by all actors as an essential aspect of ensuring welcoming cities for refugees and migrants

Source: Taran, Neves & Kadysheva (2016)

When managing initiatives for immigrants and refugees, local migration policies can both diverge from and complement national efforts (Filomeno, 2019; Palacios et al., 2024), where local governance can even take control of integration policies in the absence of overarching national structures (Graauw, 2019). In this sense, there are some relevant elements for formulating strategies aimed at welcoming local migration governance for immigrants and refugees (Table 1). Some cities receive migrants in completely different contexts and find themselves having to redesign urban strategies and actions that were initially designed just for their citizens (Gross, 2019). According to Zapata-Barrero (2024), local governments are dealing with several challenges that diverge each other, and which can overload scarce public resources, demanding innovative responses. For this reason, in certain scenarios it is necessary look at governance models and implies to consider the complex and overlapping identities of migratory flows.

2.2 Barriers in migration governance

There are several barriers that shape migration governance. According Bassi (2019) we can talk about barriers from a macro perspective where, for example, the nation-states view where they need to guarantee their sovereignty have that receiving immigrants can weaken state domination. This interpretation gives rise to the so-called **securitization of migration** (Haddad, 2008), which is overly concerned with security and less with the management and integration of migrants and can be a major barrier to migration governance (Ibreck & Seeka, 2022). Nonetheless Caponio et al., (2019) indicate that migration governance challenges and barriers can be better seen at the local level.

The lack of knowledge (of public actors and civil servants) about procedures, can be an obstacle to accessing services even in cities where migratory governance is more structured. In this sense, the **absence of standardized and integrated procedures** in public institutions that sometimes also prioritize national security (due to **securitization**) over the provision of essential services to migrants and refugees (Caponio et al., 2019). Such an approach can result in challenges to migration governance, intensification of the social and economic marginalization of migrants in vulnerability, perpetuating legal issues, and reinforcing xenophobic or distorted narratives about migrants.

Racism, for example, is another of the social challenge (Johnson, 2022; Zapata-Barrero, 2023), as is **xenofobia** (Hillmann & Pang, 2020; Mourad, 2021). These factors not only hinder the integration of migrants, especially refugees, but also contribute to the reproduction of **structural inequalities** and **social tensions** in host cities and communities (Zapata-Barrero & Cantle, 2019). The **marginalization of immigrants** and refugees can lead to the existence of what Caponio et al., (2019) call "**legal shadow zones**", where these groups are forced to rely on informal networks, parallel economies and precarious sources of income, as well as **lacking adequate representation**. Ambiguity laws and regulations can also serve as barriers both to immigrants and governance (Kloosterman, 2019). This condition of **ambiguity** not only reduces migrants' adaptive capacity but also intensifies their social and economic exclusion (Huq & Miraftab, 2020; Norman, 2021). Although often associated with institutional and legal factors, ambiguity also manifests itself in social and economic dimensions, contributing to precarious living conditions (Zapata-Barrero, 2023). It can reinforce nationalist, xenophobic or racist narratives, further exacerbating marginalization and perpetuating structural inequalities in host cities (Caponio et al., 2019).

Kloosterman (2019) considers that the **Language barriers**, **the lack of reliable information** and **knowledge about rights** can lead to more ethnically homogeneous networks of migrants and refugees, where these groups often fail to integrate into society. In addition, Yüksel (2023) points out the level of **institutional processes complexity**, coupled with language barriers and **limited access to information** in public institutions, that makes the enjoyment of rights by migrants and refugees more inaccessible, which makes governance need to think about the need for greater accessibility and institutional capacity building. Graauw (2019) reflects that municipal bodies dealing with migrant issues coordinate and streamline local efforts to promote integration. In everyday life, migrants have similar needs to the native population, but barriers caused by the difficulty of communicating well in the language of the place of reception and legal status (as a citizen) hinder access to services. I also can undermine **trust between migrants and municipal agencies**, highlighting the need for inclusive and culturally sensitive approaches (Graauw, 2019).

Solidarity can influence the reception and integration of refugees. However, the **informality of actions** that make refugees depend exclusively on the solidarity of the local population to receive refugees is a sensitive barrier to structured governance (Bazurli, 2019; Dimitriadis; Ambrosini, 2022; Ibreck; Seeka, 2022). Some migration governance approaches present itself **barriers to the social participation** of immigrant groups in the city, as they are often considered passive subjects and clients of public services (Cappiali, 2019). Even though some studies point out that migrants improve the capacity for adaptation and diversity for host communities, there is often a clash between social values and the results of receiving immigrants' actions (Caponio; Scholten; Zapata-Barrero, 2019). It can lead to conflicts and barriers to governance and adaptation for immigrants.

2.3 Barriers in SC

The barriers and challenges faced by governance are part of the daily life of cities seeking more intelligence (Bello, et al. (2024). In the SC scenario, identifying the possible barriers involved in smart governance is of paramount importance to ensure the effectiveness of the actions (Popova & Popovs, 2023). In their study on the effects and externalities of smart governance, Popova and Popovs (2023) addressed the barriers in different aspects: (i) the relationship with the use of information and communication technology (ICT), (ii) the digitalization process, (iii) new strategic visions and (iv) the rigidity of government opinions. The same study considers six different elements that impact smart governance: "information, efficiency, citizen focus, transparency, digital exclusion and regulation"(Popova & Popovs, p. 1114, 2023). When designing and implementing SC initiatives in digital transformation, for example, unintended effects can occur and reinforce inequalities in the city being barriers to the development, so it is of paramount importance to pay attention to this regard (Pereira et al., 2020).

SC also faces **privacy concerns in the massive collection of data**, the **dominance of ICT multinationals** over global urban policies, the exclusion of socially vulnerable groups in digital transformation processes, insufficient urban development, the imposition of ready-made and centralized (top-down) governance models, which together amplify inequalities (Caragliu & Del Bo, 2019). Moolngearn and Kraiwanit (2024) points out the lack of suitable financial resources for planned initiatives and policies is the most important barrier a SC can face. It is therefore crucial that stakeholders, especially governments, support cities with resources. Colding, Barthel and Sörqvist (2019) suggest **resilience** is an indispensable enabler and that it is often necessary to **apply analogue solutions combined with technological** ones to preserve democracy and respect public choice, while also calculating the costs of automation for learning and human resilience.

In an article on barriers and facilitators in global South SCs, Bello et al. (2024) highlight challenges related to integrated urban transformation, socio-economic equity, governance and infrastructure where critical interventions are still needed to break down these obstacles. The study also points to 20 barriers (Bello et al., 2024). The main barriers include: **lack of social awareness**, **digital exclusion** (lack of access to technology), **resistance to change**; **fear of digitalization**, **social exclusion** and **gentrification**, **lack of qualified human capita**l, **high cost of urban infrastructure** (operation and maintenance), imbalance of investments and **lack of resource sharing** (Bello et al., 2024).

3. Method

This qualitative and exploratory study was carried out as a multiple case study on the local migration governance networks of two cities: Porto Alegre, Brazil and Cape Town, South Africa. We choose two cities classified smart in global south emerging countries. The data collection techniques employed were in-depth interviews, observation and document analysis. The interview protocol was built on existing literature and was face and content validated by experts from universities in both countries.

Initially, migration governance networks the actors and organizations were mapped and then were contacted by email and LinkedIn. We also used the snowball technique. From May 2023 to August 2024, we collected in-depth interviews with 25 migration experts, (civil servants, managers, universities and third sector workers) (Table 2). The interviewees are listed from I1 to I25, to ensure anonymity. There were 7 interviews in Cape Town and 18 interviews in Porto Alegre. The average interview time was 64 minutes, and all the interviews were recorded (in person or virtually using the Google Meet platform). The interviews were conducted in Portuguese or English and verbatim transcribed.

To triangulate data and according to Richardson's (2012) recommendations, we analysed documents and made observations. 9 documents, including laws, reports and documents from institutions in both cities, were collected during the same period as the interviews. The documents are identified as D1 to D9. The observations were non-participant in Cape Town and non-participant in Porto Alegre (at the Porto Alegre Local Migration Conference which took place in March 2024). For the observations, a field diary was kept with notes and photographs for researcher's use.

Tab. 2 - List of interviewees

Interviewd	Smart City	Sector	Time
I1	Cape Town	University	52min56s
I2	Cape Town	Third Sector	1h4min
I3	Cape Town	Private sector	30min19s
I4	Cape Town	Third Sector	40min23s
I5	Cape Town	Third Sector	41min
I6	Cape Town	Third Sector	1h28min
I7	Cape Town	Third Sector	51min19s
I8	Porto Alegre	Third Sector	1h23min
I9	Porto Alegre	Third Sector	1h7min
I10	Porto Alegre	Third Sector	1h31min
I11	Porto Alegre	Public	1h8min
I12	Porto Alegre	Third Sector	2h37min
I13	Porto Alegre	Third Sector	1h4min
I14	Porto Alegre	Public	1h12min
I15	Porto Alegre	Third Sector	1h e 1 min
I16	Porto Alegre	Third Sector	44min42s
I17	Porto Alegre	Third Sector	1h42min
I18	Porto Alegre	Public	2h16min
I19	Porto Alegre	Third Sector	1h23min
I20	Porto Alegre	Third Sector	34min55s
I21	Porto Alegre	Third Sector	55min37s
I22	Porto Alegre	University	1h7min
I23	Porto Alegre	Public	51min1s
I24	Porto Alegre	Public	34min47s
I25	Porto Alegre	Internacional Agency	1h37min

Source: Research data (2025)

To analyse the data, we opted to carry out content analysis following the recommendations of Bardin (2016). As mentioned above, the interviews were transcribed so that all the data was in text form, after which the statements of the interviewees and the texts of the documents were coded in a systematic way. NVivo 15 software for Windows was used.

4. Cases

The two local migration governance networks studied are in Porto Alegre, Brazil and in Cape Town, South Africa. Porto Alegre has several SC initiatives, especially in governance, such as the Participatory Budget, which was set up over thirty years ago and is still in operation today (Porto Alegre, 2020). Cape Town is one of South Africa's capital cities and is considered resilient when it comes to promoting disaster mitigation actions and stands out when it comes to sustainability and poverty reduction (UN-Habitat, 2022). Cape Town has many SC initiatives (Bright Cities, 2022).

Brazil and South Africa apply the 1951 Convention on the Status of Refugees (United Nations General Assembly, 1951). Brazil has it own law on migration (Brazil, 2017). The Ministry of Justice is largely responsible for the migration issue, but it works in conjunction with other national bodies. CONARE is responsible for deciding on refugee requests (Ministry ff Justice and Public Security, 2025). In 2024, the Ministry of Justice set up the National Forum of Migrant, Refugee and Stateless Leaders (Fomigra) (Ministry of Human Rights and Citizenship, 2024), and local, state and national stages of the National Conference on Migration, Refugees and Statelessness (Comigrar) were held. South Africa started follows the 1951 Convention after Apartheid ended and has been a member of the Organization of African Unity (OAU) Refugee Convention since 1995. In South Africa, it is the Department of Home Affairs and the Refugee Reception Offices (RRO), located in the country's capitals (including Cape Town), that are responsible for carrying out the legal steps of reception, although RRO Cape Town remained closed for some periods while refugees continued to arrive in the country (Johnson, 2022). Porto Alegre is home to approximately 30,000 to 35,000 refugees of various nationalities, most of whom are displaced from the Global South-South Cape Town has approximately 400,000 foreigners, including a large number of refugees of various nationalities, especially from central and southern Africa.

5. Analysis and Discussion

The findings regarding the data collected through interviews, documents and observations, which had already been coded and related to the theoretical framework, were organized into three different topics. In this way, it was possible to examine the barriers to local migratory governance in both cases studied, as well as the possibilities for building social cohesion.

5.1 Governance context

First, it is interesting to consider that Brazil has been receiving refugees for a longer period of time, while South Africa actually started taking in refugees after the end of the Apartheid regime. Brazil is also considered to be a transit country, as the entry of foreigners is much easier than in other Latin American countries, for example (IOM BRAZIL, 2017). The process of applying for refuge is different in the two countries. In Brazil, it is an electronic process through digital government platforms such as GOV.BR, Sisconare and Sismigra, where the migrant applicant registers their information, receives communications and can monitor the status of their process (Ministry ff Justice and Public Security, 2025). In South Africa, the process is more analogue, and it was only after the pandemic (in 2020) that the refugee application form began to have a digital version (pdf) that is sent by email to the competent body (I1 to I7). And there are only a few cities in South Africa that receive this documentation, Cape Town being one of them. But it is very difficult for applicants to get to one of these offices, as there are only five in the whole country (I1, I2, I4, I5 and I7). The Cape Town office had been closed since 2012 to new applicants, so it was not possible to apply (Johnson, 2022), and the Cape Town RRO only reopened in 2023.

Although the agency responsible for carrying out the legal steps of protection, reception and documentation in Cape Town remained closed for some periods, refugees continued to arrive in the country (Johnson, 2022). The decision to close was made at national level (I1- I7). This closure had a direct influence on Cape Town's migration governance network and prompted a series of advocacy actions by civil society for the reopening of the RRO, which not only mobilized the governance network but also changed the dynamics in the city. In this sense, local migration governance in Porto Alegre is not directly involved in documentation and registration, and the Cape Town network had to manage the issue of documentation by thinking about how to make new applications in neighbouring RROs viable.

The local migratory governance network in Porto Alegre is part of a context in which there are more multi-level interactions (I8-I25). whereas the one in Cape Town has less interaction between the different levels of government, for example. In the Brazilian context, there are a greater number of institutions involved in the reception and integration of refugees. The level of proximity and dialogue with public bodies at the different levels is an aspect that can be extremely relevant to the barriers and success of the actions that the local level proposes to undertake. It should be noted that in both cities there is a massive presence of NGOs, religious organizations and immigrant associations, as well as the presence of universities actors.

5.2 Barriers

In terms of the aspects that influence and are part of the dynamics of local migratory governance networks, sixteen different barriers were found, classified into three different levels: structural and managerial, social and cultural or political.

Lack of infrastructure and financial resources are management barriers that have a direct impact on the governance network and the scope and success of the actions undertaken. The lack of infrastructure is more related to the city itself, when it has an adequate reception system, either with hostels or specific orientation spaces for immigrants, for example. In both cases, NGOs as well as legal practice centres linked to universities end up voluntarily playing the role of providing guidance on documentation, basic items and information pertinent to the first steps of reception (I1, I12, I22). In Porto Alegre, for a brief period, there was an immigrant shelter (Zero Hora, 2021) which closed due to a lack of resources (I8, I14 and I24). The underutilization of existing resources, for example, where in Porto Alegre there are empty buildings that could be renovated and used as hostels for immigrants (i20) expresses how practical and (even low-cost) solutions could be implemented to increase reception capacity.

The lack of training and **awareness of procedures**, especially among civil servants, can become an obstacle to accessing services, even in cities where migration governance is more structured. The lack of staff to assist migrants and refugees, especially staff fluent in the languages most spoken by migrants, is pointed out as a barrier. In Cape Town, for example, the translators at the Department of Home Affairs are all volunteers, and it can happen that on a day when there is more demand for translation services in a particular language, the translator for that language is not present (I1, I2, I4, I7). In Cape Town in particular, there is a great deal of dependence on solidarity efforts and volunteers (who are often foreign students doing university practical) (I2, I4).

The **lack of resources** is a critical barrier and has the potential to impact on the emergence of other barriers. Moolngearn and Kraiwanit (2024) consider the lack of resources to be the most critical barrier in a SC. In addition to the lack of infrastructure, some actions of the governance network may have to be discontinued due to lack of funds. Stürner (2020), among other aspects, discusses the demand for more resources from the federal level to the local level because the local level is, in fact, the space where public policy is applied, which is in line with I14's statement. However, in Porto Alegre, even with the approval of a municipal law establishing a migration policy (D9), there is no binding budget, which prevents specific actions for immigrants and refugees from being funded from the public budget. And without a budget, it is difficult for laws that have been passed to be translated into concrete actions to welcome and integrate people. I24's statement about the approval of a law without the

subsequent approval of binding funds demonstrates the need for migratory governance to have political strength, because when the time came to define financial resources, they were not approved.

The governance networks receive transfers from the federal government, but in both cases the resources used come more from donations and transfers from international agencies. In other words, most of governance actions and projects are also funded by the IOM and UNHCR, which in turn receive funds from the signatory countries and then distribute them among the territories. It is worth noting that after a wave of anti-immigration speeches around the world, in January 2024 the US government announced the suspension of transfers for UN actions with migrants and refugees; this decision will have a direct impact on the actions funded by the UN in Brazil (Lima, 2025). With this budget cut, both migratory regularization actions, humanitarian assistance, protection, health, technical support, migratory advice and the development of integration policies and plans will be affected in cities across the country, including Porto Alegre.

The **discontinuity of actions** in both cases ends up being a barrier that also stems from a lack of staff, infrastructure and resources, as well as political issues. I16 mentions the reduction in the capacity of actions due to a lack of resources and then the discontinuity of actions. For Ibreck and Seeka (2022), discontinuity is strongly linked to the belief that with donations and solidarity actions, it is not so necessary for the government to invest its own public resources because, in the imagination, there are already enough resources. As a result, there is no effective public policy, and the scope and continuity of actions and programs are undermined. It's interesting to note that solidarity can be seasonal and, in more vulnerable places, for example, it can be less effective because people with fewer resources may donate less. The most critical example of the consequences of a lack of continuity of action concerns the closure of the refugee reception offices (RRO) in Cape Town and the lack of local infrastructure in South Africa, which ended up accumulating applications and renewal requests, detention of undocumented people and a series of negative effects (I1 to I7). The decision was taken by the federal government citing a lack of resources and the RRO only reopened after joint advocacy actions (Johnson, 2022).

Lack of migrant's documentation, or even expired documentation, specially makes it difficult for immigrants to access education, health and social assistance, which reveals the knock-on effect of lengthy or poorly designed administrative processes (electronic or otherwise). As a result, the administrative burden is also a more strongly perceived barrier in Cape Town in relation to the documentation process. The lack of supply or access to public services (including security, employment and housing) leaves migrants in situations of extreme vulnerability. In this sense, I1 gives an example of the administrative burden and lack of documentation in Cape Town, where it is difficult to register children with their parents' names due to the parents' lack of documents, which leads to a situation of statelessness (which also violates fundamental rights). Thus, it is possible to see that administrative complexity directly affects the inclusion of immigrants and can also contribute to reinforcing social vulnerability. Most refugees are at a higher level of social vulnerability (UNHCR, 2024). It is therefore necessary for the governance network to pay attention to the need to modify processes so that they are more efficient, comprehensive and simplified.

There are **levels of institutional voids** and a **lack of multi-level coordination** in reception and integration in both cases. In the Brazilian case, the role of each level in relation to immigrants is still a little more defined and, due to the trend towards decentralization, the city has greater responsibility. In Cape Town, on the other hand, most decisions seem to be taken at the national level without alignment with the local level. In this sense, the institutional arrangements of the countries also have an impact on the local governance network. Gaps in the dialogue between the local and national levels can push immigrants and refugees into spaces where access to information and public policies is precarious, affecting this population group's enjoyment of health, education and employability services, for example, which is in line with the studies by Skodo and Zanzuchi (2023).

Failures in e-government systems or the **lack of digitization** are perceived as barriers because, even with the use of ICTs, some systems are not available in accessible and intuitive language and are used by a population group that may find it more difficult to use the technology. Despite the potential of ICTs to digitize processes (Przeybilovicz & Cunha, 2024), the implementation of technologies in migration regularization procedures can remain limited because they are generally the responsibility of federal governments. In Brazil, the process of applying for refuge is entirely electronic, carried out through three systems (GOV.BR, Sisconare and Sismigra), but these systems can present some flaws and require a higher level of digital literacy (I22). In South Africa, on the other hand, there is no e-government initiative in the refugee application process, which leads to a longer waiting time for documents to be registered and issued and a greater possibility of failures (I1, I3, I7). These aspects have an impact on the local level because documentation is important for refugees to be able to regularize their status and access the public services they need.

Lack of data and lack of knowledge management are also challenges faced in both cases. SC studies emphasize the importance of data-based decision-making (Popova & Popovs, 2023). There are no precise figures on the number of refugees living in each of the cities. This situation hinders the generation of data on the migrant population and knowledge about the problems faced in local migration governance. As many reception actions are

voluntary, there are no integrated systems where actors can record information.

Language and cultural barriers are factors that hinder the actions of the governance network. Without good infrastructure, language barriers can make immigrants even more socially vulnerable. When asylum seekers arrive asking for protection, they usually don't speak the language of the host country/region. I18 exemplifies how specific cultural practices, such as the consumption of salty tea in Haiti, can impact the health of migrants when there is no education or adequate communication. With a lack of proficiency in the local language, refugees end up experiencing what Svensson (2023) calls the dynamics of the "speaking subject" and the "other", where the capacity for interaction between natives and immigrants is limited, which influences integration and social cohesion. According to Valera et al. (p.13, 2022) the term social cohesion has its origins in fundamental questions about the elements that bind people to each other and to society as a whole and that motivate them to be part of it". The lack of language and cultural translation hinders the integration of immigrants into the community. Caponio et al. (2019) addressed diversity management, which is often overlooked in governance strategy. In this sense, the governance network needs to be prepared and able to offer language teaching and translation services. It is interesting to note that when there is a larger influx of a group or population, there may be an established community that is willing to help interpret the necessary information so that the refugees can make their first steps in the host city. In Porto Alegre there are significant communities of Haitians, Venezuelans and Warao (indigenous Venezuelan refugees), and in Cape Town of Somalis, Congolese and Sudanese, for example.

The existence of different types of prejudice: xenophobia, racism, sexism, homophobia and ableism, which also have an impact on local migration governance. I2 brings up an interesting notion which highlights that immigrants and refugees are not a homogenous population and that they have different needs. It is interesting to note that Cape Town receives many LGBTQIA+ refugees, the terminally ill and the disabled, given that in their communities of origin homosexuality is considered illegal, disability brings stigma and social exclusion, and illness makes it impossible to support a family (I2, I3, I4, I5). Thinking that refugees have the same needs masks the different vulnerabilities they face, such as disability or persecution due to sexual identity, making it difficult to respond adequately to their needs.

All this diversity without a consolidated welcoming infrastructure brings more challenges for governance. And sometimes society's prejudices are extended to immigrants and refugees, who end up experiencing racial slurs, xenophobia and other types of prejudice (I1, I2, I6, I7, I9). This situation can be aggravated when the economic situation in the host country is not so favourable. This is in line with the studies by Myers et al. (2024), who say that the local population fears that refugees will increase competition in the job market. Thus, the social situation can also influence the population's dynamics of identification and solidarity and therefore increase xenophobia. I1's account of the use of migrants as "scapegoats" for government failures shows how xenophobia can be a political instrument that perpetuates narratives that blame migrants for structural problems such as unemployment and a lack of quality public services.

Digital exclusion and **low levels of digital literacy** are also present as barriers. Whether in the direct actions of local migratory governance or in broader actions, it is necessary to consider that some digital governance or ICT application initiatives can reinforce social vulnerability. Digital transformation processes often end up excluding some population groups (Menegotto et al., 2020). I22 highlights how digital platforms are not intuitive or accessible for immigrants, especially for those who lack basic knowledge, exacerbating barriers to accessing documentation and public services. Immigrants face difficulties in understanding and navigating digital processes (I1, I6), such as sending forms or using emails. The lack of digital literacy leaves them vulnerable to errors and delays, compromising their access to rights. Digital exclusion goes against the transformative potential of SC (Pereira et al., 2020), which should promote inclusive access to technologies.

To overcome this barrier, it is necessary to simplify the systems, carry out training and capacity building and provide accessible technical support to the actors who are directly linked to the use of e-government tools. In this sense, Colding et al. (2019) talk about the need to combine analogue and technological tools according to different needs. It is interesting to note that artificial intelligence and chatbots may not meet the needs and specificities of refugee care, especially when they are not available in several languages and may contribute to reinforcing vulnerability. It is also interesting to look at the intersectionality of barriers. Cultural and linguistic barriers, for example, amplify prejudice and digital exclusion, creating overlapping challenges. For example, a lack of language skills affects navigation on digital platforms, while cultural prejudices make it difficult to welcome migrants into institutional spaces.

Ambiguities have a direct impact on the actions of migration governance or are derived from the actions of migration governance at various levels. The absence of a clear commitment to migration issues is delicate, especially in systems where decisions depend on political leadership to move forward. Top-down governance, mentioned by I2, can create a vacuum when the central authority does not prioritize migrants. There is often a need for judicialization due to omissions and delays in resolving cases (I5). There seems to be a disconnect between the existence of laws favourable to migrants and the implementation of public policies that offer practical support.

According to I22, although the city "opens the door" to migrants, it does not guarantee an effective welcome. This reflects the existence of protection but also the fact that reception is still weak.

As I24 pointed out, even with recent regulatory frameworks, assistance to migrants depends predominantly on civil society. The dependence on civil society to receive and refer migrants' points to the lack of a solid public infrastructure. This gap can be accentuated by neoliberal visions that tend to transfer the responsibilities of the state to private initiative, as pointed out by I24. Paradoxically, the difficulty expressed by the administrative burden, the backlog of applications and the lack of efficient documentation for applicants and refugees can cause other problems. In this case, many individuals are undocumented due to a lack of efficient state registration capacity. In Cape Town, the large number of pending refugee and renewal applications, scheduled for future years, exposes immigrants to serious risks, such as detention for lack of valid documentation. The lack of administrative capacity may reflect poorly structured public policies or a lack of financial resources. This condition of ambiguity not only reduces migrants' adaptive capacity but also intensifies their social and economic exclusion (Huq & Miraftab, 2020; Norman, 2021). Although often associated with institutional and legal factors, ambiguity also manifests itself in social and economic dimensions, contributing to precarious living conditions (Zapata-Barrero, 2023). In addition, it can reinforce nationalist, xenophobic or racist narratives, further exacerbating marginalization and perpetuating structural inequalities in host cities (Caponio et al., 2019) (Caponio; Scholten; Zapata-Barrero, 2019).

5.3 Reflections on the possibilities for achieving social cohesion for immigrants and refugees

It is considered that at the local level it is possible to closely (and simultaneously) examine the availability or unavailability of public services, the different dynamics, access to resources, the power relations involved in governance, society's prejudices and the social and political conflicts involved in local migratory governance. Based on the barriers experienced by the local migratory governances studied, it is clear that it is possible to increase the strategies that can have an impact on actions to welcome and integrate immigrants and refugees.

According to the studies by Taran et al. (2016) on the governance agenda for refugees and immigrants, welcoming involves thinking about equal treatment and opportunities and the prohibition of discrimination (whether through legislation, planning, policy or practice) in cities. It is considered important to connect immigrants and refugees to society because being part of the collective of life in society is closely linked to producing social cohesion. Social cohesion helps combat xenophobia since in a cohesive society there are higher levels of solidarity and belonging. Spicker (2014) argues that inclusion and social cohesion are aspects of the same social construction. Therefore, integrating immigrants and refugees into society is part of the list of lasting solutions sought for this population group (Taran et al., 2016). In their book on social cohesion in Latin America, Valera et al. (2022) proposed a political agenda of social cohesion for equality, sustainability and resilience that involves: guarantees of well-being and universal, comprehensive and sustainable social protection systems, social inclusion and social labour policies, policies for a culture of equality based on equality and the strengthening of democratic institutions for trust. In this sense, we propose a framework based on the barriers and the possibilities of interventions that can promote social cohesion for migrants (Table 3).

Tab. 3 - Actions that promote social cohesion for immigrants and refugees in smart cities

Barriers	Potential interventions
Language and cultural barriers	Ideation of programs that encourage linguistic and cultural exchange between immigrants and refugees and all population groups in the city. Expansion of cultural mediation actions focused on immigrants
Prejudices	Educational campaigns in schools and awareness campaigns promoting diversity and inclusion; anti-discrimination training (on different types of prejudice) for civil servants and members of the community. Creating and enforcing legislation on xenophobia and racism
Institutional voids and lack of multi-level coordination	Creation of specific municipal bureaus or sectors, councils and inter-institutional committees to deal with issues pertaining to immigrants as well as to enable the coordination of actions between different levels of government and organizations
Administrative burden and corruption	Propose improvements and standardization of processes; think strategically about how to simplify and computerize administrative processes and implement/or strengthen transparency and control systems to reduce episodes of corruption
Digital exclusion and digital literacy	Offer or expand free internet access points, data packages and technological devices in community centers; promote digital literacy courses to ensure digital inclusion of immigrants and reduce connectivity bottlenecks and participation in social life in the city.
Lack of infrastructure, financial resources and discontinuity of actions	Expansion of partnerships and establishment of shelter and documentation infrastructure. Creating references for migrants. Seeking effective funding to maintain essential infrastructure. Inclusion of actions pertinent to reception in budget laws to guarantee access to resources and expansion of public policies that are also related to the integration of immigrants create long-term action plans

Lack of social participation	Establishing consultative and participatory community councils that can be inclusive and where immigrants and refugees can express their needs and contribute to local decision-making. Promoting and encouraging volunteering and participation in community events
Knowledge and data management	Development of data collection and analysis systems to inform decision-makers, policymakers, governance actions and the general population. Adopt data-based decision-making. Publicize information on the migration agenda to the city's population.
Legal and social ambiguities	Revision and harmonization of legislation to ensure clarity and protection for immigrants and refugees. Prioritize the creation of guiding policies. Involve more experts in migration and social integration to develop and implement effective policies

Source: authors (2025)

These strategies can facilitate integration and strengthen ties between immigrants, refugees and local society, reducing social inequalities and promoting a more hospitable and inclusive environment in cities.

6. Final Remarks

Aiming to identify barriers experienced by the local migration governance network in two SC located in the Global South and reflect on the possibility of increasing social cohesion for immigrants and refugees, this article mapped different barriers (management, infrastructure, socio-cultural and political). It was possible to see that the barriers are interconnected with each other and there are many ambiguities (legal, social or political) that make it difficult for governance to work. Politics are also a factor that influences governance, and institutional voids can even be a strategy to deal with the migration issue in a more effective way.

Even though the cities of Porto Alegre and Cape Town are considered SC, the economic and social context of the local population must be taken into account, which can also face challenges in the area of human rights. Brazil is located on the most unequal continent in the world and South Africa is considered the most violent country in the world. There are also issues of racial prejudice, xenophobia and other types of discrimination in both countries. Brazil, which went through an intense process of colonization and enslavement of immigrants from the African continent, and South Africa, which was also colonized, experienced an Apartheid system for decades (which only ended in 1996). These aspects also influence social dynamics and wicked problems.

Continued efforts and a critical increase in resources are essential to guarantee the rights and dignity of refugees. Smart governance can support migration governance where the use of technology, collaboration and participation tools can be enhanced. However, due to the context of the sensitive data involved in working with refugees, in addition to proposing the use of ICT tools, a cautious and judicious approach is needed, as the aim is not to increase surveillance of migrants, but to use the tools to improve migratory governance in the context of SC.

Finally, in addition to governance barriers, even after being documented and welcomed, refugees can experience difficulties that affect their access to public services and structural benefits in the urban apparatus (which can be more easily accessed by citizens, tourists and other categories of migrants), so thinking about inclusion that leads to social cohesion is important. In this sense, a framework was proposed to think about the possibilities of strengthening social cohesion, which can also lead to overcoming the barriers faced by local migratory governance. As a limitation, we did not interview government actors from Cape Town's migration governance network. Durable solutions may require specific capacities of local migration governance in this sense, and as future research we recommend investigating the impact of underreporting the number of immigrants and refugees in cities of the global south. Looking at the maturity of governance in terms of the continuity of reception and integration actions; analysing discourses and different interests and possibilities of coalition.

Acknowledgement

- **Funding or Grant:** This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001
- **Contributor Statement***: Author 1: conceptualisation, writing-original draft, methodology, investigation, review & editing. Author 2: validation and supervision. Author 3: validation and supervision.
- **Use of AI***: We do not use AI tools
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Bardin, L. (2016). Análise de Conteúdo. São Paulo: Edições 70. *São Paulo: Edições 70*, p. 279.

Bassi, M. (2019). Lampedusa: dynamics of bordering and "encampment". In T. Caponio, P. Scholten, & R. Zapata-barrero (Orgs.), *The Routledge Handbook of the Governance of Migration and Diversity in Cities* (p. 343–352). New York:

Routledge.

Bello, A. O., Okanlawon, T. T., Wuni, I. Y., Arogundade, S., & Oyewobi, L. O. (2024). Exploring the nexus between the barriers and drivers for sustainable smart cities in developing countries: The case of Nigeria. *Sustainable Development*, *32*(4), 4097–4113. https://doi.org/10.1002/sd.2861

Bjørner, T. (2021). The advantages of and barriers to being smart in a smart city: The perceptions of project managers within a smart city cluster project in Greater Copenhagen. *Cities*, *114*(January). https://doi.org/10.1016/j.cities.2021.103187

Bolívar, M. P. R., Muñoz, L. A., & Muñoz, C. A. (2022). Modelling Strategic Planning Practices Considering Socially Vulnerable Groups in Smart Cities. In L. Amaral, D. Soares, & L. Zheng (Orgs.), *Proceedings of the 15th International Conference on Theory and Practice of Electronic Governance* (p. 440–448). https://doi.org/https://doi.org/10.1145/3560107.356031

Brasil. *Lei de Migração*. , (2017).

Bright Cities. (2022). *Smart City Diagnosis - Cape Town* (p. 3–5). p. 3–5. Recuperado de https://www.brightcities.city/smart-city-profile/South-Africa-Western-Cape-Cape-Town

Burns, R., & Andrucki, M. (2021). Smart cities: Who cares? *Environment and Planning A*, *53*(1), 12–30. https://doi.org/10.1177/0308518X20941516

Caponio, T., & Pettrachin, A. (2023). Modes of Migration City Network Mobilization in the EU and US Multilevel Institutional Systems: The Neglected Role of Politics. *International Migration Review*, *57*(4), 1374–1401. https://doi.org/10.1177/01979183221149921

Caponio, T., Scholten, P., & Zapata-barrero, R. (2019). *The Routledge Handbook of the Governance of Migration and Diversity in Cities*. New York: Routledge.

Caragliu, A., & Del Bo, C. F. (2019). Smart innovative cities: The impact of Smart City policies on urban innovation. *Technological Forecasting and Social Change*, *142*(July 2018), 373–383. https://doi.org/10.1016/j.techfore.2018.07.022

Cardullo, P., & Kitchin, R. (2019). Being a 'citizen' in the smart city: up and down the scaffold of smart citizen participation in Dublin, Ireland. *GeoJournal*, *84*(1). https://doi.org/10.1007/s10708-018-9845-8

Colding, J., Barthel, S., & Sörqvist, P. (2019). Wicked problems of smart cities. *Smart Cities*, *2*(4), 512–521. https://doi.org/10.3390/smartcities2040031

Echebarria, C., Barrutia, J. M., & Aguado-Moralejo, I. (2020). The Smart City journey: a systematic review and future research agenda. *Innovation: The European Journal of Social Science Research*, *34*(2), 159–201. https://doi.org/10.1080/13511610.2020.1785277

Elander, I., Granberg, M., & Montin, S. (2022). Governance and planning in a 'perfect storm': Securitising climate change, migration and Covid-19 in Sweden. *Progress in Planning*, *164*(November 2021), 100634. https://doi.org/10.1016/j.progress.2021.100634

Filomeno, F. A. (2019). Global cities and multievel immigration governance in Latin America. In T. Caponio, P. Scholten, & R. Zapata-Barrero (Orgs.), *The Routledge Handbook of the Governance of Migration and Diversity in Cities* (p. 145–156). New York: Routledge.

Graauw, E. de. (2019). City immigrant affairs offices in the United States taking local control of immigrant integration. In T. Caponio, P. Scholten, & R. Zapata-Barrero (Orgs.), *The Routledge Handbook of the Governance of Migration and Diversity in Cities* (p. 168–181). New York: Routledge.

Gross, J. S. (2019). The governance of SuperdiverSiTy a tale of two north american cities. In *The Routledge Handbook of the Governance of Migration and Diversity in Cities* (p. 231–241). New York: Routledge.

Haddad, E. (2008). *The Refugee in International Society: Between Sovereigns*. New York: Cambridge University Press.

Hillmann, F., & Pang, C. L. (2020). Migration-led Regeneration : On how cities become more unequal with mixed population flows. *Cosmopolitan Civil Societies: an Interdisciplinary Journal*, *12*(1). https://doi.org/: http://dx.doi.org/10.5130/ccs.v12i1.7297

Huq, E., & Miraftab, F. (2020). "We are All Refugees": Camps and Informal Settlements as Converging Spaces of Global Displacements. *Planning Theory and Practice*, *21*(3), 351–370. https://doi.org/10.1080/14649357.2020.1776376

Ibreck, R., & Seeka, A. (2022). Civicness in exile: The solidarities and struggles of South Sudanese refugees in Cairo. *Journal of Civil Society*, *18*(2), 219–238. https://doi.org/10.1080/17448689.2022.2068628

IOM. (2019). International Migration Law No. 34 - Glossary on Migration. In *International Migration Law*. Recuperado de https://publications.iom.int/books/international-migration-law-ndeg34-glossary-migration

Johnson, J. (Jay) G. (2022). Challenging Policies and Contextualizing Rights: Civil Society Litigation and Refugee and Asylum Seeker Governance in South African Cities. *Journal of Immigrant and Refugee Studies*, *0*(0), 1–14.

https://doi.org/10.1080/15562948.2022.2061097

Kloosterman, R. C. (2019). Migrant entrepreneurs and cities: new opportunities, newcomers, new issues. In T. Caponio, P. Scholten, & R. Zapata-barrero (Orgs.), *The Routledge Handbook of the Governance of Migration and Diversity in Cities* (p. 63–74). New York: Routledge.

Kvashnin, Y. (2020). European Cities as Migration Policy Actors. *CONTEMPORARY EUROPE-SOVREMENNAYA EVROPA*, (7), 101–112. https://doi.org/10.15211/soveurope72020101112

Lima, P. D. (2025, janeiro 27). Governo Lula convoca reunião de emergência após EUA suspender verba para braço da ONU que apoia migrantes e refugiados no Brasil. *O Globo*, p. 1–7. Recuperado de https://g1.globo.com/politica/blog/daniela-lima/post/2025/01/27/governo-lula-convoca-reuniao-de-emergencia-apos-eua-suspender-verba-para-braco-da-onu-que-apoia-migrantes-e-refugiados-no-brasil.ghtml

Menegotto, L., Luciano, E., Palacios, R., & Wiedenhöft, G. (2020). Exclusão Digital em processos de Transformação Digital: uma revisão sistemática de literatura Digital. *Gestão.Org*, *18*(2), 1679–1827. Recuperado de http://www.revista.ufpe.br/gestaoorg198ExclusãoDigitalemprocessosdeTransformaçãoDigital:umarevisãosistemáticadeliteratura

Mills, D. E., Izadgoshasb, I., & Pudney, S. G. (2021). Smart city collaboration: A review and an agenda for establishing sustainable collaboration. *Sustainability (Switzerland)*, *13*(16). https://doi.org/10.3390/su13169189

Ministério da Justiça e Segurança Pública. *INSTITUCIONAL - Estrutura organizacional Comitê Nacional para os Refugiados*. , (2025).

Ministério dos Direitos Humanos e da Cidadania. (2024). Fórum Nacional de Lideranças Migrantes, Refugiadas e Apátridas (FOMIGRA). Recuperado 15 de dezembro de 2024, de https://www.gov.br/mdh/pt-br/navegue-por-temas/migrantes-refugiados-e-apatridas/forum-nacional-de-liderancas-migrantes-refugiadas-e-apatridas-fomigra#:~:text=O Fórum Nacional de Lideranças,refugiadas e apátridas no Brasil.

Moolngearn, P., & Kraiwanit, T. (2024). Barriers To Development of Smart Cities: Lessons Learned From an Emerging Economy. *Corporate and Business Strategy Review*, *5*(2), 255–262. https://doi.org/10.22495/cbsrv5i2art22

Mourad, L. (2021). Brothers, Workers or Syrians? The Politics of Naming in Lebanese Municipalities. *Journal of Refugee Studies*, *34*(2), 1387–1399. https://doi.org/10.1093/jrs/feab012

Myers, E., Sacks, A., Tellez, J. F., & Wibbels, E. (2024). Forced displacement, social cohesion, and the state: Evidence from eight new studies. *World Development*, *173*(October 2023), 106416. https://doi.org/10.1016/j.worlddev.2023.106416

Norman, K. P. (2021). Urbanization, informal governance and refugee integration in Egypt. *Globalizations*, *0*(0), 1–16. https://doi.org/10.1080/14747731.2021.1907510

OIM. (2022a). *Govenaça Migratória Local: ferramentas e métodos* (M. Torelly, A. L. Anschau, & A. Dias, Orgs.). Brasília: Organização Internacional para as Migrações - OIM.

OIM. (2022b). *Indicadores De Governança Da Migração República Federativa Do Brasil | Segundo Perfil 2022*. Recuperado de www.iom.int

OIM Brasil. (2023). PACTO GLOBAL PARA MIGRAÇÃO. Recuperado 18 de setembro de 2024, de PACTO GLOBAL PARA UMA MIGRAÇÃO SEGURA, ORDENADA E REGULAR website: https://brazil.iom.int/pt-br/pacto-global-para-uma-migracao-segura-ordenada-e-regular

ONU. (2017). Plataforma Agenda 2030. Recuperado de http://www.agenda2030.org.br/

Palacios, R. A., Luciano, E. M., & Pereira, G. V. (2024). Urban Governance and refugees: a systematic literature review. *ACM International Conference Proceeding Series. DGO 2024, June 11–14, 2024, Taipei, Taiwan*, 341–351. https://doi.org/10.1145/3657054.3657096

Pereira, G. V., Estevez, E., Cardona, D., Chesñevar, C., Collazzo-Yelpo, P., Cunha, M. A., … Scholz, R. W. (2020). South american expert roundtable: Increasing adaptive governance capacity for coping with unintended side eects of digital transformation. *Sustainability (Switzerland)*, *12*(2). https://doi.org/10.3390/su12020718

Pereira, G. V., Parycek, P., Falco, E., & Kleinhans, R. (2018). Smart Governance in the Context of Smart Cities : A Literature Review. *Information Polity*, (May). https://doi.org/10.3233/IP-170067

Popova, Y., & Popovs, S. (2023). Effects and Externalities of Smart Governance. *Smart Cities*, *6*(2), 1109–1131. https://doi.org/10.3390/smartcities6020053

Porto Alegre. (2020). Orçamento Participativo. Recuperado 29 de abril de 2020, de http://www2.portoalegre.rs.gov.br/op/default.php?p_secao=1129

Przeybilovicz, E., & Cunha, M. A. (2024). Governing in the digital age: The emergence of dynamic smart urban governance modes. *Government Information Quarterly*, *41*(1), 101907. https://doi.org/10.1016/j.giq.2023.101907

Richardson, R. J. (2012). *Pesquisa social: Métodos e Técnicas* (3º ed). São Paulo: Atlas.

Ruijer, E., Van Twist, A., Haaker, T., Tartarin, T., Schuurman, N., Melenhorst, M., & Meijer, A. (2023). Smart Governance Toolbox: A Systematic Literature Review. *Smart Cities*, *6*(2), 878–896. https://doi.org/10.3390/smartcities6020042

Sabchev, T. (2022). The role of local political leadership in the reception of forced migrants: evidence from Greece. *Territory, Politics, Governance*, *10*(3), 306–326. https://doi.org/10.1080/21622671.2021.1927815

Skodo, A., & Zanzuchi, M. B. (2023). *Improving Stakeholder Coordination in Refugee Resettlement: Improving Stakeholder Coordination in Refugee Resettlement* (p. 31). p. 31. Recuperado de https://www.migrationpolicy.org/sites/default/files/publications/mpie-refugee-resettlement-coordination-2023_final.pdf

Smart Urban Intermediaries - SUI. (2018). *Smart cities, social innovation and smart urban development* (p. 10). p. 10. Recuperado de https://centerforborgerdialog.dk/wp-content/uploads/2019/06/smart-urbi-Smart-Cities.pdf

Spicker, P. (2014). Cohesion, Exclusion and Social Quality. *International Journal of Social Quality*, *4*(1). https://doi.org/10.3167/ijsq.2014.040107

Stürner, J. (2020). *A New Role for Cities in Global and Regional Migration Governance ?* (A.-K. M. Stiftung, A. Surwillo-Hahn, & R. Bosch, Orgs.). Recuperado de https://www.bosch-stiftung.de/sites/default/files/publications/pdf/2020-09/Study_Cities_Migration_2020.pdf

Svensson, H. (2023). Language dimensions of social cohesion: the significance of linguistic inequalities in the context of refugee settlement. *Journal of Multilingual and Multicultural Development*, 1–14. https://doi.org/10.1080/01434632.2023.2251945

Taran, P., Neves de Lima, G., & Kadysheva, O. (2016). Cities Welcoming Refugees and Migrants. In *UNESCO inclusive and Sustainable CITIES series*. Recuperado de http://unesdoc.unesco.org/images/0024/002465/246558e.pdf

UN-Habitat. (2022). Envisaging the Future of Cities. *World City Report 2022*, p. 422. Nairobi: UN-Habitat.

UNHCR. (2024). *Global Trends - Forced displacement in 2023*. Recuperado de https://www.unhcr.org/refugee-statistics

United Nations General Assembly. (1951). *Convention Relating to the Status of Refugees* (p. 21). p. 21. Recuperado de https://www.unhcr.org/media/states-parties-including-reservations-and-declarations-1951-refugee-convention?_gl=1%2A1k0wczp%2A_gcl_au%2AOTcyOTMwOTc3LjE3MzY1MjkzNzE.%2A_rup_ga%2ANTA2MDk5NjQ5LjE3MzY1MjkzNzE.%2A_rup_ga_EVDQTJ4LMY%2AMTczNjUyOTM3MS4xLjEuMTczNjU

Valera, C. M., Marinho, M. L., Robles, C., & Tromben, V. (2022). *Social cohesion and inclusive social development in Latin America: a proposal for an era of uncertainties*. https://doi.org/109-21-039-7

Yüksel, K. (2023). Ambiguity and migration governance in the satellite city of Duzce, Türkiye. *Asian and Pacific Migration Journal*, *32*(4), 636–659. https://doi.org/10.1177/01171968241232201

Zapata-Barrero, R. (2023). Urban migration governance under the resilience lens: conceptual and empirical insights. *Ethnic and Racial Studies*, *46*(13), 2833–2862. https://doi.org/10.1080/01419870.2023.2166793

Zapata-Barrero, R. (2024). Resilient urban turnaround in migration governance studies. *International Migration*, *62*(4), 20–40. https://doi.org/10.1111/imig.13277

Zapata-Barrero, R., & Cantle, T. (2019). City governance of migration and diversity: interculturalism as a city policy paradigm. In T. Caponio, P. Scholten, & R. Zapata-barrero (Orgs.), *The Routledge Handbook of the Governance of Migration and Diversity in Cities* (p. 193–203). New York: Routledge.

Zero Hora. (2021). *Uma porta aberta longe de casa : Porto Alegre ganha centro de atendimento a imigrantes e refugiados*. p. 1–7.

Track 17: Social Media and Government - Democratic challenges, regulation, uses of platforms, and actors' behavior

Track Description

In recent years, we have learned about the risks for governments and political institutions posed by social media. At the same time, innovation capabilities have emerged from the latest evolutions of social media and government. Among other issues, TikTok, virtual reality, and other social platforms and areas have abruptly emerged as global players in the entertainment sector, prompting government and other actors to engage with new audiences and social groups. Besides, some political and public institutions' challenges remain in the process of evolution. Some key aspects include polarization of the public sphere, growing claims about the potential harm of social media to our democratic communities, or the potential limitations of institutional communications with citizens due to a lack of trained human resources and government specialists. This track focuses on digital technologies that enable integration, are people-centric, and create open platforms for collaborative multi-user co-creation of services and products. Particularly, the post-COVID-19 has forced government, private, and non-profit agencies worldwide to find new ways to deliver services, and this is especially important using social media technologies. In addition, the track was open to other aspects of governments' service delivery and social media, including theoretical and conceptual advancements, methodological and data innovations, and case- and practice-based implications arising from diverse contexts.

Track Chairs

R. Sandoval-Almazan, Universidad Autónoma del Estado de México, México
J. I. Criado, Universidad Autónoma de Madrid, Spain
N. Sabatini, Gdansk University of Technology, Poland; Università della Svizzera italiana, Switzerland
K. Brito, Universidade Federal Rural de Pernambuco, Brazil

Contents

Factors Influencing the Potential Adoption of Social Media for Citizen-Based Monitoring in South Africa.....1086
L. S. Matlala

Flying chairs, heated takes: a discourse analysis of audience comments on the São Paulo Mayoral debate across five major YouTube news channels 1105
G. B. Kurtz, S. de P. Carraro, C. R. G. Teixeira, R. Tietzmann, I. H. Manssour, and M. S. Silveira

From Theory to Telegram: Enabling Factors of Anti-vaccine Disinformation in Brazil 1119
J. Ricard, E. C. de M. Silva, I. Yañez, and L. Hora

Social media and deliberation in the period of COVID-19 crisis: transforming political interaction between citizens and Russian authorities in the digital sphere 1137
D. Volkovskii and O. Filatova

Using Generative AI for Identifying Electoral Irregularities on Social Media 1150
S. Moura, E. Santos, P. Sampaio, and K. Brito

Factors Influencing the Potential Adoption of Social Media for Citizen-Based Monitoring in South Africa

Lesedi Senamele Matlala [a]

[a] School of Public Management Governance and Public Policy, University of Johannesburg, South Africa, lmatlala@uj.ac.za, https://orcid.org/0000-0002-6110-9902

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. Social media platforms have globally transformed governance, serving as vital tools for real-time communication, transparency, and public engagement. These platforms are widely used in South Africa for government-citizen communication and engagement. Still, their application in citizen-based monitoring (CBM)—a participatory governance mechanism that enables citizens to monitor public service delivery and hold governments accountable—remains unrealized. Despite South Africa's relatively high internet penetration rate of 68% and widespread social media adoption, systemic, institutional, and socio-economic barriers hinder its use for CBM. This study explores the factors influencing the potential adoption of social media for CBM in South Africa, offering insights into the opportunities and constraints shaping this emerging governance tool. Using a mixed-methods approach, the research incorporates qualitative data from interviews with government officials, media representatives, and civic organizations alongside quantitative findings from a citizen survey. The study identifies critical barriers, including unequal access to digital infrastructure, limited digital literacy among citizens and government officials, the absence of policy frameworks for social media governance, and socio-economic disparities perpetuating a digital divide. Moreover, trust deficits between citizens and government institutions present significant challenges to adopting social media for participatory monitoring. However, the research also highlights enabling factors, such as growing digital adoption, isolated cases of innovative practices, and an increasing recognition of social media's potential to enhance governance accountability. This study contributes to the discourse on digital governance by examining the factors influencing social media adoption for CBM in South Africa. It provides actionable recommendations, including investing in digital literacy programs, strengthening infrastructure, and fostering trust through participatory policy frameworks. By contextualizing South Africa's experience within the broader African governance landscape, the research lays a foundation for future strategies to harness social media's potential in bridging the gap between citizens and governments through monitoring and accountability initiatives.

Keywords. Social media, citizen-based monitoring, digital governance, public accountability
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1063

1. Introduction

The global digital revolution has significantly reshaped governance, with social media platforms like Twitter, Facebook, and WhatsApp emerging as vital tools for enhancing transparency, accountability, and real-time citizen engagement in public administration [1; 2]. In countries such as the United Kingdom and Canada, governments have successfully integrated these platforms to improve responsiveness and facilitate participatory policymaking [3; 4]. These tools have redefined citizen-government interaction, enabling engagement in governance processes that were previously

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

inaccessible to many. However, in developing contexts like South Africa, the potential of social media remains largely untapped—particularly for citizen-based monitoring (CBM), a mechanism through which citizens monitor service delivery and hold government accountable. While global examples like SeeClickFix in the United States and social media engagement by Australia's Department of Human Services highlight how digital tools can enhance CBM and improve service responsiveness [6; 7], the same cannot yet be said for South Africa, where structural and socio-economic challenges limit effective adoption.

Despite a 68% national internet penetration rate and widespread social media use, particularly via WhatsApp and Facebook, South Africa's application of these platforms for CBM remains underdeveloped [8]. While digital platforms have proven effective for crisis communication—such as during the COVID-19 pandemic—inequities persist that hinder broader engagement. Urban areas report internet connectivity above 85%, while rural areas remain significantly underserved, with just 40% connectivity [10]. High data costs, compounded by low digital literacy—only 28% of South Africans report confidence in using online tools—further inhibit participation, especially among low-income and rural populations [8; 9]. These disparities restrict access to social media-based governance tools for those who most need to monitor public services. Moreover, trust deficits between citizens and the state—stemming from perceptions of inefficacy or political manipulation of digital platforms—create an additional barrier to adoption [10; 13]. Thus, while South Africa demonstrates strong potential for digital governance, it also faces distinct socio-political and infrastructural barriers that must be addressed for CBM to become a transformative tool.

Learning from global best practices in digital governance, such as Sweden's integration of open data platforms with social media and Denmark's policy frameworks enabling citizen oversight [2; 4], South Africa has a clear opportunity to improve its CBM systems. However, the fragmented nature of its e-governance policies and lack of institutional preparedness hinder this transition [11; 12]. A focused examination of the systemic, institutional, and socio-economic factors shaping the adoption of social media for CBM is therefore both urgent and necessary. This study responds to that need, offering an in-depth exploration of the barriers and enablers of digital CBM adoption in South Africa. By combining global comparisons with a localized analysis, it highlights not only the gaps but also the potential pathways for reform. In doing so, the study contributes to a broader understanding of how social media can be meaningfully integrated into participatory governance in resource-constrained environments and sets the foundation for more inclusive, accountable, and responsive service delivery in South Africa.

2. Preliminary Literature Review

The global expansion of social media for governance has led to the emergence of citizen-based monitoring (CBM) platforms designed to enable citizens to track public service delivery and provide real-time feedback. Examples include FixMyStreet in the UK, Adaa in Saudi Arabia, Ushahidi in Kenya, SeeClickFix in the US, and GovChat in South Africa, each showcasing different ways of integrating social media into participatory governance [14; 15; 16; 17; 18]. These platforms demonstrate how structured digital feedback mechanisms can enhance transparency and accountability. However, their success is often contingent upon strong institutional capacity, robust digital infrastructure, and well-defined policy frameworks. For example, while Ushahidi successfully aggregated reports during Kenya's 2013 elections using social media and SMS, the delayed government response and reliance on donor funding highlighted sustainability challenges within institutional governance contexts [16; 19].

Platforms like SeeClickFix and GovChat similarly show the promise of social media in enabling real-time citizen reporting and enhancing government responsiveness [17; 20]. Yet, challenges persist—particularly in developing countries—where governments are often hesitant to fully embrace these tools due to fears of criticism and lack of institutional readiness [21]. In South Africa, municipalities

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

frequently use social media for one-way communication rather than interactive engagement, reducing the potential for meaningful citizen participation [22]. The Nigerian #EndSARS movement provides another relevant example, where although social media was critical in exposing abuses, the lack of formal government mechanisms for digital feedback limited the long-term governance impact [23]. These cases underscore that while social media has democratizing potential, its effectiveness is shaped by political will, institutional culture, and governance structures.

In South Africa, barriers such as digital divides, low digital literacy, and the absence of cohesive e-governance policies further undermine the use of social media for CBM. With internet penetration at only 40% in rural areas compared to 85% in urban centres, and just 28% of South Africans expressing confidence in using digital platforms, accessibility and competency remain serious challenges [21; 22; 24; 25]. Additionally, without standardized frameworks for managing social media-driven monitoring, public officials struggle to process citizen feedback, eroding trust in digital initiatives [14; 15; 26; 27]. These limitations discourage citizen engagement and reinforce scepticism about the effectiveness of social media in holding the government accountable. Existing literature tends to emphasize technological and participatory dimensions of CBM but often neglects the structural and socio-political conditions required for scalability. This study addresses these gaps by examining the systemic, institutional, and socio-economic factors that shape social media adoption for CBM in South Africa. It situates the South African experience within global trends and offers targeted policy insights for improving digital participatory governance.

3. Analytical Framework

This study employs an integrated analytical framework combining the Technology Acceptance Model (TAM), the Participatory Governance Framework, and Institutional Theory to unpack the systemic, institutional, and socioeconomic factors influencing the adoption of social media for CBM in South Africa. TAM, developed by Davis (1989), focuses on perceived usefulness and ease of use as key adoption drivers, which is especially relevant in South Africa's context of digital divides and affordability constraints, where marginalized groups often lack the digital literacy needed to navigate complex platforms [14; 15; 16]. Government officials, meanwhile, must balance the potential benefits of public engagement against risks such as misinformation, inadequate institutional capacity, and weak policy alignment [17]. Although case studies from Kenya and the Philippines show that social media can effectively enhance CBM, their success depends on institutional readiness—something South Africa currently lacks [18; 19]. The Participatory Governance Framework emphasizes trust and responsiveness as prerequisites for meaningful engagement, yet South African platforms like GovChat struggle with follow-through, reinforcing citizen distrust and limiting participation, particularly among disadvantaged communities [14; 22; 23; 24]. Institutional Theory further explains how fragmented municipal strategies, incoherent policies, and bureaucratic inertia inhibit the widespread adoption of digital tools. In contrast to countries like South Korea and Saudi Arabia—where platforms like Adaa are supported by structured governance policies—South Africa's inconsistent approach to digital governance continues to stall implementation [15; 17; 26; 27; 28]. Collectively, these frameworks provide a holistic view of the barriers and opportunities shaping social media's potential for inclusive, participatory governance in South Africa.

4. Methodological framework

A mixed-methods approach was adopted to comprehensively investigate the systemic, institutional, and socio-economic factors influencing the adoption of social media for CBM in South Africa. This approach aligns with the study's aim to capture both quantitative and qualitative insights into stakeholders' perceptions and the contextual challenges of leveraging social media as a tool for participatory

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

monitoring. Combining quantitative surveys and in-depth interviews allowed for a holistic analysis of diverse stakeholder perspectives, ensuring a robust foundation for the study.

4.1 Survey Design

The research utilized a carefully constructed sampling strategy to ensure representativeness across South Africa's nine provinces, accounting for urban and rural distinctions. From an initial target of 6912 participants, with 384 allocated per province, the study surpassed expectations by securing 7282 responses. The sample reflected the country's diverse socio-economic and demographic contexts, capturing perspectives from both digitally connected urban areas and under-resourced rural communities. Approval from the University of Johannesburg's ethical review board confirmed adherence to rigorous ethical standards in research design and execution. Structured surveys incorporating closed-ended questions were employed to gather quantitative data on citizens' awareness of CBM, perceptions of social media use for CBM, preferences for CBM tools, and involvement in participatory monitoring efforts. The survey questions were designed to evaluate participants' familiarity with public service monitoring and their perspectives on using social media platforms for governance. Statistical methods were applied to analyze patterns and correlations, offering insights into regional and socio-economic disparities in social media adoption for CBM. These data formed the foundation for exploring systemic challenges such as the digital divide, trust deficits, and perceptions of institutional responsiveness.

4.2 Interview Design

To complement the quantitative data, 12 in-depth interviews were conducted with key stakeholders, including government officials (4), representatives of community-based organizations (CBOs) (4), and members of community media (4). The interviews provided rich qualitative insights into the nuances and complexities surrounding social media adoption for CBM. Open-ended questions allowed participants to share their experiences, challenges, and opportunities related to social media integration in participatory governance. The qualitative approach uncovered stakeholder-specific perspectives on institutional readiness, socio-economic barriers, and citizen engagement dynamics. The interviews addressed questions that could not be fully explored through quantitative surveys, including the institutional capacity to handle social media-driven feedback, trust issues between citizens and government entities, and specific regional or organizational barriers to CBM implementation. Secondary data sources, including academic literature and practical reports on CBM, citizen engagement, and social media governance practices, were consulted to contextualize and enrich the findings. This triangulated methodology ensured a comprehensive understanding of the systemic factors affecting the adoption of social media for CBM in South Africa.

Table 1: Sector specifications of the respondents

Organisation	Province	Sector	Respondent code	Experience (yrs)
A	Gauteng	Government	ARE1	5 years +
B	Gauteng	Government	BRE2	5 years +
C	Gauteng	Government	CRE3	5 years +
D	Gauteng	Government	DRE4	5 years +
E	Mpumalanga	Community media	ERE5	5 years +
F	Free State	Community media	FRE6	5 years +
G	Gauteng	Community media	GRE7	5 years +
H	Limpopo	Community media	HRE8	5 years +
I	Western Cape	CBO	IRE9	5 years +
J	Gauteng	CBO	JRE10	5 years +

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

K	Gauteng	CBO	KRE11	5 years +
L	KZN	CBO	LRE12	5 years +

Source: (Author's own construction 2023)

4.3 Contextual Relevance

The mixed-methods design offered a nuanced understanding of how systemic barriers—such as digital divides and socio-economic inequalities—intersect with institutional challenges to influence social media adoption for CBM. The quantitative survey provided broad patterns and generalizable insights, while the qualitative interviews added depth by capturing stakeholders' lived experiences navigating these challenges. Together, these methods enabled the study to identify specific institutional reforms, policy recommendations, and technological adaptations necessary for integrating social media into CBM frameworks within South Africa. By combining these diverse data sources, the study ensures a comprehensive analysis of the factors affecting social media's role in participatory monitoring, contributing to the discourse on digital governance and citizen engagement in developing contexts.

5. Findings and discussions

This section presents the study's results, which aim to explore the factors influencing the adoption of social media for CBM in South Africa.

5.1 Ownership and Accessibility of Social Media

5.1.1 Ownership of Social Media Accounts

The findings reveal a high prevalence of social media account ownership among respondents, with 83% reporting active accounts across various platforms (as illustrated in Figure 1). This high percentage underscores the potential for leveraging social media as a tool for CBM in South Africa. Among the platforms used, WhatsApp emerged as the most popular, followed by Facebook and Twitter, reflecting patterns consistent with global trends in platform adoption for communication and engagement purposes [28; 29]. Urban respondents reported higher ownership rates than their rural counterparts, with 92% of urban residents owning at least one social media account, compared to 68% in rural areas. This disparity is largely attributable to differences in access to internet infrastructure and affordability, as noted in the literature on digital divides in South Africa [30; 31]. Urban areas benefit from higher broadband penetration and more reliable network connectivity, while rural areas face challenges such as limited mobile network coverage and high data costs [32]. These findings align with the analytical framework, particularly Institutional Theory, which highlights how systemic inequalities in digital infrastructure can shape technology adoption for governance purposes [33].

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

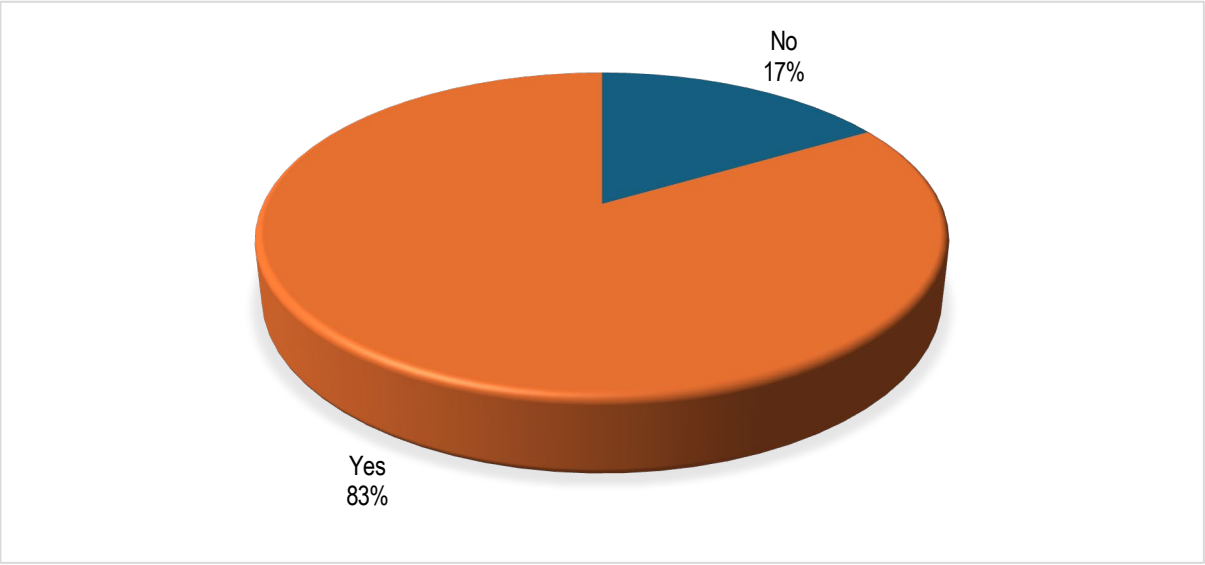


Figure 1: Percentage of respondents who have a social media account

Source: Author's own construction (2023)
N = 7282

Age and education levels further influenced ownership rates (see Figure 2). Respondents aged 18–35 exhibited the highest levels of social media account ownership (95%), while individuals over 55 reported significantly lower rates (48%). Similarly, respondents with tertiary education were likelier to own social media accounts than those with only primary or secondary education. These patterns suggest that digital literacy is critical in facilitating social media adoption, as younger and more educated individuals are generally more comfortable navigating digital platforms [29; 30]. This finding echoes the TAM, which posits that perceived ease of use and perceived usefulness are key determinants of technology adoption [34]. In this case, individuals with higher digital literacy are more likely to perceive social media as accessible and valuable for communication and monitoring.

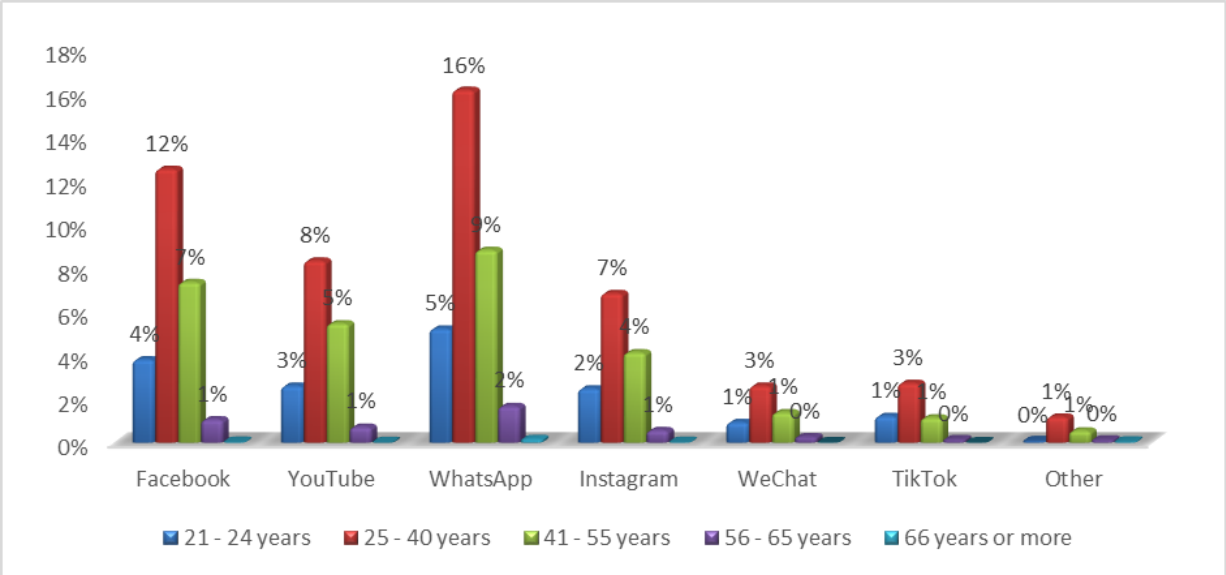


Figure 2: Ownership of social media platform by age

Source: (Author's own construction, 2023)
N = 7282

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The data reveal notable regional variations in social media platform preferences across South Africa, with respondents in Gauteng and the Western Cape—areas with better internet access—favouring platforms like Twitter and LinkedIn for professional engagement, while those in Limpopo and the Eastern Cape predominantly use WhatsApp due to its low data requirements and accessibility on basic smartphones [28; 32; 35]. This pattern reflects global trends indicating that platform adoption is shaped by local context and resource availability. High social media ownership among urban, young, and educated users offers a promising base for CBM initiatives; however, the persistent digital divide, driven by urban-rural disparities and socio-economic inequalities, remains a critical barrier [36; 37]. To ensure equitable adoption, targeted strategies must focus on expanding digital infrastructure, lowering data costs, and implementing robust digital literacy programs in underserved areas. These findings underscore a key tension outlined in the analytical framework: while social media holds significant potential for participatory monitoring, its effectiveness is limited by systemic inequalities and institutional readiness. As emphasized in the Participatory Governance Framework, trust, inclusivity, and institutional support are essential for transforming social media into a legitimate CBM tool [20; 29]. Thus, ownership alone is not enough—real impact requires addressing issues of access, trust, and policy coherence through comprehensive governance reforms [30, 31, 38].

5.1.2 Accessibility to Digital Infrastructure

Access to digital infrastructure is a foundational requirement for adopting social media in CBM, yet the study reveals persistent disparities across demographic and geographic lines. As illustrated in Figure 3, only 35% of respondents reported having internet access in their dwellings, while 8% explicitly lacked access, and an additional 57 respondents did not provide a response—likely indicative of connectivity challenges. This data underscores ongoing structural barriers to digital inclusion in South Africa's governance landscape [39; 40]. Younger respondents (aged 25–40) showed the highest levels of connectivity (17%), reflecting their relative digital fluency and alignment with the TAM, which posits that perceived ease of use and usefulness drive adoption [42]. In contrast, respondents above the age of 55 exhibited significantly lower levels of access, consistent with findings from Mawela (2017) and Loader & Mercea (2011), which highlight generational gaps in digital engagement [41]. However, access alone does not guarantee participation in CBM; other factors—such as distrust in institutions and doubts about the efficacy of digital reporting—remain critical barriers. These findings point to the need for targeted, age- and education-sensitive interventions to promote both digital literacy and civic engagement across all age groups [43].

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

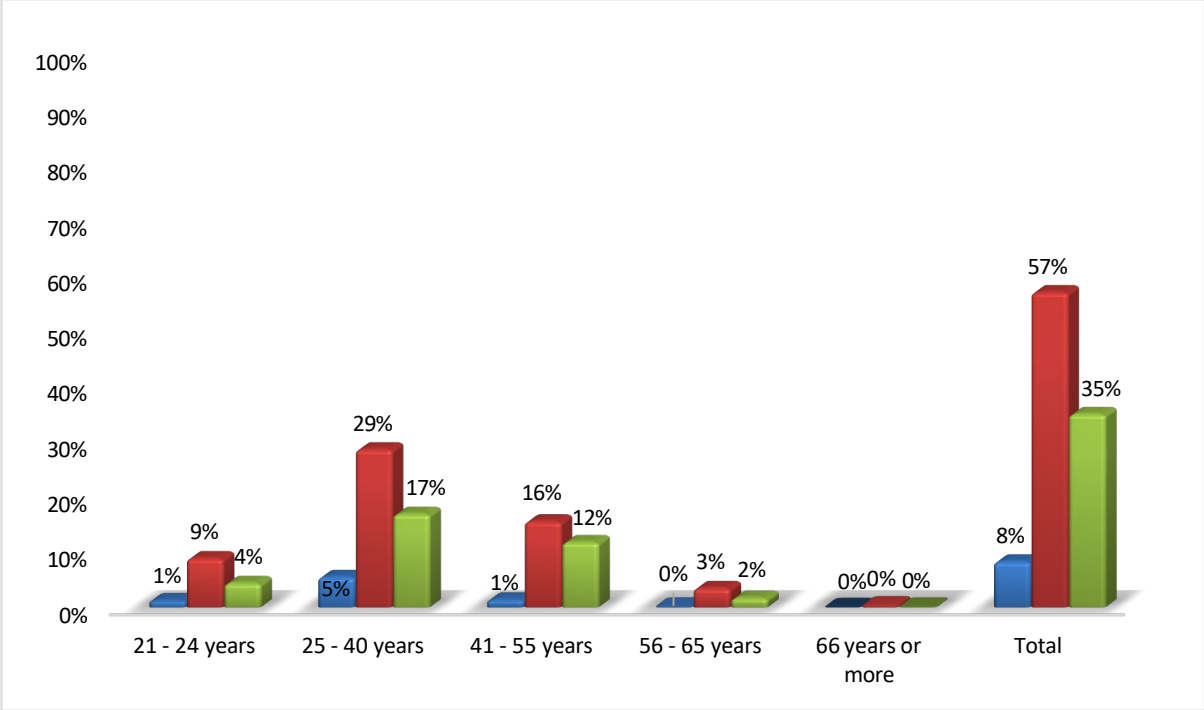


Figure 3: Internet connection in the dwelling

Source: Author's own construction (2023)
N = 7282

Geographical disparities compound these challenges, with urban respondents reporting significantly higher internet access than those in rural settings. This reflects a broader national trend in South Africa, where rural areas face systemic infrastructural deficiencies, limited broadband coverage, and unaffordable mobile data prices that severely constrain connectivity [44; 45]. According to Institutional Theory, such infrastructural limitations represent deeper organizational and systemic obstacles that hinder the equitable adoption of digital tools for governance [46]. Furthermore, the data show that respondents with tertiary education were more likely to report internet access, reinforcing the link between digital connectivity and socio-economic advantage [47]. Provincial patterns also reveal stark inequalities: Gauteng and the Western Cape showed far higher rates of internet penetration compared to under-resourced provinces like Limpopo and the Eastern Cape [48]. These findings suggest that without significant investment in broadband expansion, affordable data packages, and localized digital literacy training, social media will remain an exclusive rather than inclusive CBM mechanism. Strategic interventions at both national and provincial levels are essential to ensure that digital governance frameworks are equitably accessible to all citizens, especially those in underserved regions [49; 50].

5.2 Perceived Usefulness of Social Media for CBM

5.2.1 Perceptions of Social Media's Role in Monitoring

The findings present a mixed outlook on the perceived usefulness of social media for CBM in South Africa. According to survey data (see figure 4), 33% of respondents found social media to be accessible and practical for monitoring public services. In comparison, 21% disagreed, indicating that a substantial portion of participants either lack confidence in its effectiveness or face systemic barriers to its use. The remaining respondents expressed uncertainty or neutrality, which likely reflects limited exposure to or understanding of the use of social media for CBM purposes. This aligns with studies suggesting that

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

many citizens in developing contexts are only beginning to grasp digital platforms' role in enhancing governance [39; 40]. Furthermore, younger respondents were more likely to express confidence in social media's accessibility for monitoring. In comparison, older respondents and rural participants appeared less optimistic, likely due to challenges such as limited digital literacy, lack of infrastructure, and high data costs, which persist as significant barriers [41].

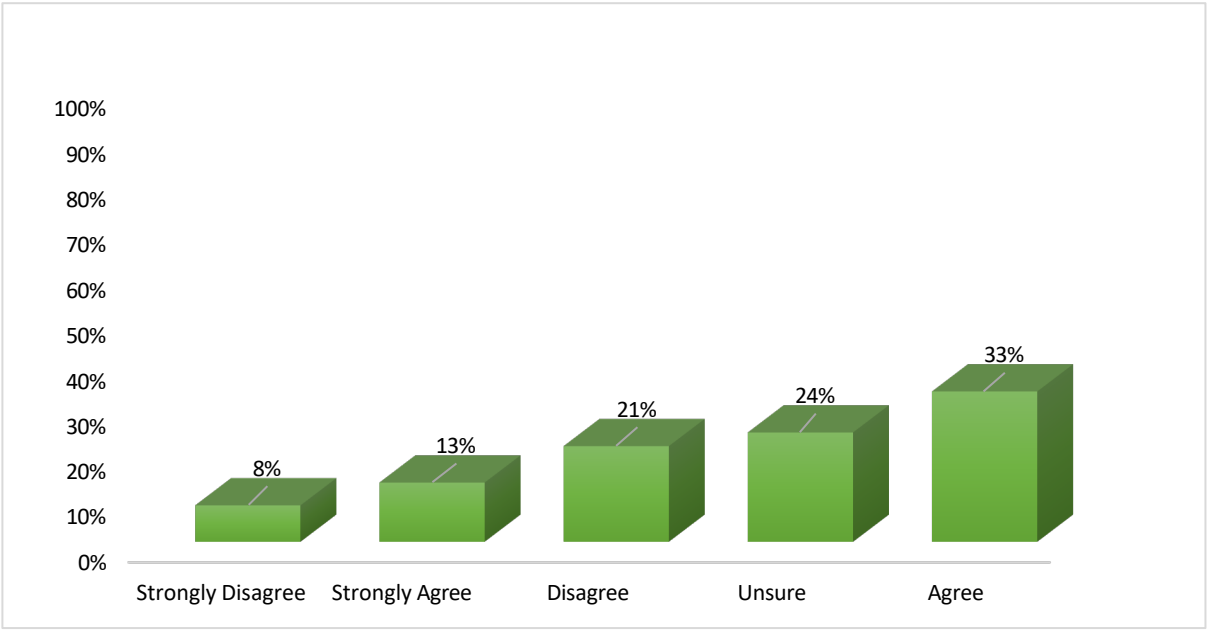


Figure 4: Perception of ease of access of monitoring service delivery via social media
Source: Author's own construction (2023)
N = 7282

When asked about the perceived effectiveness of social media for monitoring public services, 37% of respondents agreed that it is an effective tool. In comparison, 16% disagreed, and the remaining participants expressed neutrality (see Figure 5). These findings suggest that while social media's potential for CBM is recognized, doubts remain regarding its practical application. This skepticism could be attributed to systemic issues such as misinformation and institutional unresponsiveness, both of which are identified in existing research as critical barriers to the adoption of social media for governance purposes [39; 40]. Additionally, urban respondents expressed higher levels of agreement regarding social media's effectiveness than their rural counterparts, a disparity reflecting ongoing infrastructural and socio-economic inequalities [40].

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

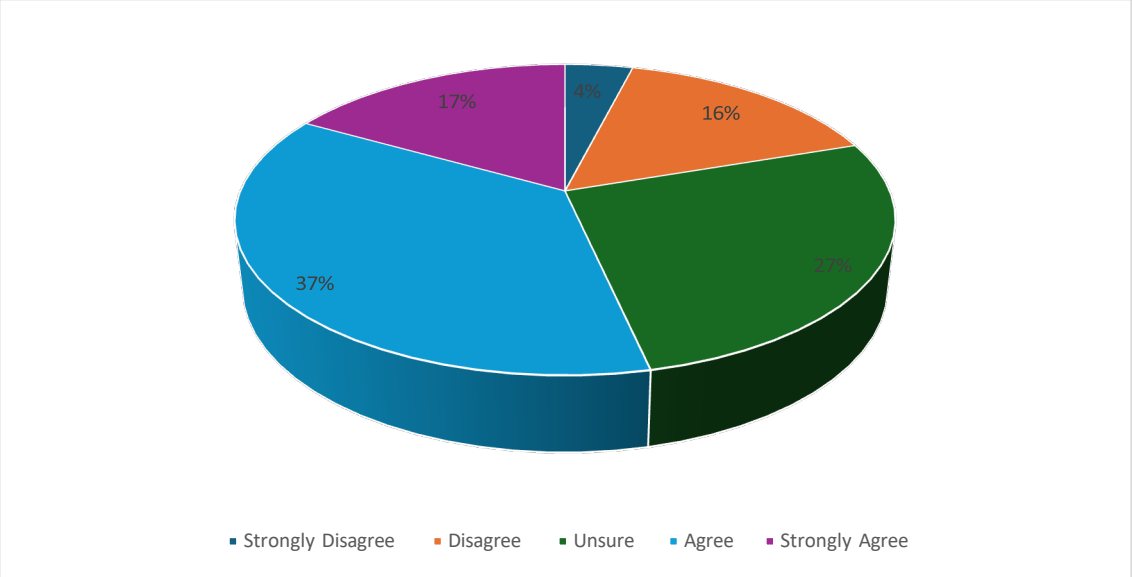


Figure 5: Perceptions of the effectiveness of monitoring service delivery via social media
Source: (Author's own construction, 2023)
N = 7282

Insights from interviews added depth to these survey findings, providing a nuanced understanding of stakeholder perceptions. Government officials, for example, acknowledged the potential of social media for real-time feedback but expressed reservations about its effectiveness due to challenges such as misinformation and resource limitations. CBOs were more optimistic, highlighting social media's role in amplifying community voices and bridging gaps between citizens and government entities. However, they also pointed to resource and digital literacy constraints as obstacles to fully utilizing these platforms for CBM. Local media representatives emphasized the speed and reach of social media, particularly in disseminating information to underserved communities, but noted the challenges of combating misinformation and maintaining credibility.

Table 2: Stakeholder Perspectives on Social Media for CBM

Stakeholder Group	Perceived Benefits	Perceived Challenges	Illustrative Quotes
Government Officials	- Allows for real-time citizen feedback	- Misinformation undermines credibility - Resource constraints and institutional capacity limitations	"False narratives often escalate quickly" (CRE3).
CBOs	- Amplifies marginalized voices	- Resource constraints in mobilizing digitally excluded populations - Challenges engaging rural and low-literacy populations	"Social media provides a platform for communities to highlight issues" (JRE10).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Local Media	- Rapid dissemination of local issues to the community - Enhances awareness of public service failures	- Struggles to maintain credibility due to misinformation	"Social media quickly informs communities about local issues" (HRE8).

The generational and regional disparities observed in the survey data (see figure 6) are consistent with global trends, where younger and urban populations tend to perceive digital tools as more accessible and effective due to higher levels of digital literacy and infrastructure availability [30; 33]. These disparities likely contribute to the skepticism expressed by older and rural respondents, who face more significant barriers to digital participation. Additionally, the neutrality expressed by a considerable proportion of respondents may reflect the limited institutionalization of social media in governance, as highlighted in the literature. The absence of structured processes for addressing citizen feedback on social media likely undermines confidence in its effectiveness, a finding corroborated by the views of government officials, who pointed to resource and policy gaps as key challenges.

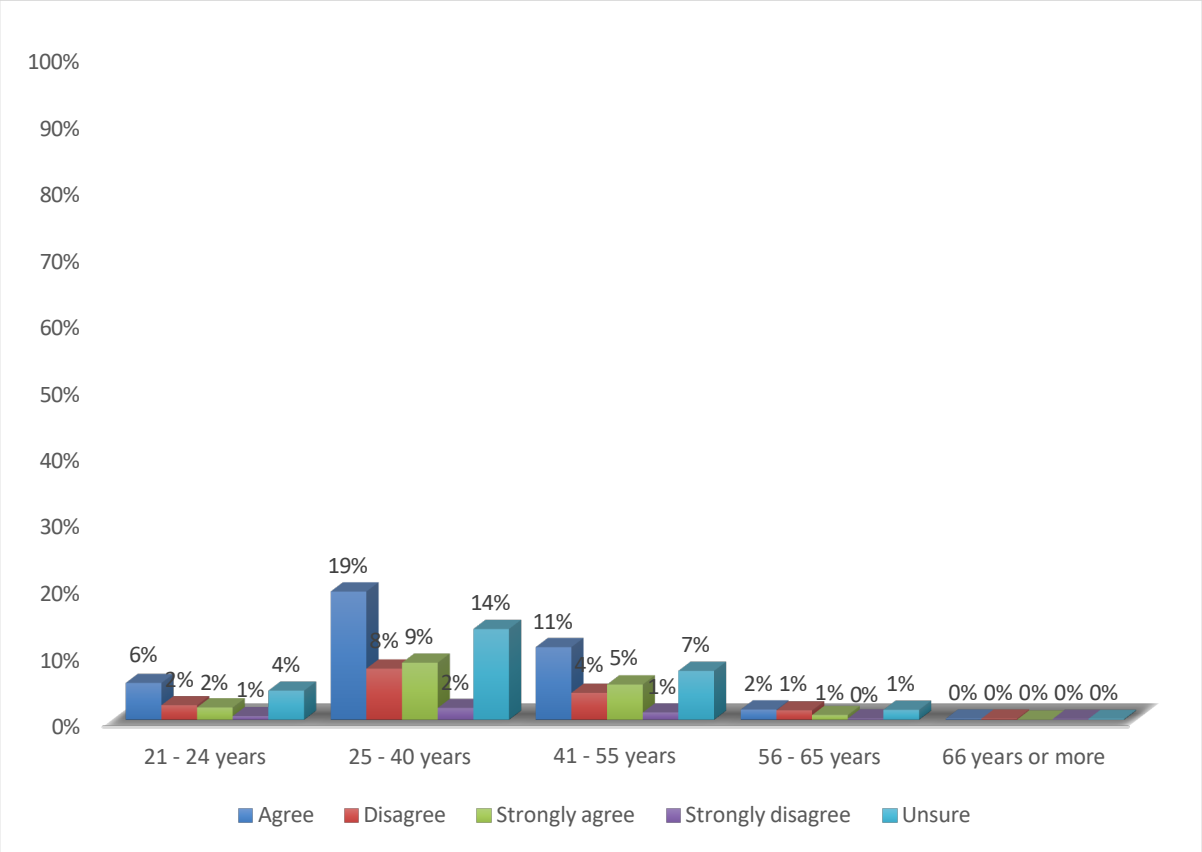


Figure 6: Social media as an effective tool for monitoring by age
Source: Author's own construction (2023)
N = 7282

On the other hand, CBOs and local media representatives demonstrated a more positive outlook on social media's role in CBM, emphasizing its participatory potential. However, their perspectives also underscored the need to address digital literacy and access disparities to maximize the reach and impact of these platforms. These findings suggest that while social media holds significant promise as a tool for CBM, its perceived usefulness is shaped by systemic barriers and stakeholder-specific challenges, as noted in prior research. The contrast between optimistic and skeptical views highlights the complexity

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of integrating social media into CBM frameworks and the necessity of addressing underlying disparities to realize its potential fully.

5.2.2 Barriers to Social Media Use for CBM

The study identifies a range of systemic, institutional, and socio-economic barriers that hinder the adoption of social media for CBM in South Africa. Key challenges include trust deficits, fear of surveillance, government unresponsiveness, authenticity concerns, privacy issues, misinformation, digital literacy gaps, and the persistent digital divide. As summarized in Table 3, these barriers interact to create an environment where citizens—particularly those in marginalized communities—are reluctant or unable to engage meaningfully in digital monitoring processes. Respondents expressed deep skepticism toward government intentions, viewing digital initiatives as performative rather than substantive. Statements like "citizens feel their complaints are often ignored" (JRE10) and "people hesitate to engage online because they fear being monitored" (HRE8) reflect broader concerns about government transparency, data misuse, and retaliation. These concerns are compounded by weak privacy safeguards and South Africa's history of service delivery failures, making social media an untrusted space for civic engagement [41; 42; 43; 44; 45].

Table 3: Thematic Summary of Barriers to Social Media Use for CBM

Barrier	Description	Interconnected Effects
Trust Issues	Low trust in government and institutions undermines citizen participation.	Reduces citizen willingness to engage in CBM initiatives.
Fear of Surveillance	Fear that social media monitoring could lead to retaliation or misuse of data.	Discourages citizens from reporting issues via social media.
Lack of Responsiveness from Authorities	Authorities often fail to act on issues raised by citizens, leading to frustration.	Erodes confidence in the impact of citizen-based monitoring.
Authenticity Concerns	Difficulty verifying the credibility of social media content discourages engagement.	Undermines trust in the platform as a reliable medium for monitoring.
Privacy Concerns	Concerns about data protection and misuse hinder citizens' willingness to participate.	Restricts citizens' participation due to safety and ethical concerns.
Digital Divide	Unequal access to technology creates barriers for marginalized communities.	Excludes disadvantaged groups, weakening representativity in CBM efforts.
Misinformation	False or misleading information circulating on social media reduces credibility.	Dilutes the effectiveness of valid concerns raised on social media.
Limited Digital Literacy	Limited understanding of social media tools restricts effective citizen participation.	Limits the use of digital tools in marginalized and rural areas.

Institutional shortcomings further exacerbate these barriers. Respondents highlighted the lack of capacity within government structures to respond effectively to digital feedback, with CRE3 noting, "posts rarely lead to actionable outcomes because we lack the capacity to process them systematically." Without structured mechanisms or adequate training, public agencies struggle to turn digital input into policy or service improvements, reinforcing citizen disengagement [47; 48]. Additionally, the prevalence of misinformation diminishes the perceived reliability of social media, with GRE7 remarking that "misinformation makes it harder for citizens to trust any information, even if it's accurate" [49; 50; 51]. Privacy concerns—especially among older and rural respondents—were frequently cited, as many people are unsure how their data will be used and protected (IRE9) [52; 53]. The digital divide also remains a formidable obstacle, with high data costs and poor rural infrastructure excluding large segments of the population from digital participation [55]. Collectively, these barriers emphasize the urgent need for robust data protection, increased institutional responsiveness, digital literacy initiatives, and infrastructural investment to ensure that social media can fulfill its promise as an inclusive CBM tool.

5.3 Enabling Factors for Social Media Adoption in CBM

The adoption of social media for CBM in South Africa is supported by a range of enabling factors that go beyond digital access to include psychological, social, and institutional dynamics. Key enablers

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

identified in this study include perceived ease of use, perceived usefulness, social influence, and trust in the platform, all of which are contextualized within South Africa's socio-political landscape. WhatsApp and Facebook emerged as dominant platforms due to their user-friendly interfaces, particularly among younger demographics. As Respondent IRE9 noted, "WhatsApp is easy to use, even for people who are not tech-savvy," aligning with TAM's emphasis on usability as a core adoption driver [66]. Perceived usefulness was another strong enabler, with WhatsApp groups being used to raise community issues quickly and efficiently—paralleling the use of FixMyStreet in the UK [67]. In addition, social influence played a motivating role, especially among youth groups. As JRE10 stated, "If everyone is using it to communicate with government, people will follow," reflecting the growing normalization of social media as a tool for civic engagement [68].

Enabler	Description	Illustrative Examples	Stakeholder Perspectives
Perceived Ease of Use	The simplicity of using social media platforms facilitates adoption among users, especially younger demographics.	Platforms like WhatsApp and Facebook, known for their intuitive interfaces, dominate usage in South Africa.	"WhatsApp is easy to use, even for people who are not tech-savvy" (IRE9).
Perceived Usefulness	Social media's utility in raising awareness, sharing information, and reporting issues enhances its appeal.	WhatsApp groups are used to report community service delivery problems directly to local stakeholders.	"It's useful for quickly raising issues that affect the community" (GRE7).
Social Influence	The role of peers and social networks in encouraging the use of social media for CBM.	Youth groups promoting social media campaigns for governance accountability in urban areas.	"If everyone is using it to communicate with government, people will follow" (JRE10).
Sense of Belonging	Social media fosters a sense of community by connecting citizens with shared concerns.	Local WhatsApp groups discussing community challenges and solutions.	"It makes us feel connected to others who care about the same issues" (HRE8).
Trust in the Platform	Confidence in the credibility and reliability of platforms to facilitate engagement and deliver results.	Platforms like Twitter are seen as credible tools for disseminating real-time updates and amplifying voices.	"Twitter gives a platform to make issues visible to everyone, including officials" (CRE3).
Access to Technology	Increasing penetration of smartphones and affordable data packages enabling broader use of social media.	High smartphone ownership rates among younger demographics; mobile networks improving coverage in rural areas.	"Most people in the community have smartphones now, even in rural areas" (BRE2).
Positive Social Norms	Growing cultural acceptance of social media as a legitimate platform for engagement and monitoring.	Social media is increasingly viewed as an expected channel for citizen feedback.	"People expect the government to use social media now; it's becoming normal" (FRE6).
Relative Advantage	Perception that social media provides unique benefits over traditional CBM methods like in-person reporting.	Social media allows for real-time updates and engagement, unlike manual complaint forms.	"It's faster and easier than going to an office to file a complaint" (DRE4).
Competitive Pressure	Peer pressure within communities and among government agencies to adopt social media as a tool for governance.	Municipalities adopting platforms like GovChat to remain competitive with modern governance trends.	"Departments feel they need to use these tools because others are" (CRE3).
Ability to Connect	Social media enables citizens to easily interact with government, peers, and stakeholders.	Platforms facilitate direct communication with local officials and community leaders.	"Social media helps us reach people who can actually make a difference" (JRE10).

Trust in platforms like Twitter, valued for real-time updates and public visibility, was another enabler, as emphasized by Respondent CRE3: "Twitter gives a platform to make issues visible to everyone, including officials," echoing experiences in cities like Seoul [69]. Sense of belonging and ability to connect were also essential, with respondents reporting that social media fosters community cohesion and enables direct communication with officials and peers. Respondent HRE8 shared, "It makes us feel connected to others who care about the same issues." Broader enablers like access to technology, positive social norms, relative advantage over traditional reporting, and competitive pressure among municipalities also contribute to adoption. These factors collectively illustrate that while infrastructure remains essential, social and institutional perceptions are equally critical for enabling social media integration into CBM frameworks.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5.4 Intersection of Access, Perception, and Institutional Readiness

The adoption and effectiveness of social media for CBM in South Africa hinge on the interconnected dynamics of access, public perception, and institutional readiness. Survey data show that only 35% of respondents have home internet access, while 8% explicitly lack connectivity, exposing persistent digital inequalities that disproportionately affect rural and low-income communities. High data costs and poor network coverage in underserved areas severely limit digital participation, as noted by government official CRE3: "Without stable internet access, these platforms can never reach their full potential." This digital divide reflects the systemic constraints emphasized by Institutional Theory, which argues that unequal access to infrastructure reinforces broader socio-economic disparities [70]. Consequently, the citizens who experience the worst service delivery are often the least able to participate in digital monitoring efforts, undermining the inclusivity and effectiveness of CBM.

Equally important are citizen perceptions of social media's utility and institutional capacity to act on feedback. Although 33% of respondents believe social media is a practical tool for public service monitoring, 21% remain skeptical due to concerns over misinformation, lack of responsiveness, and privacy risks. As HRE8 put it, "People don't trust that their complaints will be taken seriously," underscoring how past inaction erodes trust. This aligns with the Technology Acceptance Model (TAM), which highlights that perceived usefulness and institutional responsiveness are central to adoption [71; 72]. Institutional readiness is also a critical factor: government officials cited a lack of clear protocols, training, and coordinated policy frameworks as barriers to operationalizing social media for CBM. As ARE1 stated, "There is no clear protocol for handling citizen feedback received through social media." The fragmented implementation of platforms like GovChat reveals that despite some promise, CBM effectiveness is limited by inconsistent governance structures [73; 74]. To harness the full potential of social media in governance, South Africa must address digital access, improve public trust, and implement coherent, scalable e-governance strategies.

6. Implications of Findings

The findings of this study reveal that the adoption of social media for CBM in South Africa is shaped by a complex interplay of systemic, institutional, and socio-economic factors, with significant implications for digital inclusion and participatory governance. Digital access remains a critical determinant, as higher connectivity among urban populations enables greater engagement, while rural and low-income communities remain largely excluded—reinforcing the structural inequalities identified in Institutional Theory. This exclusion threatens the legitimacy and effectiveness of CBM efforts by sidelining the very groups most affected by poor service delivery. Simultaneously, public perception of social media's usefulness is undermined by widespread distrust in government, misinformation, and a lack of institutional responsiveness—factors that align with the Participatory Governance Framework, which stresses that trust and visible action are essential for sustained citizen engagement. Institutional readiness further constrains CBM potential, with the study identifying fragmented municipal policies, insufficient training, and the absence of standardized feedback mechanisms as core challenges. As platforms like WhatsApp and Twitter become increasingly embedded in civic life, concerns around surveillance, privacy, and content credibility underscore the contested nature of digital spaces. To avoid reinforcing existing power asymmetries, the study argues that social media must be integrated into CBM through targeted reforms—expanding access, building trust, enhancing institutional capacity, and embedding clear governance protocols that ensure meaningful, inclusive, and accountable digital participation.

7. Conclusion and Future Research Directions

Social media has emerged as a powerful tool for communication, engagement, and participatory governance, yet its application in CBM remains constrained by systemic, institutional, and socio-economic barriers. The findings of this study illustrate how digital inequalities, trust deficits, and institutional unpreparedness collectively shape the feasibility of social media as a governance tool in South Africa. While the increasing adoption of social media presents opportunities for enhancing citizen engagement, the persistent reluctance of government institutions to embrace these platforms for accountability mechanisms reflects broader governance challenges. The study highlights how access

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

disparities exclude marginalized populations from meaningful participation in CBM, reinforcing pre-existing inequalities in digital governance. Furthermore, the absence of clear institutional protocols, combined with fears of surveillance and misinformation, limits these platforms' perceived credibility and effectiveness in holding public institutions accountable. However, the study also identifies enabling factors—such as the growing normalization of digital engagement, the influence of peer networks, and the demonstrated potential of localized social media-driven initiatives—that suggest a pathway for broader adoption if systemic barriers are addressed. These findings align with global experiences, where the success of technology-driven CBM initiatives has depended not just on access to digital platforms but also on institutional willingness, public trust, and structured policy interventions. The South African context underscores the need for governance frameworks that do not merely incorporate social media as a supplementary communication tool but integrate it into structured participatory governance models. Without addressing digital divides, strengthening institutional capacity, and fostering public confidence, social media-driven CBM initiatives risk being ineffective or reinforcing governance asymmetries. As digital technologies continue to evolve, future research and policy efforts must remain focused on aligning digital inclusion, regulatory frameworks, and institutional responsiveness to ensure that social media can function as a meaningful tool for accountability rather than just a symbolic platform for engagement. Future research should explore the scalability and sustainability of grassroots and citizen-led initiatives—such as community WhatsApp groups—as formal mechanisms for participatory governance within CBM frameworks.

8. Recommendations

Several targeted recommendations must be implemented to address the systemic, institutional, and socio-economic barriers limiting the adoption of social media for CBM in South Africa. First, strengthening trust through transparent engagement processes is essential, given the widespread skepticism about government responsiveness. Establishing formal mechanisms where authorities publicly acknowledge citizen feedback, provide updates on actions taken, and create clear follow-up processes will enhance credibility. Additionally, proactive communication addressing surveillance and data privacy concerns is necessary to reassure users. Institutional capacity must also be improved, as findings highlighted resource and skills deficits among government officials managing social media interactions. Training programs should equip officials with the ability to engage with citizens effectively, while dedicated CBM units within municipalities or provincial departments can standardize and streamline responses. Developing clear operational guidelines for CBM-related social media use will further improve institutional coherence. Another critical aspect is mitigating misinformation, as the spread of false information erodes trust in CBM platforms. Collaborative efforts between government bodies, civil society, and social media platforms should establish verification mechanisms and fact-checking processes. Public education campaigns on identifying credible information and integrating artificial intelligence moderation tools can also help mitigate misinformation risks. Additionally, privacy concerns must be addressed through robust data protection policies aligned with global best practices, with clear public communication ensuring citizens understand how their data is safeguarded.

Beyond institutional readiness and trust-building, expanding digital access remains a fundamental requirement, particularly for rural and low-income populations. The study's findings reinforce the need for targeted interventions to address digital disparities. Policymakers should explore partnerships with telecommunications providers to introduce subsidized data packages for CBM engagement, particularly through platforms like GovChat. Establishing community internet hubs and mobile data subsidy programs will further ensure that marginalized populations can participate meaningfully in digital governance. Furthermore, localized and citizen-led initiatives should be leveraged to strengthen CBM at the grassroots level. Existing informal monitoring mechanisms, such as community WhatsApp groups, can be scaled into formalized governance processes through municipal support, funding, and technical assistance. Tools tailored to user needs, particularly multilingual and disability-accessible platforms, should be prioritized to ensure inclusivity. Additionally, social media should be strategically leveraged to amplify marginalized voices, with municipal authorities actively monitoring community-driven digital campaigns and hashtags to incorporate citizen feedback into service delivery planning. Establishing formal collaborations with crowdsourcing platforms that aggregate citizen concerns can further enhance the effectiveness of CBM. These recommendations align directly with the study's findings, providing actionable steps to overcome barriers, enhance institutional responsiveness, and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

foster greater trust in the use of social media for CBM in South Africa. By addressing these challenges, the potential of digital platforms to improve transparency, accountability, and participatory governance can be fully realized.

Citing Related Work

There are no in the current document.

ACKNOWLEDGMENTS

HISTORY DATES

References

[1] Chadwick, A. (2009). Web 2.0: New challenges for the study of e-democracy. The Journal of E-Democracy, 7(4), 10-15.
[2] OECD. (2021). Digital Government Review of Norway. OECD Publishing.
[3] Bertot, J. C., Jaeger, P. T., & Grimes, J. M. (2012). Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. Government Information Quarterly, 29(3), 365-374.
[4] Meijer, A., & Bolívar, M. P. R. (2012). The implementation of social media for participation in the public sector. In Proceedings of the 2012 International Conference on e-Government.
[5] UNDP. (2021). Participatory Governance and Citizen Engagement: A Global Perspective. United Nations Development Programme.
[6] Eom, T., Park, J., & Yoo, C. (2018). The use of social media for citizen participation in local government: The case of SeeClickFix. Public Administration Review, 78(5), 812-821.
[7] Howard, A., & Parks, L. (2012). The Australian Government's engagement with social media. Australian Journal of Political Science, 47(2), 229-245.
[8] ICASA. (2022). South Africa's Internet Usage Statistics 2022. Independent Communications Authority of South Africa.
[9] Statistics South Africa. (2022). The role of digital platforms in public service delivery in South Africa.
[10] Afrobarometer. (2023). South Africa's Digital Divide: Bridging the Gap. Afrobarometer Report No. 45.
[11] Draai, S. (2010). Governance, transparency, and the challenges of implementing e-governance in South Africa.
[12] Farelo, T., & Morris, M. (2006). E-Government Policy Framework in South Africa.

[13] Matsilele, T. (2019). Public Perceptions on Digital Governance and Accountability in South Africa. South African Journal of Public Administration.
[14] Peled, A., & Unkule, G. (2016). FixMyStreet: The use of social media in citizen-based monitoring. International Journal of Urban Governance, 8(2), 145-160.

[15] Almalki, M., & Mohammed, M. (2018). Adaa: Enhancing citizen participation through social media in Saudi Arabia. Government Information Quarterly, 35(4), 581-594.

[16] Okolloh, O. (2009). Ushahidi: Mapping post-election violence and the use of social media in disaster management. Journal of African Technology and Development, 6(3), 220-234.

[17] Charowa, K., Gavaza, F., & Mavodza, M. (2020). GovChat: Leveraging social media for improving service delivery in South Africa. African Journal of Public Administration, 28(3), 320-332.

[18] Charowa, K., Gavaza, F., & Mavodza, M. (2020). GovChat: Leveraging social media for improving service delivery in South Africa. African Journal of Public Administration, 28(3), 320-332.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

[19] Chege, M., & Kiunguyu, A. (2019). Ushahidi and citizen engagement: Lessons from Kenya's election monitoring. International Journal of Political Participation, 22(1), 67-81.

[20] Doppelt, B. (2013). SeeClickFix: A platform for citizen engagement and accountability. Urban Affairs Review, 48(2), 239-256.

[21] Matsilele, T. (2019). Public Perceptions on Digital Governance and Accountability in South Africa. South African Journal of Public Administration.

[22] ICASA. (2022). South Africa's Internet Usage Statistics 2022. Independent Communications Authority of South Africa.

[23] Ogunlana, A., & Olalekan, O. (2018). #EndSARS and social media's role in mobilizing advocacy. Nigerian Journal of Political Science, 35(1), 59-72.

[24] Mawela, S. (2017). Digital literacy and the implications for social media use in governance. South African Journal of Information Studies, 22(2), 45-53.

[25] Afrobarometer. (2023). South Africa's Digital Divide: Bridging the Gap. Afrobarometer Report No. 45.

[26] Farelo, T., & Morris, M. (2006). E-Government Policy Framework in South Africa.

[27] Draai, S. (2010). Governance, transparency, and the challenges of implementing e-governance in South Africa.
[14] Peled, A., & Unkule, G. (2016). FixMyStreet: The use of social media in citizen-based monitoring. International Journal of Urban Governance, 8(2), 145-160.

[15] Almalki, M., & Mohammed, M. (2018). Adaa: Enhancing citizen participation through social media in Saudi Arabia. Government Information Quarterly, 35(4), 581-594.

[16] Okolloh, O. (2009). Ushahidi: Mapping post-election violence and the use of social media in disaster management. Journal of African Technology and Development, 6(3), 220-234.

[17] Eom, T., Park, J., & Yoo, C. (2018). The use of social media for citizen participation in local government: The case of SeeClickFix. Public Administration Review, 78(5), 812-821.

[18] Chege, M., & Kiunguyu, A. (2019). Ushahidi and citizen engagement: Lessons from Kenya's election monitoring. International Journal of Political Participation, 22(1), 67-81.

[19] Doppelt, B. (2013). SeeClickFix: A platform for citizen engagement and accountability. Urban Affairs Review, 48(2), 239-256.

[20] Bonsón, E., Casaló, L. V., & Escobar-Rodríguez, T. (2012). Local e-Government 2.0: Social media and citizen participation in local governments. Online Information Review, 36(4), 1-20.

[21] OECD. (2021). Digital Government Review of Norway. OECD Publishing.

[22] Loader, B. D., & Mercea, D. (2011). Social media and democratic engagement: What does the evidence say? Information, Communication & Society, 14(6), 703-719.

[23] Matsilele, T. (2019). Public Perceptions on Digital Governance and Accountability in South Africa. South African Journal of Public Administration.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

[24] Charowa, K., Gavaza, F., & Mavodza, M. (2020). GovChat: Leveraging social media for improving service delivery in South Africa. African Journal of Public Administration, 28(3), 320-332.

[25] Scott, W. R. (2014). Institutions and Organizations: Ideas, Interests, and Identities. SAGE Publications.

[26] Farelo, T., & Morris, M. (2006). E-Government Policy Framework in South Africa.

[27] Draai, S. (2010). Governance, transparency, and the challenges of implementing e-governance in South Africa.

[28] ICASA. (2022). South Africa's Internet Usage Statistics 2022. Independent Communications Authority of South Africa.
[28] Meijer, A., Bolívar, M. P. R., & Jansen, D. (2012). Social media and public governance: The evolution of government use of social media for public engagement. *Journal of Public Administration Research and Theory*, 22(4), 1-15.

[29] Loader, B. D., & Mercea, D. (2011). Social media and democratic engagement: What does the evidence say? *Information, Communication & Society*, 14(6), 703-719.

[30] Mawela, S. (2017). Digital literacy and the implications for social media use in governance. *South African Journal of Information Studies*, 22(2), 45-53.

[31] Afrobarometer. (2023). South Africa's Digital Divide: Bridging the Gap. *Afrobarometer Report No. 45*.

[32] ICASA. (2022). South Africa's Internet Usage Statistics 2022. *Independent Communications Authority of South Africa*.

[33] Scott, W. R. (2014). *Institutions and Organizations: Ideas, Interests, and Identities*. SAGE Publications.

[34] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340.

[35] OECD. (2021). *Digital Government Review of Norway*. OECD Publishing.

[36] Matsilele, T. (2019). Public Perceptions on Digital Governance and Accountability in South Africa. *South African Journal of Public Administration*.

[37] Farelo, T., & Morris, M. (2006). *E-Government Policy Framework in South Africa*.

[39] Scott, W. R. (2014). *Institutions and Organizations: Ideas, Interests, and Identities*. SAGE Publications.

[40] ICASA. (2022). South Africa's Internet Usage Statistics 2022. *Independent Communications Authority of South Africa*.
[41] National Digital Inclusion Report (2023). Internet Connectivity and the Digital Divide in South Africa.
[42] Statistics South Africa (2022). *Internet Access and Digital Participation Report*.
[43] Independent Communications Authority of South Africa (ICASA). (2022). *South Africa's Digital* Connectivity Landscape.
[44] Report on Public Trust and Social Media Governance in Africa (2022).
[45] Data Privacy and Surveillance Risks in Digital Governance (2021).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

[46] South African Human Rights Commission (2023). Digital Rights and Freedoms Report.
[47] Participatory Governance Frameworks in Africa (2022). OECD Digital Policy Brief.
[48] Institutional Challenges in E-Governance Adoption (2023).
[49] Fake News and Public Perception Study (2022).
[50] Policy Gaps in South Africa's Social Media Regulations (2021).
[51] The Role of Social Media in Governance: An Empirical Analysis (2023).
[52] South African Cybersecurity and Privacy Laws (2022).
[53] Barriers to Digital Inclusion: A Policy Review (2023).
[54] Public Perceptions of Misinformation and Government Trust (2023).
[55] Digital Transformation and Internet Accessibility in South Africa (2022).
[56] Institutional Readiness for Digital Governance in Developing Countries (2023).
56] Peled, A., & Unkule, D. (2016). FixMyStreet: An Evaluation of an Innovative Governance Model.
[57] Mawela, N. (2017). Digital Engagement and Social Media in South Africa: Patterns of Adoption and Impact.
[58] Bonsón, E., et al. (2012). Governance, Social Media, and Transparency: A Participatory Framework.
[66] Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology.
[67] Peled, A., & Unkule, D. (2016). FixMyStreet: An Innovative Community Governance Model.
[68] Bonsón, E., et al. (2012). Public Engagement and Social Media in Governance.
[69] Eom, S. J., et al. (2018). Adoption of Twitter for Municipal Governance: Case Study of Seoul.
[70] ICASA, (2022). South Africa's Internet Usage Statistics.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Flying chairs, heated takes: a discourse analysis of audience comments on the São Paulo Mayoral debate across five major YouTube news channels

Gabriela B. Kurtz[a*], *Stéfano de P.* Carraro[b], *Carlos R. G.* Teixeira[b], *Roberto* Tietzmann[b], *Isabel H.* Manssour[b], *Milene S.* Silveira[b].

[a]University Canada West, Vancouver, Canada.

[b]Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. The 2024 São Paulo mayoral election sparked intense political discourse, particularly following a highly publicized altercation during a live debate on September 15. The incident, in which candidate José Luiz Datena struck Pablo Marçal with a chair, led to widespread discussion on social media, particularly on YouTube. This study investigates the dynamics of online discourse surrounding this event, focusing on audience engagement and sentiment across five major YouTube news channels: UOL, Folha de São Paulo, CNN Brasil, Poder360, and Itatiaia. Using a discourse analysis approach adapted from Teixeira et al. (2018), we collected and categorized 500 top-ranking YouTube comments, classifying them into four primary categories: Humor, Support, Criticism and Protest, and Neutral. A second layer of analysis further refined support and criticism, differentiating between pro-Datena, pro-Marçal, and general political dissatisfaction. Our findings reveal that humor was the dominant response across all platforms, suggesting a tendency toward memefication and satire in Brazilian digital political discourse. However, significant polarization was observed, with Datena receiving both overwhelming support and the highest level of criticism across outlets. Media framing influenced audience reactions, as outlets with in-depth coverage fostered broader critiques, while those with shorter, sensationalist clips amplified polarized sentiments. This study contributes to research on political communication and social media discourse by demonstrating how digital platforms mediate political controversies and shape public perception. The results highlight the role of algorithmic content curation in reinforcing ideological divides and fostering emotionally charged interactions. By offering a systematic analysis of audience reactions, this study provides insights into the evolving nature of digital political engagement in Brazil and lays the groundwork for future research on media framing and discourse analysis in online environments.

Keywords. Social media and politics, Discourse analysis, YouTube, Mayoral election, Political polarization.

Research paper, DOI: https://doi.org/10.59490/dgo.2025.989

1. Introduction

Brazil is the largest country in South America and has a population of nearly 213 million inhabitants[1]. Internet usage there grew rapidly, with 84% of the population aged 10 online at least once in the last three months (nic.br, 2023b; União Internacional de Telecomunicações, 2020). This represented a significant increase from

[1]https://tinyurl.com/5e4n8b85

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

a 34% share in 2008, highlighting the dramatic expansion of internet access in the country. Access quality in Brazil is unequally distributed, according to Castello, 2024, with wealthier regions in the South and Southeast having better access than the Northeast, North, and Central-West regions, which experience slower and less reliable internet connections. This disparity reflects long-standing socioeconomic and infrastructural differences across the country.

São Paulo is the wealthiest and most populous state in Brazil, with over 45 million residents[2], and also has the best connectivity (nic.br, 2023a). It is located in the southeastern region of the country. The state is home to Brazil's main industries and serves as a focal point for political and economic events that hold national significance and impact. The mayoral election in the state's capital, also named São Paulo, is often seen as a proxy for national political trends, foreshadowing potential alignments, movements, and rising political stars.

The 2024 mayoral election was deeply divided in the initial round. For weeks during the campaign leading to October 6, three candidates remained close in the polls[3], repeatedly exchanging leads while holding between 20% and 30% of voter's intentions each. The incumbent mayor, Ricardo Nunes of the centrist MDB party, and personally aligned to far right former president Jair Bolsonaro, sought reelection. His direct challengers were Guilherme Boulos of the left-wing PSOL party, with ties to current president Lula, and Pablo Marçal of the PRTB, a populist outsider and former career coach who resisted categorization.

José Luiz Datena, of the center-right PSDB party, a well-known Brazilian television host of sensationalist crime shows, was among the candidates polling low[4]. Datena, in spite of being a household name, held a dubious reputation as a candidate, after announcing his candidacy for public office and then withdrawing four times over the past few decades, besides shuffling affiliations among eleven parties[5].

On Sunday, September 15th, the debate broadcasted exclusively on TV Cultura took an unexpected turn after Mr. Marçal provoked Mr. Datena by referencing a sexual harassment allegation against him, which Mr. Datena dismissed as unproven and slanderous. The altercation escalated, with Mr. Datena referring to Mr. Marçal as a "little bandit" and Mr. Marçal calling Mr. Datena a "coward." Debate footage next shows Mr. Datena approaching Mr. Marçal and striking him with a chair, leading to the debate's interruption and Mr. Datena's expulsion from the premises.

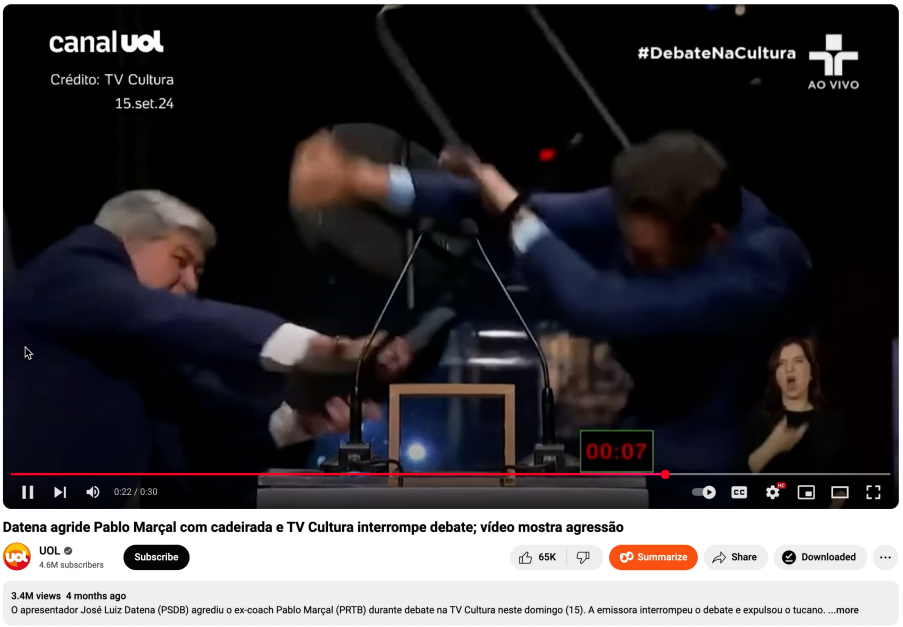


Fig. 1 – Moment when José Luiz Datena hits Pablo Marçal with a chair during transmission

[2] https://tinyurl.com/m2w2fvwt
[3] https://tinyurl.com/mtxmv3y2, https://tinyurl.com/56vk5r7c
[4] https://tinyurl.com/yt4fc29p
[5] https://tinyurl.com/2p8y9zvd

The incident garnered widespread attention and sparked discussion across various social media platforms, with different camera angles and video clips of varying lengths circulating widely. It also became a national news story, portrayed either as a deplorable example of the state of political debate in Brazil or as a quasi-comedic sketch, with protagonists and antagonists assigned and placed in direct conflict within spontaneous narratives. The varied responses piqued our research interests as an interdisciplinary group featuring computer science and communication scholars.

This study investigated the dynamics of online discourse in Brazil, focusing on how viewers and internet users engage with and shape debates on digital platforms. Specifically, the research examines how the online community reacts to and participates in discussions sparked by controversial or noteworthy incidents, as reflected in their comments and interactions on platforms such as YouTube.

The research methodology employed a multifaceted approach. First, the study examined how five distinct media outlets reported on YouTube the "Cadeirada" (Chair strike) incident as it became known. This enabled a comparative analysis of how different media sources framed the event and potentially influenced public perception. Second, the research collected and analyzed viewer comments accompanying these media publications on YouTube. Specialized tools and a tailored script were developed to gather and organize the data from the YouTube API. Furthermore, a pre-existing classification methodology was refined and applied to categorize the different types of online discourse observed in the viewer comments. This systematic approach enabled the researchers to identify patterns, trends, and dominant themes within the online conversation. By visualizing and presenting these findings, the study aims to stimulate further discussion and understanding of online discourse patterns in Brazil.

The remainder of this paper is organized as follows. Background and related work are presented in Sections 2 and 3. Section 4 describes the methodology used, and Section 5 presents a visual analysis of one case study about a political episode that happened in Brazil in 2024. Section 6 presents our final remarks and goals for future research.

2. Background

The selection of channels prioritizes companies headquartered in Brazil, centered in the Southeast region. It is important to highlight that the channels collected on YouTube did not have broadcasting rights, being the only official images of the debate, from a single channel, TV Cultura (as previously mentioned). Next, we provide a brief description of the channels to situate their scale and relevance. UOL is considered "the largest Brazilian content, technology, services, and payment methods company"[6] having started its activities in 1996. Folha de São Paulo defines itself as "one of the largest and most influential national daily newspapers"[7] and is part of the Folha Group, one of the main Brazilian media conglomerates[8], with non-editorial connections to UOL. CNN's national branch presents itself as "the first news channel in the country to debut first on digital and then on television"[9], having begun broadcasting in 2020. Poder 360 is an internet-native vehicle launched in 2017, a spinoff of a blog by journalist Fernando Rodrigues previously hosted on UOL[10]. Ultimately, Radio Itatiaia is the neighboring state's main radio station and one of the three most important in the country, founded in 1952 and featuring a mix of news, commentary, and sports[11].

The video collection process involved: 1) Defining a search string "datena agride pablo marçal com cadeirada" (translation: datena strikes pablo marçal with a chair); 2) Inputting it into YouTube in early November 2024; 3) Selecting videos posted by journalistic or media company sources to maintain journalistic ethical balance. We arbitrarily set a limit of five videos and excluded videos from the original broadcaster, TV Cultura. The collected posts came from the five YouTube channels: UOL, Poder 360, Rádio Itatiaia, Folha de São Paulo, and CNN Brasil. 4) Collect information about the selected posts, videos, their production, and metadata such as title, duration, updated number of views, and channel SocialBlade ranking. 5) Organize a chart sorted by the video's number of views. 6) Collect and organize comments using our scripts for further analysis. A summary of the findings related to the posts is presented below.

[6] https://tinyurl.com/zr6jyrt6
[7] https://tinyurl.com/4b72485x
[8] https://tinyurl.com/4hrmz8h8
[9] https://tinyurl.com/dka9p375
[10] https://tinyurl.com/4swzedrd
[11] https://tinyurl.com/yc5shc69

YT Channel name	Channel SB Rank	Shortened URL	Title and translation	Views	Duration (seconds)
UOL	364	https://shorturl.at/g3Wyj	Datena agride Pablo Marçal com cadeirada e TV Cultura interrompe debate; vídeo mostra agressão / TV Cultura debate interrupted as Datena assaults Pablo Marçal with a chair; video footage captures the attack	3,4M	30
Folha de São Paulo	724	https://shorturl.at/3UCl4	Datena agride Marçal com cadeirada durante debate da TV Cultura / Datena attacks Marçal with a chair during TV Cultura debate	935K	21
CNN Brasil	287	https://shorturl.at/B3fTC	Datena ataca Marçal com cadeira durante debate na TV Cultura | CNN Brasil / Datena attacks Marçal with a chair during a debate on TV Cultura | CNN Brasil	460K	28
Poder 360	668	https://shorturl.at/c9HYq	Assista aos bastidores da cadeirada de Datena em Marçal / Watch behind the scenes of Datena's chair in Marçal	447K	368
Itatiaia	557	https://shorturl.at/wgK4t	VEJA O MOMENTO QUE PABLO MARÇAL É AGREDIDO POR DATENA EM DEBATE DA TV CULTURA / WATCH THE MOMENT PABLO MARÇAL IS ATTACKED BY DATENA IN A TV CULTURA DEBATE	122K	28

Outside of CNN, none of the media companies that published these videos specializes in television or television news, in spite of having a YouTube channel and live broadcasts. This mostly explains the lack of a news story format and the presence of a video snapshot in 4 of the 5 videos. In these, the duration ranges from 21 to 30 seconds and is centered on the provocations that Mr. Marçal makes moments before being attacked. Little is shown after the chair is thrown as well.

The video edited by Poder 360 has a duration of a little more than six minutes and takes a different approach, as it adds other moments outside the debate broadcast. Edits videos made by the candidate's advisors on the debate corridors and some views, apparently, of spectators who are in the audience at a higher point of view than the transmission. There are no voiceovers, nor narrative captions, or subtitles, and the picture frame shifts from horizontal to vertical according to the source. Although technically simple, it provides a sense of the moments that preceded the chair attack itself, allowing the viewer to observe that the provocations made by the candidate Marçal had already been causing friction backstage. This suggests that the accusations thrown at Mr. Datena were premeditated, although the Poder 360 video does not make a conclusion or evaluation that points to this. The style is similar to videos made by fans at music concerts that combine an edition of hundreds of shots made independently. Here we have an attempt to offer viewers a backstage view that seeks to complement and visually explain what other vehicles have not been able to do.

The titles focused on the denotative characteristics of the actions depicted, avoiding value judgments or addressing the public identity of the candidates. This approach is justified as the media coverage targets an audience already familiar with the municipal election campaign. Based on an analysis of these videos, we can confirm that all news and media companies have adopted a balanced stance regarding the events that transpired during the debate, even if Poder 360's approach could be defined as richer than the others, as is featured more background shots.

3. Related Work

YouTube's algorithms have transformed the ways information is curated and consumed, reshaping cultural and sociopolitical dynamics. Rieder et al., 2018 provide a foundational analysis of the platform's ranking mechanisms, demonstrating how visibility is modulated by a combination of user engagement metrics, platform priorities, and cultural context. Their study identified three key patterns in ranking: stability, "newsy" content spikes, and hybrid morphologies. Stable patterns reflect long-standing popular content, while "newsy" spikes capture sudden bursts of interest in trending topics. The hybrid patterns, combining features of both, illustrate how YouTube dynamically adapts recommendations to reflect user behavior and external events. This nuanced understanding of algorithmic patterns shows that YouTube is not a passive distributor of content but an active mediator of attention. Further, the study revealed a preference for YouTube-native content—often from independent creators—over mainstream media outlets. This preference underscored the platform's role in fostering alternative narratives, including controversial or niche voices, by rewarding content that maximizes watch time and engagement. The privileging of native content highlights how the algorithm aligns with

YouTube's commercial goals of increasing user retention and advertising revenue, often at the expense of neutrality or diversity.

Complementing this technical analysis, Bishop, 2020 delves into the emergence of algorithmic "experts" who guide creators on how to optimize visibility on YouTube. These experts act as intermediaries, decoding the platform's opaque recommendation system and offering strategies to navigate it effectively. However, their advice is often grounded in a meritocratic narrative that overlooks structural inequalities in content creation and visibility. For instance, creators who lack resources or access to data analytics tools may struggle to compete, despite employing the same optimization techniques. Bishop also critiques the subjective and selective nature of algorithmic expertise. While these experts frame their strategies as objective and data-driven, they often reinforce the biases embedded within YouTube's algorithm, such as prioritizing advertiser-friendly content. This dynamic further entrenches inequalities by privileging certain types of content—typically mainstream or sensational—over others, limiting the diversity of voices on the platform. The study calls for a more critical understanding of how YouTube's ecosystem shapes creator behavior and amplifies certain narratives, contributing to broader discussions on algorithmic accountability. These studies show that YouTube's algorithm is not neutral—it actively shapes what content gets seen and how creators and audiences interact with the platform.

YouTube's recommendation system is designed to increase user engagement by suggesting content similar to what users have previously watched, aiming to maximize viewer satisfaction. This real-time feedback loop tailors videos to match individual interests, considering factors such as watch time, engagement (likes, comments, shares), relevance, and user history [12] In 2024, YouTube began testing an endless scroll feature for full-length videos, similar to TikTok's format, allowing users to swipe up to discover new content. This change aims to enhance content discovery and support audience growth for new creators. However, it raises concerns about diminishing creators' control and prioritizing immediate engagement over community-building and quality [13].

YouTube's role in political discourse and polarization has been a topic of global research. García Marín, 2023 examined how YouTube's recommendations vary across topics, finding that while the algorithm doesn't consistently push users toward extreme content, some themes, like COVID-19 and far-right politics, are more polarizing. Their findings align with studies like Bail, 2022, which show that YouTube can deepen political polarization by reinforcing ideological preferences. However, other research, like Rasmussen and Petersen, 2022 suggests that YouTube often steers users toward more mainstream content, acting as a moderating force in some cases. In the U.S., researchers found that YouTube's algorithm amplifies political biases by showing content that aligns with users' existing beliefs. The platform amplified his conservative and reactionary messages while sidelining content from other candidates, contributing to the spread of polarized narratives. These findings illustrate how YouTube's algorithm can adapt to different political contexts, influencing public opinion and voter behavior.

In Brazil, the 2018 presidential elections provided a vivid example of how YouTube's algorithm influences political discourse. Reis et al., 2020 highlight how the platform's recommendation system acted as a powerful tool for disseminating conservative narratives, with a strong bias toward Jair Bolsonaro's campaign themes. Through a systematic analysis of over 764,000 video recommendations, their study showed that content aligned with Bolsonaro received disproportionate visibility, dominating search results and reinforcing anti-leftist and anti-human rights rhetoric. This was achieved through "semantic galaxies" — clusters of interconnected videos that created echo chambers favoring Bolsonaro's messaging while marginalizing opposition voices. The study revealed that algorithmic recommendations are shaped by a combination of user activity, platform design, and external campaign strategies, including the use of bots and coordinated digital marketing. Channels such as Jovem Pan News and Verdade Política played pivotal roles in amplifying Bolsonaro's visibility, further illustrating the interplay between traditional media, digital influencers, and YouTube's algorithms. Similarly, another study by Reis et al., 2019 emphasized that YouTube's algorithm was instrumental in prioritizing videos critical of Bolsonaro's opponents, such as Fernando Haddad and Lula, even when the search terms directly referenced those candidates. This suggests that the platform's recommendation system was not neutral but actively modulated visibility in ways that favored specific political ideologies.

De Albuquerque and Rodas, 2022 explored how YouTube's recommendation algorithm contributes to polit-

[12] https://tinyurl.com/2r652yv6
[13] https://tinyurl.com/3mktwc55

ical radicalization by creating ”information systems” customized for each user. Their study shows that the algorithm keeps users on the platform longer by suggesting content that matches their preferences. During the 2018 Brazilian elections, this led to the promotion of far-right ideas, especially those supporting Jair Bolsonaro. The researchers conducted an experiment simulating new users and found that even when starting with non-political content, the algorithm eventually directed users to political and polarizing videos, reinforcing echo chambers and spreading false information.The study explains that YouTube's system connects different topics to guide users toward specific types of content. This process creates a kind of ”synthetic reality” where users are exposed mainly to ideas that the platform thinks will keep them engaged. This behavior benefits YouTube financially, as it increases ad revenue, but it also risks undermining democracy by limiting diverse perspectives and amplifying extreme views.

4. Research Methodology

To perform a comparative analysis of the different sources of media, we used, as a basis, the research methodology presented by Teixeira et al., 2018. In their work, the authors proposed a taxonomy for discourse analysis to help understand the intent and types of Twitter (now called X) users' conversations about political scandals. Since our focus is on YouTube comments, we made some refinements.

Our study examines five distinct media outlets that reported on YouTube about the “Cadeirada” (Chair strike) incident. The selection criteria were based on popularity and influence, regional representation, and journalistic credibility, prioritizing channels with significant audience engagement in Brazil. To ensure unbiased analysis, we excluded videos from TV Cultura, the original broadcaster of the debate, to focus on secondary media framing. This approach allows a comparative analysis of how different media sources shaped public perception of the event.

Our methodology for analyzing and comparing comments from different YouTube channels is structured in steps. The process begins with data collection, carried out individually for each channel, ensuring the information is organized independently. Each channel's 100 most relevant comments were then selected and subjected to peer review. Finally, the resulting data was uploaded to an interactive online dashboard, which provided visual tools to facilitate comparative analysis between channels. These steps are detailed below.

For **data gathering**, we used a script written in Python, whose main purpose is to consume Google's YouTube Data API, receiving the comments of a given video and saving the gathered data in a CSV format. We used CSV, Requests, and Re libraries to develop the script, using requests to communicate with Google's API and get the raw data, to which we applied regex and replace functions to regularize the CSV file, ensuring its integrity. Finally, we used the CSV library to persist the gathered data in a CSV file, with its main advantage being that it has total compatibility with spreadsheets such as Excel, allowing for better data analysis in the future. The script is available on our GitHub[14] and can be used for collection in other contexts. You must download the script and insert the video link with your YouTube API Key, for which you can expect a response to your request in a formatted CSV file.

Following the steps of Teixeira et al., 2018, in the **data selection**, we focused on the 100 most influential comments of each channel (CNN, FolhaSP, Itatiaia, Poder 360, UOL). The query parameters included the 100 most relevant comments per video, as ranked by YouTube's algorithm, ensuring a focus on the most engaged discussions. The script also collected metadata such as timestamps, user engagement metrics (likes and replies), and comment text. While using YouTube's ranking system provides valuable engagement-driven insights, it also introduces selection bias, as comments with fewer engagements may be overlooked. Future research may explore alternative selection methods, such as random sampling or timeframe-based collection, to enhance representativeness.

Then, comment categorization was done using an online and collaborative spreadsheet. Two reviewers separately analyzed each comment, classifying it into one of the four proposed categories: Humor, support, criticism and protest, and neutral. In the context suggested in this work of discourse analysis, the category “News” introduced in the original work is not applicable. The News category was relevant in the context of X, since users would mention facts by liking them to news on the web, which is not something that occurs in YouTube channels. *Humor* refers to comments in a joking tone. *Support* refers to those who promote one of the speakers

[14] https://github.com/DAVINTLAB/DGO-2025

(or candidates in our case study). *Criticism and protest* are those comments that present dissatisfaction with an exposed fact or situation. *Neutral* are comments that are indifferent or the position could not be inferred from the comment.

After the primary classification, a second level of categorization was introduced to identify the polarization of support and criticism. Support was further classified into pro-Datena and pro-Marçal, while criticism was divided into critiques of Datena, critiques of Marçal, and general dissatisfaction with the political climate. This refinement allowed for a deeper understanding of how different audience segments reacted to the event and how media framing influenced discourse. The results provide insight into echo chambers within digital political discussions, aligning with prior research on political discourse on social media.

To help the **content analysis**, we have developed an interactive dashboard with some simple visualizations that are available online[15]. First, you need to upload the files, both the file containing all the data gathered and the spreadsheets with the classifications; you can submit as many files as you want, just make sure to have both files so the app can work in its intended way. Then, you can analyze a variety of charts that include charts such as a stacked bar chart displaying the classification proportions in the files, a detailed pie chart for each video displaying its in depth classifications, a bar chart for the comments per video and a dashboard that allows to identify the top users commenting in each video as well as the users who commented on the most amount of videos, helping identify potential bots or spams. The dashboard ensures that results are accessible and interpretable, reinforcing transparency in data presentation. Future improvements may include natural language processing (NLP) techniques to complement manual classification and enhance scalability.

This methodology presents some limitations. The reliance on YouTube's ranking system means that less-engaged comments may not be included. Manual classification introduces subjectivity, even though we used multiple reviewers and inter-rater agreement metrics to mitigate this issue. Additionally, the analysis focuses on five media outlets, which may not fully capture the broader discourse on YouTube. To address these challenges, we ensured transparency in classification, maintained strict reviewer independence, and incorporated a validation process. Regarding ethics, we strictly adhered to research guidelines by only analyzing publicly available comments, not storing any personally identifiable information, and following ethical standards for digital data collection and content analysis.

5. Case Study

The selected time frame for collection corresponds to December 5th, 2024. As mentioned in the methodology, the top 100 comments in each video were selected, and the comparison focuses on those comments. This stacked bar chart illustrates the categorization of YouTube comments by type (Neutral, Criticism and Protest, Support, and Humor) across different news outlets (CNN, FolhaSP, Itatiaia, Poder360, UOL).

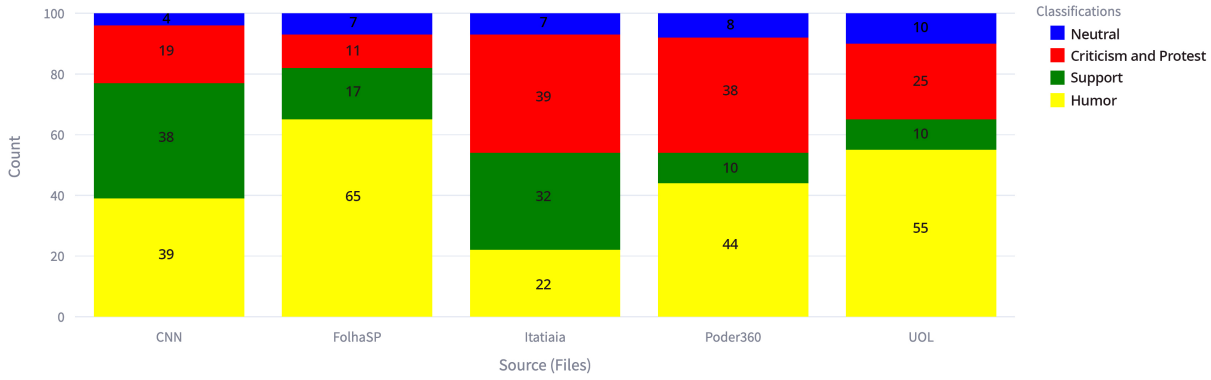


Fig. 2 – Categorization of YouTube comments by type.

The chart reveals a relatively consistent distribution of comment types across all five news outlets (CNN, FolhaSP, Itatiaia, Poder360, and UOL). Each outlet features all four categories: Humor, Support, Criticism, and Protest, and Neutral. However, slight variations exist, particularly in the proportions of Criticism and Protest,

[15] Link omitted due to double-blind review.

and Humor. Criticism and Protest (red category) are prominently represented in all outlets but slightly more prevalent in Itatiaia and Poder360, indicating that these platforms might have attracted more viewers dissatisfied with the incident or its coverage. The Humor category (yellow) consistently accounts for a significant portion of comments across all platforms, but for Itatiaia, and it is higher in Folha SP and UOL. This may indicate that the public generally perceived the event as comical or absurd in most outlets. Another conjunction relates to the fact that Folha SP and UOL are the channels that are most popular and garnered the highest number of views in the respective videos. This aligns with the conclusions on Teixeira et al., 2018, which observed humor's prevalence during controversial events. Humor often serves as a way for online audiences to navigate discomfort with contentious or absurd events. In this case, the physical altercation during a live debate likely struck viewers as both shocking and ludicrous, leading to widespread joking commentary. The methodological framework's inclusion of humor captures the way contentious events, especially in the political arena, are quickly "memefied" in the digital sphere. The predominant presence of humor suggests that, regardless of the media outlet, viewers engaged in a shared cultural practice of trivializing the event, perhaps as a critique of the political figures or as a means of diffusing tension. This was more visible in the highest viewed videos, suggesting a trend in humorous behavior in mainstream outlets.

The Support category (green) maintains a balanced presence across platforms but appears marginally lower in Poder360 and UOL, suggesting these outlets might have less content or framing that aligns with supportive narratives. The Neutral category (blue) has a minor presence across all outlets, signifying that most users engaged in subjective discourse rather than neutral observations.

The Criticism and Protest category is the second most prominent, reflecting a significant portion of viewers expressing dissatisfaction, either with the actions of individuals in the incident or the broader context. We also analyzed the focus of the comments (pro-Datena, pro-Marçal, or general), but we will delve into this section later in this analysis. The smaller presence of Support and Neutral comments suggests limited backing for specific actors or purely factual discussions. This could indicate polarization, with viewers gravitating toward humor or critique rather than neutrality or outright support.

Each media outlet likely influenced the tone of the comments based on how they framed the incident in their video titles, descriptions, and focus. For instance, Poder360's more detailed coverage, including "behind-the-scenes" footage, may have attracted a higher proportion of critical or investigative discourse, as viewers reacted to contextual revelations rather than just the chair-throwing moment. On the other hand, outlets like UOL and Itatiaia, which focused on concise clips of the altercation, may have encouraged comments emphasizing humor or immediate emotional reactions.

The dominance of Criticism and Protest in outlets like Itatiaia, suggests that their audience may perceive the event as emblematic of broader issues, such as the decline of political discourse or the sensationalism of media coverage. Conversely, CNN Brasil, despite being known for its international credibility, exhibits similar trends to domestic outlets, showing that even global brands may not escape the polarized and humor-driven engagement patterns of local audiences in such events.

The substantial representation of Criticism and Protest reflects widespread dissatisfaction among viewers, either directed at the individuals involved in the altercation or the broader political and media landscape. This aligns with the study's methodology, which emphasizes identifying critical patterns in online discourse. Viewers may have used the comment sections not only to critique the behavior of the candidates but also to express frustration with what the incident symbolized an erosion of professionalism in politics or sensationalism in media coverage. The prominence of criticism in certain outlets suggests that specific audiences are more likely to express discontent.

The differing proportions of comment categories across outlets may point to the formation of echo chambers. Each platform's audience appears to engage with the incident in ways that reflect their broader ideological leanings and expectations of content from that outlet. The findings also suggest that while media outlets strive for balanced reporting, their framing decisions—such as what to highlight in video titles or how much context to provide—play a significant role in shaping public perception and discourse. Outlets like Poder360, with richer contextual content, may foster more critical and layered discussions, while concise clips from UOL and CNN might lead to quick, emotionally driven reactions. The data also highlights cultural nuances in Brazilian digital discourse. The strong presence of humor highlights a tendency to approach political controversies with a mix of irreverence and satire, a recurring theme in Brazilian online interactions. This cultural lens enriches

the findings by connecting them to broader behavioral patterns in the country's digital ecosystem.

While we were working on the general classifications, we also noticed that it would not be possible to get an accurate grasp of the political discourse polarization if we did not understand who the audience was supporting and criticizing. So, differently from our inspired methodology from Teixeira et al., 2018, we had to create a second step - after the categorization of Humor, Support, Criticism and Protest, and Neutral, we moved to understand where the polarization was in each channel.

For the support distribution, we had two sub-categories: supporting Datena and supporting Marçal. The support distribution across the five news outlets (CNN, FolhaSP, Itatiaia, Poder360, and UOL) highlights significant polarization in audience alignment with either Datena or Marçal. One important factor to mention in this part of the analysis is that we ware considering percentages to get a grasp of the general climate among videos, but we may also need to consider the absolute numbers, as different videos received a distinct proportion of "support" categorized comments. For CNN, we categorized a total of 38 support comments, Folha SP 17, Itatiaia 32, and Poder 360 and UOL 10 comments.

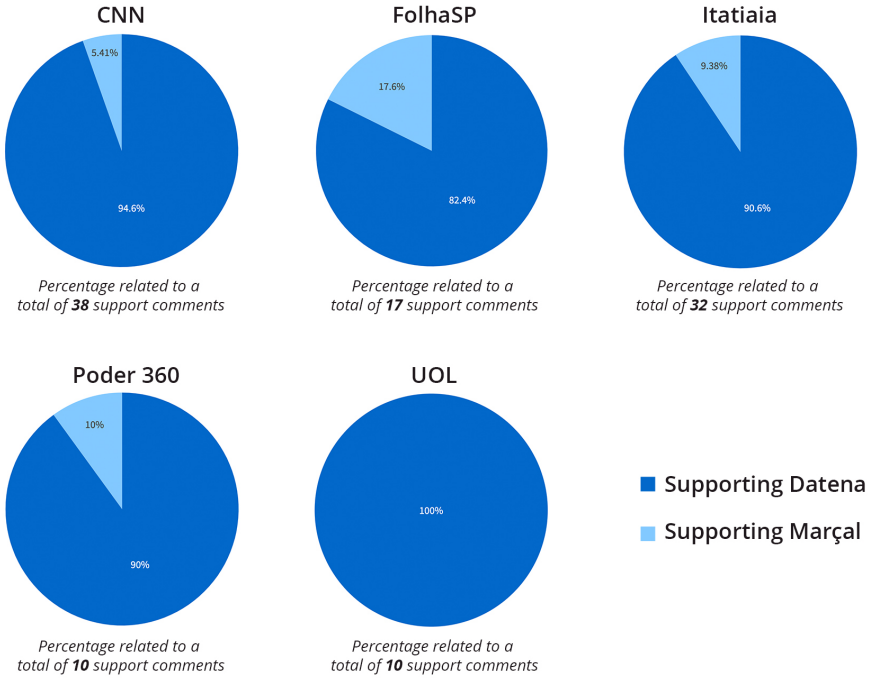


Fig. 3 – Support distribution.

At CNN, a striking 94.6 percent of comments expressed support for Datena, while only 5.4 percent backed Marçal. This overwhelming preference for Datena suggests that either the framing of CNN's content or the platform's general audience heavily leans toward his narrative.

FolhaSP displayed the highest percentage of Marçal supporters, but it still follows the general trend from the other channels. With 82.4 percent of the comments supporting Datena and 17.6 percent favoring Marçal, this relatively higher proportion of support for Marçal compared to CNN indicates that FolhaSP's audience encompasses a broader range of opinions, possibly influenced by the outlet's content presentation or a more diverse audience demographic.

At Itatiaia, the polarization was strong, with 90.6 percent of comments supporting Datena and only 9.4 percent favoring Marçal. Similarly, Poder360 showed a significant lean toward Datena, with 90 percent of comments expressing support for him and 10 percent backing Marçal. These patterns align closely with the trend observed on CNN, where audiences predominantly sided with Datena.

UOL had an interesting 100 percent support to Datena. This particular piece of data, however, represents only 10 percent of the total comments in the categorized section. This means that we cannot affirm that UOL has more viewers inclined to Datena, since the sample is too small. On the other hand, when compared to CNN's

data, out of 38 comments in the support category, 32 were classified as in support of Datena. In terms of absolute numbers, it is more significant than UOL's.

Overall, the analysis reveals that Datena dominated the support across all platforms, with his backing ranging from 82.4 percent (FolhaSP) to 94.6 percent (CNN). This consistent pattern indicates either his broader appeal or the influence of media framing in shaping audience perceptions. On the other hand, Marçal received his highest support from FolhaSP (17.6 percent), which also emerged as the least polarized outlet. It is also worth mentioning that, out of the 500 analyzed comments, roughly 1/5 represented support (totaling 107), and the vast majority supported Datena, totaling almost 20 percent of the entire base analyzed. This means that the most popular and supported comments overall were supporting the candidate who hit his opponent with a chair during the live transmission. That, however, did not offer him a significant advantage in the Mayoral run. In an electoral poll performed after the event, Marçal lost 2 percent of his preference, and Datena got 2 percent more - but that could also be part of the error margin present in the poll [16]. The online repercussion was not enough to change tides for the candidate.

Looking into the Criticism and Protest category, we also created sub-classifications to help us understand the role of polarization in the discourse. In the comments, we noticed not only that the audience was supporting one or the other candidate, but also generally criticizing the situation and the political climate. For this reason, we decided to create three sub-categories: criticizing Datena, criticizing Marçal, and general critics. The next images represent the comparison of each media channel.

The distribution of criticisms across media outlets reveals key insights into audience polarization and dissatisfaction. At CNN, the majority of comments (52.6 percent) were general criticism, while 26.3 percent targeted Marçal. Criticism for Datena accounted for 21.1 percent of comments, indicating a mix of dissatisfaction with both candidates and the broader political context. This suggests that CNN's framing of the event resonated negatively with viewers, especially regarding Datena's actions, though there was also notable criticism of Marçal and the overall situation.

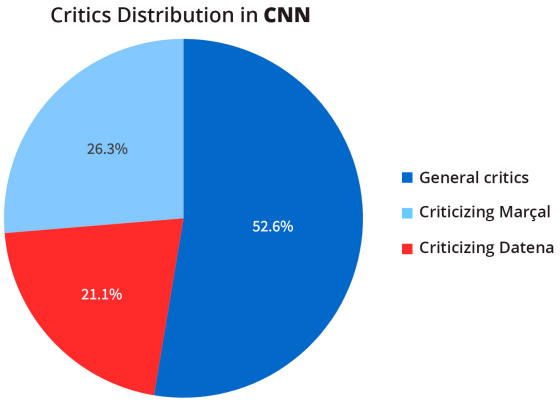


Fig. 4 – CNN distribution of criticisms.

FolhaSP showed a more unbalanced criticism distribution, with 45.5 percent General, 18.2 percent at Datena, and 36.4 percent categorized as criticism towards Marçal. This slightly higher proportion of criticism of Marçal suggests that FolhaSP's audience might be more inclined to critique the overarching political climate and the specific candidate.

[16] https://tinyurl.com/3km7dzdb

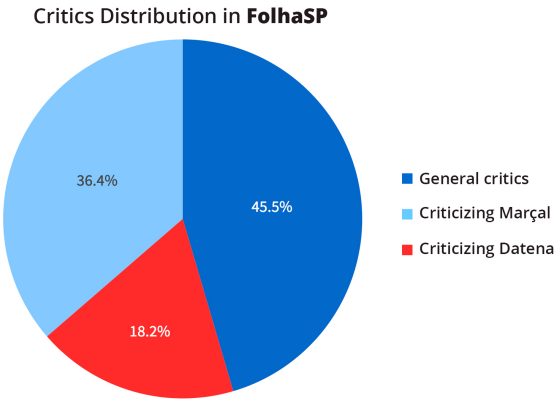


Fig. 5 – FolhaSP distribution of criticisms.

At Itatiaia, criticism was more evenly distributed among the three categories. Criticism of Datena accounted for 30.8 percent, Marçal received 33.3 percent, and general criticism made up 35.9 percent of comments. This even split indicates a less polarized audience compared to other outlets, with dissatisfaction spread equally across candidates and the broader situation. Itatiaia's audience appears to have a more diverse set of opinions, reflecting varied reactions to the event. Another important observation here is related to the origin of Itatiaia as a news channel - differently from the others, it is from the state of Minas Gerais (also the state where Pablo Marçal is originally from). Even though the Mayoral elections were in São Paulo, because it is the largest city in Brazil, their outcomes are influential on the whole country. However, the origin of the news channel might have influenced the audience type, while we cannot affirm it for certain, it could be another explanation for this outcome.

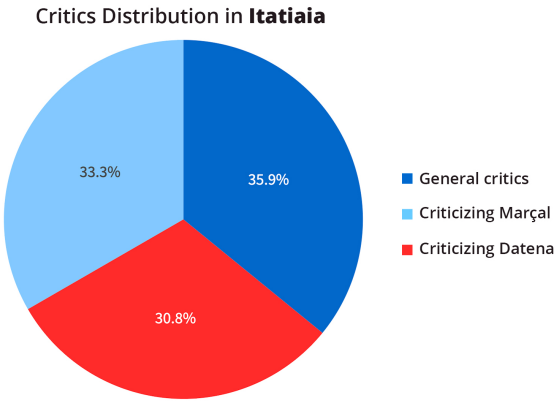


Fig. 6 – Itatiaia distribution of criticisms.

Poder360 followed a similar pattern to FolhaSP, with 23.7 percent of comments criticizing Datena, 36.8 percent targeting Marçal, and 39.5 percent expressing general criticism. Poder360's audience displayed significant dissatisfaction with the political context, suggesting that the outlet's coverage encouraged broader critiques rather than focusing narrowly on the candidates.

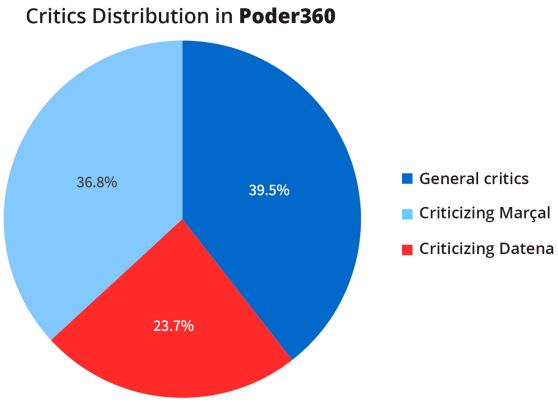


Fig. 7 – Poder360 distribution of criticisms.

UOL's audience exhibited the highest number of general criticism, with 20 percent of comments criticizing Datena, 20 percent targeting Marçal, and another 60 percent offering general criticism. The high proportion of general criticism shows that the audience was not leaning towards a specific candidate - instead, they were more generally upset about the political context.

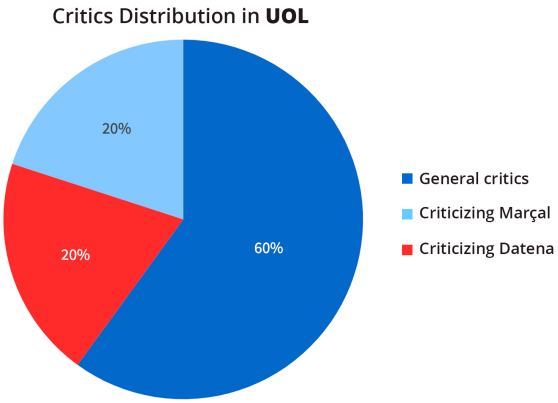


Fig. 8 – UOL distribution of criticisms.

General criticism was most prevalent on UOL, CNN and FolhaSP where broader dissatisfaction with the political climate was evident. Folha SP' and Poder 360's audiences had a slightly higher dissatisfaction towards Marçal, though. These findings suggest that media framing played a significant role in shaping audience reactions, with certain outlets encouraging a broader critique of the situation while others focused attention on individual candidates.

The combined analysis of support and criticism shows a complex reaction from the audience toward Datena and Marçal. Datena received more support than Marçal across all platforms, with outlets like CNN, UOL, and Itatiaia showing over 90 percent supportive comments for him. This mix of reactions suggests that while many people support Datena, likely because of his public persona or political alignment, others were dissatisfied with his actions during the debate, such as the chair-throwing incident. The event likely divided viewers, with some defending him and others strongly opposing his behavior.

According to the theoretical framework, digital platforms like YouTube play a key role in shaping these reactions. Media outlets frame events in ways that influence how audiences perceive them, and YouTube's algorithms amplify content that gets strong reactions, whether positive or negative. This means Datena's dramatic actions during the debate likely drew both supporters who agreed with him and critics who disapproved. Interestingly, on platforms like CNN and UOL, many comments also criticized the overall situation or the state of politics rather than just the candidates. This shows that some viewers were frustrated with the broader

political climate, not just the individuals involved.

In simpler terms, the mix of strong support and criticism for Datena reflects how polarizing figures create both loyal fans and vocal opponents. The way media outlets reported the event and how YouTube promoted content played a big role in shaping these reactions. It highlights how digital platforms encourage debates that often focus on the most dramatic or controversial aspects of events.

6. Final Remarks

This study explored how people engaged with a controversial political debate during São Paulo's 2024 mayoral election by analyzing YouTube comments across five major news outlets. We used a refined version of Teixeira et al., 2018 methodology to categorize comments into Humor, Support, Criticism and Protest, and Neutral, with additional sub-categories for support and criticism. The findings showed strong audience engagement, characterized by a mix of humor, support, and criticism, reflecting the polarized nature of the incident and the broader political climate in Brazil.

The first goal was to understand how audiences engaged with political discourse on YouTube. Humor emerged as the dominant category, showing how people used jokes and satire to respond to the absurdity of the chair-throwing incident. This aligns with Teixeira et al., 2018, who found that humor plays a key role in helping people process political controversies. Platforms like YouTube amplify this tendency by providing space for playful, yet meaningful, public discussions, as Herring, 2005 explains in the context of computer-mediated discourse.

The second objective was to identify patterns of support and criticism. Datena consistently received the most support, with over 90 percent of supportive comments on outlets like CNN and UOL. However, he also faced the highest level of criticism across all platforms. This mix of support and criticism highlights a polarized reaction where some audiences align with Datena's public persona while others strongly disapprove of his actions during the debate. This finding reflects research by Reis et al., 2019 and Reis et al., 2020, which showed that digital platforms often amplify such ideological divides. It also underscores the performative nature of online political discourse, where people express loyalty but are not afraid to voice disapproval.

The third objective examined how media framing shaped audience responses. The way outlets presented the debate significantly influenced the tone of the comments. For example, Poder360's in-depth coverage, including behind-the-scenes footage, generated a more balanced criticism ratio among general, Datena, and Marçal, while CNN and UOL's shorter, more sensational clips amplified polarized reactions focused on the candidates' behavior. This reflects findings by Rieder et al., 2018, who demonstrated how platforms amplify emotionally charged content to drive engagement. These framing decisions highlight the power of media in shaping public discourse.

This study aligns with key ideas from computer-mediated discourse analysis Herring, 2005 and content analysis Bardin, 1977. These frameworks emphasize how technology, language, and social dynamics shape online discourse. By refining Teixeira et al., 2018 taxonomy to include sub-categories for support and criticism, we captured the nuances of how people reacted to the debate. YouTube's design, which allows for detailed discussions compared to platforms like X, made it possible to identify more complex audience behaviors. The study also supports research by Bishop, 2020 and De Albuquerque and Rodas, 2022 on how algorithms amplify polarized narratives and create echo chambers, which further fueled the mix of humor, support, and criticism.

The case allowed other interesting analyses and developments with regard to the way in which the vehicles and, consequently, their audiences position themselves. The five different channels using images from the same broadcast, only varying the time and format of the cuts of the same event, subjectively reveal their communication strategies. Another interesting finding in this particular part of the analysis was the fact that Folha SP, which is the largest media channel in São Paulo (and its audience is presumably mostly from the state), had the highest number in the Humor category. Itatiaia, the channel from another state, Minas Gerais, had a more critical approach in the audience comments. It is almost as if the population from São Paulo did not believe in its candidates and the seriousness of the Mayoral election, preferring to laugh about it, rather than criticize it. Instead of the traditional way of showing discontentment with protest, results indicate that they preferred humor to demonstrate it. However, a potential limitation of this study is the ideological orientation of each

analyzed YouTube channel, which may attract audiences with specific political leanings. Thus, the comments reflect the viewpoints of each platform's audience rather than a representative sample of the general electorate.

Overall, this study shows how digital platforms like YouTube are not just neutral spaces but actively shape political discourse through their design and media content. It highlights how humor and polarization dominate online discussions, offering valuable insights into the dynamics of Brazil's digital public sphere and laying the groundwork for future research.

Acknowledgement

Carraro would like to thank the Tutorial Education Program (PET). Manssour would like to thank the financial support of the CNPq Scholarship - Brazil (303208/2023-6). While preparing and revising this manuscript, we used ChatGPT, Grammarly, and Google Translate to enhance clarity and grammatical precision, as English is not our first language. The authors take full responsibility for the content and its technical accuracy.

References

Bail, C. (2022). *Breaking the social media prism: How to make our platforms less polarizing*. Princeton University Press.

Bardin, L. (1977). *L'analyse de contenu*. Presses universitaires de France. https://books.google.ca/books?id=afcD3h0WL0kC

Bishop, S. (2020). Algorithmic experts: Selling algorithmic lore on youtube. *Social Media + Society*, *6*(1), 2056305119897323. DOI: https://doi.org/10.1177/2056305119897323.

Castello, G. (2024). Conectividade significativa no brasil: O retrato da população [Accessed: "2025-01-17"]. In *Conectividade significativa: Propostas para medição e o retrato da população no brasil*. https://cetic.br/pt/publicacao/conectividade-significativa-propostas-para-medicao-e-o-retrato-da-populacao-no-brasil/

De Albuquerque, J. P. S., & Rodas, C. M. (2022). Radicalização política no youtube: O papel dos sistemas algorítmicos na construção de regimes de informação. *XXII ENCONTRO NACIONAL DE PESQUISA E PÓS-GRADUAÇÃO EM CIÊNCIA DA INFORMAÇÃO*.

García Marín, J. (2023, January). Miedo (in)fundado al algoritmo: Las recomendaciones de youtube y la polarización. *I+D+i PID2021-128272NB-I00 financiado por MCIN/ AEI/10.13039/501100011033/ FEDER "Una manera de hacer Europa"*. DOI: https://doi.org/10.3916/C74-2023-05.

Herring, S. C. (2005). Computer-mediated discourse. *The handbook of discourse analysis*, 612–634.

nic.br. (2023a). Pesquisa sobre o uso das tecnologias de informação e comunicação nos domicílios brasileiros: Pesquisa TIC Domicílios 2023 [Microdados] [Accessed: "2025-01-17"]. https://cetic.br/pt/pesquisa/domicilios/microdados/

nic.br. (2023b). Pesquisa sobre o uso das tecnologias de informação e comunicação nos domicílios brasileiros: TIC Domicílios 2023 [Indicadores] [Accessed: "2025-01-17"]. https://cetic.br/pt/tics/domicilios/2023/individuos/

Rasmussen, S. H. R., & Petersen, M. B. (2022). From echo chambers to resonance chambers: How offline political events enter and are amplified in online networks.

Reis, R., Zanetti, D., & Frizzera, L. (2019). Algorítmos e desinformação: O papel do youtube no cenário político brasileiro. *VIII Congresso da Associação Brasileira de Pesquisadores em Comunicação e Política*.

Reis, R., Zanetti, D., & Frizzera, L. (2020). A conveniência dos algoritmos: O papel do youtube nas eleições brasileiras de 2018. *Compolítica*, *10*(1), 35–58.

Rieder, B., Matamoros-Fernández, A., & Coromina, Ò. (2018). From ranking algorithms to 'ranking cultures': Investigating the modulation of visibility in youtube search results. *Convergence*, *24*(1), 50–68. DOI: https://doi.org/10.1177/1354856517736982.

Teixeira, C. R. G., Kurtz, G., Leuck, L. P., Tietzmann, R., de Souza, D. R., Lerina, J. M. F., Manssour, I. H., & Silveira, M. S. (2018). Humor, support and criticism: A taxonomy for discourse analysis about political crisis on twitter. *Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age*. DOI: https://doi.org/10.1145/3209281.3209330.

União Internacional de Telecomunicações. (2020). Manual for measuring ICT access and use by households and individuals, 2020 edition [Accessed: "2025-01-17"]. https://www.itu.int/en/ITU-D/Statistics/Pages/publications/manual.aspx

From Theory to Telegram: Enabling Factors of Anti-vaccine Disinformation in Brazil

Julie Ricard [a*], *Ergon* Cugler de Moraes Silva [b], *Ivette* Yañez [c], *Leticia* Hora[d].

[a] Centro de Estudos em Administração Pública e Governo, Escola de Administração Pública e Governo, Fundação Getulio Vargas, São Paulo, Brazil, julie.ricard@fgv.edu.br, ORCID 0000-0003-2304-5781.

[b] Centro de Estudos em Administração Pública e Governo, Escola de Administração Pública e Governo, Fundação Getulio Vargas, São Paulo, Brazil, contato@ergoncugler.com, ORCID 0000-0002-5753-1705.

[c] Data-Pop Alliance, Mexico city, Mexico, iyanez@datapopalliance.org, ORCID 0009-0007-9415-5490.

[d] Universidade de São Paulo, São Paulo, Brazil, leticiahora1@usp.br, ORCID 0000-0001-5277-0312.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. This study addresses two central questions: (1) What enabling factors associated with information disorder are identified in the literature? and (2) Which of these factors manifest in anti-vaccine Telegram communities in Brazil, facilitating the spread and normalization of related disinformation? Combining a systematic literature review with empirical analysis of nearly 10 million posts from Brazilian conspiracy theory groups on Telegram (2016–2024), the research identifies 18 enabling factors—classified into sociopolitical and informational ecosystem dimensions—that contribute to information disorder. Of these, 11 are empirically observed in the analyzed Telegram communities. Drawing on both qualitative and computational methods—including time series, content, and link analysis—the study proposes a conceptual model that illustrates how these conditions interact and reinforce one another, creating an environment in which disinformation can flourish. The findings contribute to ongoing theoretical analyses on the sociotechnical dynamics of disinformation.

Keywords. Disinformation, Information Disorder, Anti-vaccine, Telegram
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1064

1. Introduction

Disinformation has become one of the most pressing challenges of our time, undermining not only the integrity of information ecosystems but also social cohesion and the foundations of democratic governance. While various taxonomies and definitions have been proposed (Celliers & Hattingh, 2020; Kapantai et al., 2021), much of the existing research remains fragmented—often focused on specific platforms, actors, or mechanisms in isolation. This limited scope constrains our understanding of the full life cycle of *information disorder*, a term encompassing disinformation, misinformation, propaganda, conspiracy theories, and other phenomena that pollute the information environment. As proposed by Ricard et al. (2025), this cycle is shaped by motivated agents, technological affordances, and broader structural conditions.

We argue that addressing information disorder requires a more holistic approach—accounting for the broader social, political, and economic factors that allow disinformation to take root and spread. Prior research suggests that certain enabling conditions—such as public health crises (Pickel et al., 2022; Edwards III, 2020), sociopolitical instability, and declining trust in institutions (Dowling & Legrand, 2023; Kweon, 2023)—foster environments in which disinformation flourishes. These factors not only make societies more susceptible to disinformation but, as part of a feedback loop, are often exacerbated by it, reinforcing the very tensions that allowed it to emerge in the first place.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This study addresses two guiding questions: (1) What enabling factors associated with information disorder are identified in the literature? and (2) Which of these factors manifest in anti-vaccine Telegram communities in Brazil? We focus on Telegram due to its central role in hosting ideologically driven, loosely moderated communities that have become key hubs for health-related disinformation. During the COVID-19 pandemic, anti-vaccine narratives gained significant traction in Brazil—frequently amplified by political figures, religious leaders, and health influencers. These narratives have since persisted and expanded, undermining public trust in routine immunizations, including childhood vaccines. As a result, combatting vaccine-related disinformation has become a public health priority for Brazil's federal government.

To address these questions, we adopt a mixed-methods approach that combines a systematic literature review of 95 scholarly articles with an empirical analysis of nearly 10 million posts from public Brazilian Telegram groups (2016–2024). The study identifies and analyzes 18 enabling factors—across sociopolitical and informational dimensions—and proposes a conceptual model illustrating how these conditions interact to support the spread and normalization of disinformation. The findings aim to contribute to theoretical debates on the sociotechnical dynamics of disinformation while offering practical insights for the design of more effective public policy responses.

2. Methodology

This study employs a mixed-methods design that integrates a systematic literature review with empirical analysis. These complementary methods strengthen the validity of the findings and allow for a multidimensional examination of information disorder and its enabling conditions.

2.1 Systematic Literature Review

The systematic review followed a rigorous and transparent protocol. Keyword selection was guided by established disinformation typologies, covering the phases of creation, dissemination, and impact. Searches were conducted across four academic databases—Web of Science, Scopus, SciELO, and AIS—applying thematic and temporal filters (2016–2024), as well as quality thresholds (Q1 by SJR). A double-blind screening process narrowed the initial pool to 95 peer-reviewed articles, which were then coded using MAXQDA software. Figure 1 shows the screening flow of the studies analyzed.

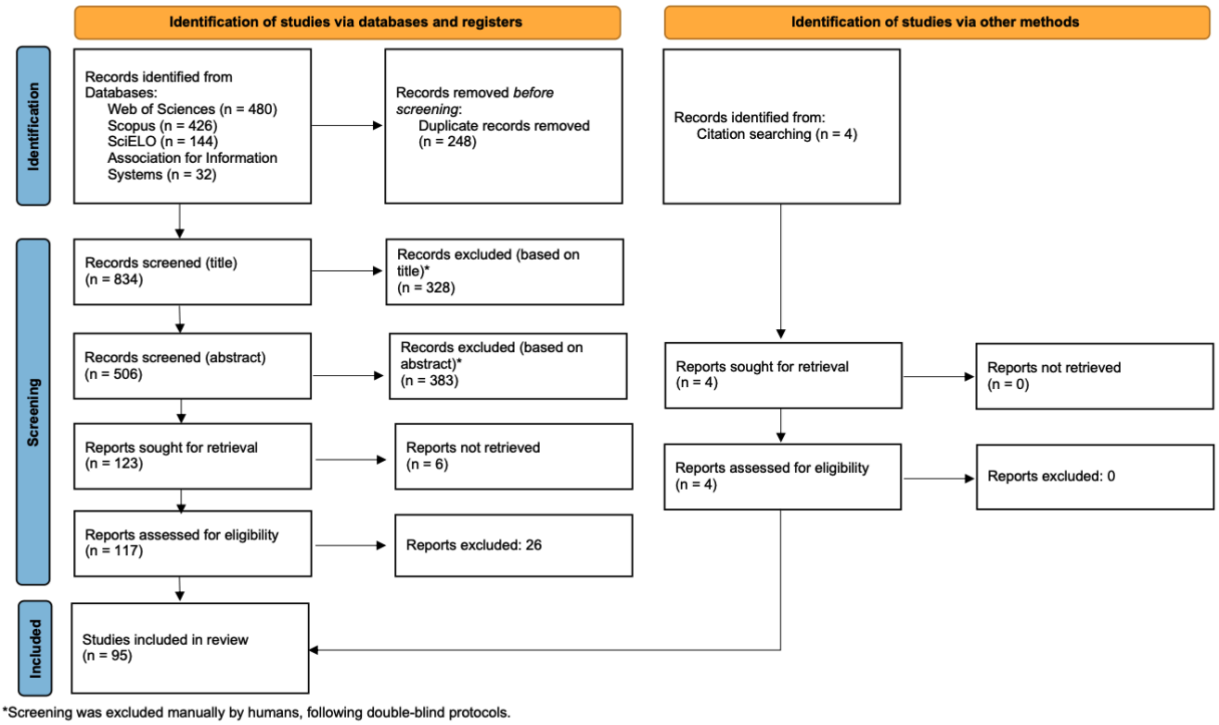


Fig. 1 - PRISMA Diagram

From this analysis, we identified 18 enabling factors that contribute to information disorder, grouped into two main dimensions: Sociopolitical Enabling Factors and Informational Ecosystem Enabling Factors. The first dimension includes the following factors: (i) Lack or loss of trust, (ii) Crises and periods of uncertainty, (iii) High levels of political polarization and ideology, (iv) Populism, (v) High levels of affective polarization, (vi) Social tensions, (vii) Historical traumas and grievances, (viii) Geopolitical tensions, (ix) Economic hardship, and (x)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Religion. The second category of factors include: (xi) Decline of traditional journalism and disintermediation, (xii) Fragmentation into partisan niches and audiences, (xiii) Infodemic, (xiv) Attention economy, (xv) New monetisation models, (xvi) Endogenous vulnerabilities of digital media, (xvii) Media consumption habits, and (xviii) Digital divide and unequal access. These 18 factors form the conceptual foundation for the empirical analysis and are discussed in detail in the subsequent sections.

2.2 Telegram Empirical Analysis

Guided by the enabling factors identified in the literature, we conducted an empirical analysis using a dataset of 10 million posts from Brazilian Telegram communities focused on conspiracy theories, spanning May 2016 to November 2024. The data were collected using TelegramScrap, an open-source tool developed by one of the authors and made publicly available with documentation for replication. The tool is publicly available, along with a whitepaper detailing its code and usage (Silva, 2023). From an initial pool of over 42 million posts from 1,612 public Latin American Telegram groups, we filtered 10,732,257 posts from 968 Brazilian communities, representing 69.8% of the dataset. Selection criteria included language, relevance of keywords, and thematic focus. All data were drawn from public groups and anonymized in accordance with Brazil's General Data Protection Law (LGPD).

Web scraping was conducted using customized Python scripts and libraries such as *requests*, *BeautifulSoup*, *Telethon*, and *gspread*. Communities were retained only if they showed consistent patterns of conspiratorial or disinformation-related activity. Posts under 10 characters or without semantic value were excluded. After processing, two core datasets were constructed: Dataset A: 10.7 million posts from general Brazilian conspiracy communities, and Dataset B: 2.2 million posts from communities explicitly focused on health disinformation (e.g., anti-vaccine, off-label drug promotion), which we refer to as "Health-related Telegram Communities (HRTC)" ahead.

This approach allowed us to trace the presence and evolution of key enabling factors across time, themes, and engagement metrics. Analyses included: Narrative and thematic mapping through keyword frequency and time series; Engagement metrics, including views, shares, and reactions; and Link-based analysis to identify dominant external domains and assess fragmentation. For enabling factors less directly measurable via quantitative metrics—such as loss of trust, populism, historical grievances, economic hardship, and grassroots information flows—we conducted qualitative observations.

3. Results: Enabling Factors of Information Disorder

3.1 Conceptual Framework

Despite a growing body of research on disinformation, there remains a lack of holistic frameworks that capture disinformation's full life cycle—from enabling sociopolitical and informational factors to impacts on society. Relatedly, while considerable attention has been paid to individual-level and psychological susceptibilities—such as cognitive biases or affective polarization—less emphasis has been placed on the broader structural dimensions that underpin information disorder.

To address this gap, we draw on the *Information Disorder Framework* (Ricard et al., 2025), that offers a holistic approach to explain how socio-political and informational vulnerabilities can be leveraged by agents of information disorder—whether politically, ideologically, or financially motivated—to strategically craft disinformation narratives responding to their interests. These narratives are disseminated through a range of tactics, impacting both the information ecosystem and society at large.

As part of this study, we focus on the first stage of the above-mentioned framework: the socio-political and informational ecosystem enabling factors of information disorder. The model posits that these factors are actively exploited by motivated agents of disinformation, who tailor narratives to resonate with existing grievances and societal divisions. Below, we outline findings from both the literature review and the empirical analysis, seeking to answer two central questions: (1) What enabling factors associated with information disorder are identified in the literature? and (2) Which of these factors manifest in anti-vaccine Telegram communities in Brazil, facilitating the spread and normalization of related disinformation?

3.2 Literature Review

This study focuses on just one of the phases of the conceptual framework presented above, the enabling factors that allow disinformation to take root and circulate. These conditions are categorized into two broad categories: (i) sociopolitical enabling factors and (ii) informational ecosystem enabling factors. The objective here is to synthesize how these factors are defined and discussed across the literature, in order to refine the conceptual model introduced above and offer a more comprehensive understanding of the structural foundations of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

information disorder.

While our scope is limited to research in political science, public administration, and international relations, it is important to note that psychological and cognitive factors—such as motivated reasoning (Jiang, 2023; Enders & Smallpage, 2019), conspiratorial thinking (Yair et al., 2024; Martini et al., 2022), confirmation bias (Heckler & Ronquillo, 2019), and authoritarian dispositions (Yendell & Herbert, 2022)—are frequently cited as individual-level drivers of susceptibility to disinformation. However, such factors were intentionally excluded from our analysis, as this study prioritizes structural and collective mechanisms over individual predispositions.

The following typology summarizes the 18 enabling factors identified in the literature, categorized by their sociopolitical and informational dimensions. These factors provide the foundation for the subsequent empirical analysis of Brazilian Telegram groups and inform the development of the conceptual model described above.

Socio-political Enabling Factors

This category refers to the social, economic, political, and cultural conditions that disinformation actors can exploit to exacerbate existing societal divisions. It is consistently identified in the literature as a foundational dimension of information disorder. Historical grievances, political tensions, and cultural cleavages are frequently instrumentalized, shaping persuasive narratives that anchor and legitimize disinformation.

Lack or loss of trust: The erosion—or absence—of trust in key institutions is one of the most widely cited enabling factors of disinformation. Declining trust in government (Islam et al., 2023; Dowling & Legrand, 2023; Zimmermann, 2020), public institutions (Koc-Michalska et al., 2023), and the media (Freiling et al., 2023) reduces societal resilience and renders populations more susceptible to misleading narratives. Critically, trust erosion functions both as a condition that enables disinformation and as a consequence of its spread, reinforcing a feedback loop that deepens democratic fragility.

Crises and periods of uncertainty: Disinformation thrives in moments of social, political, or health-related crisis. The literature documents a marked increase in conspiracy beliefs and disinformation susceptibility during the COVID-19 pandemic (Kweon, 2023; Pickel et al., 2022). Edwards III (2020) emphasizes that global uncertainty heightens public anxiety, which disinformation actors exploit. These dynamics are especially visible in electoral periods, where pre-election uncertainty amplifies public vulnerability (Karekwaivanane, 2019).

High levels of political polarization and ideology: High levels of political polarization—whether ideological or affective—consistently correlate with increased exposure to and circulation of disinformation (Faris et al., 2017, cited in Keller et al., 2020; Jian, 2023; Lombana-Bermudez et al., 2022; Jungherr & Rauchfleisch, 2024). Mauk and Grömping (2023) link disinformation exposure to shifting beliefs about electoral legitimacy. Outside the electoral context, De Zuniga et al. (2023) show that different types of polarization—affective, ideological and perceived in society—play a negative role in political persuasion through socio-digital media. Research also finds that conservatives tend to be particularly susceptible to accepting and sharing disinformation (Guess, Nyhan & Reifler, 2020, as cited in Hughes and Waismel-Manor, 2021; Kweon & Choi, 2023; Enders & Smallpage, 2019; Jungherr & Rauchfleisch, 2024).

High levels of affective polarization: Defined by intense identification with one's political group and hostility toward out-groups, affective polarization increases susceptibility to disinformation that aligns with partisan worldviews (Jenke, 2022). Importantly, Jenke notes that even politically sophisticated individuals are vulnerable when content reinforces their in-group identity. Hate speech and "us vs. them" narratives, as described by Ndahinda and Mugabe (2024), are examples of this dynamic, particularly in ethnically or politically charged contexts, such as that of the Democratic Republic of Congo.

Populism: Populism both enables and is enabled by disinformation. Populist governments are associated with environments where disinformation circulates more easily (Arceneaux & Truex, 2023; Massari, 2018, as cited in Lôbo & Bolzan de Morais, 2019). Studies also suggest that belief in disinformation fosters support for populist leaders (Serani, 2023), while populist rhetoric often includes narratives conducive to misinformation, such as anti-elitism or anti-scientific sentiment (Kweon & Choi, 2023).

Social tensions: Disinformation often targets emotionally charged social issues—such as minority rights, gender roles, or race relations—amplifying polarization and outrage (Bjola & Papadakis, 2020; Balfour, 2020). Studies show how racial tensions (Yendell & Herbert, 2022; Gunther et al., 2019; Pickel et al., 2022), gender norms (Stabile et al., 2019), and broader societal inequalities are weaponized to generate conflict and undermine consensus.

Historical traumas and grievances: Disinformation narratives frequently invoke historical traumas to heighten

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

emotional impact and legitimacy. This includes both local and international examples, such as narratives among Vietnamese-American communities (Nguyen et al., 2023) or appeals to long-standing geopolitical distrust, as seen in Russian-Western tensions (Perl et al., 2018).

Geopolitical tensions: Disinformation narratives are often anchored in geopolitical tensions, such as the conflicts between NATO, the US, Russia and Ukraine (Bolton, 2021). These types of narratives are used to promote specific agendas or foreign interference (Dawson & Innes, 2019).

Economic hardships: Economic precarity, including unemployment, inflation, and sanctions, can intensify social frustration and reduce critical engagement with information sources. These grievances are frequently mobilized to build disinformation narratives that position specific groups or institutions as responsible for economic decline (Kermani, 2023; Hughes & Waismel-Manor, 2021).

Religion: Religiosity—particularly in its authoritarian or fundamentalist forms—is linked in the literature to increased susceptibility to disinformation and conspiratorial beliefs (Yendell & Herbert, 2022; Czech, 2022). Religious frameworks can operate as moral and political systems resistant to scientific or empirical counter-narratives, further entrenching disinformation (Hidalgo, 2022).

Informational Ecosystem Enabling Factors

These factors refer to structural weaknesses in the way information is produced, disseminated, and consumed—often shaped by technological affordances, market logics, and shifts in media habits. The weakening of traditional journalism and the consolidation of fragmented, algorithm-driven media environments that prioritize inflammatory narratives that feed the “attention economy” have altered the flow of information in ways that facilitate the spread and credibility of disinformation.

Infodemic: The sheer volume of online content—often referred to as the "infodemic"—creates challenges for information discernment. As Maati et al. (2023) note, information overload can overwhelm users, blurring the line between credible and misleading content and increasing cognitive fatigue.

Attention economy: In the digital era, information disorder is fueled by the "attention economy," which rewards content that maximizes user engagement. Algorithms—acting as gatekeepers—prioritize sensationalism and emotionally charged narratives over accuracy, systematically favoring divisive content that drives traffic (Torreblanca, 2023; Bolton, 2021; Wu, 2016).

New monetization models: Driven by the logic of the attention economy, platforms’ automated advertising systems not only permit but actively encourage the creation of websites that resemble legitimate media outlets (Torreblanca, 2023). These sites blend authentic news stories with misleading content to attract audiences and capture advertising revenue.

Decline of mainstream journalism and disintermediation: The diminishing role of traditional journalism—once the primary gatekeeper of verified information—is widely recognized as a key enabling factor (Dahlgren, 2018, cited in Bolton, 2021). As Torreblanca (2023) explains, this disintermediation has displaced professional editors and fact-checkers, allowing unverified content to circulate freely. While this shift has democratized information access, it has also increased exposure to misleading or harmful narratives (Balfour, 2020).

Media consumption habits: The relationship between media consumption habits and vulnerability to disinformation is complex and not fully agreed upon in the literature. Some studies suggest that consuming news via social media increases vulnerability to disinformation due to the platform’s structure and the prevalence of misleading information (Bjola and Papadakis, 2020; De Zúñiga, 2023; Keller, 2020). Others emphasize that indirect exposure may be similarly problematic (Gadjanova et al., 2022).

Fragmentation into partisan niches and audiences: The current information landscape is increasingly fragmented, with users engaging primarily within ideological "echo chambers" (Mauk & Grömping, 2024; Lombana-Bermudez, 2022; Krafft & Donovan, 2020). This segmentation reinforces pre-existing biases, reduces exposure to diverse viewpoints, and facilitates the uncritical circulation of disinformation.

Endogenous vulnerabilities of digital media: Digital platforms introduce unique vulnerabilities that facilitate rapid and targeted disinformation. The speed, personalization, and emotional resonance of content in socio-digital environments make it particularly potent. Torreblanca (2023) and Vićić and Gartzke (2023) emphasize how the immediacy and interactivity of digital media personalize content consumption, heightening individual susceptibility. Chernobrov (2022) further highlights dimensions such as intimacy and emotional

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

proximity that make users more vulnerable.

Digital divide and unequal access: Inequitable access to the internet and digital tools also shapes exposure to information disorder. In contexts such as Ghana, the digital divide creates a distinction between direct and indirect internet users, with the latter often relying on secondhand information shared by family or community members (Gadjanova et al., 2022). Limited connectivity and digital literacy compound vulnerability by reducing users' capacity to verify or contextualize content.

3.3 Empirical Analysis

To complement the literature-based typology of contextual vulnerabilities, we conducted an empirical analysis of over 10 million public posts shared in Brazilian conspiratorial Telegram groups between 2016 and 2024—including 2.2 million posts specifically from Health-Related Telegram Communities (HRTC). The aim was to assess how the vulnerabilities identified in the literature manifest in real-world disinformation ecosystems. Focusing on Telegram, one of the most active platforms for disinformation circulation in Brazil, this section examines how sociopolitical and informational vulnerabilities are referenced, reinforced, or exploited over time. The findings offer empirical grounding for the conceptual model and demonstrate that these enabling factors are not only theoretical constructs, but actively leveraged in disinformation campaigns.

Socio-political Enabling Factors

Lack or loss of trust: Although no direct empirical test was conducted for this factor, the scale and persistence of conspiracy theory communities on Telegram—reaching over 2.5 million users—already reflect a broader climate of institutional distrust. Data from the Edelman Trust Barometer show significant fluctuations in institutional trust in Brazil from 2016 to 2024, with media trust dropping from 54% in 2016 to 41% in 2019. Government trust followed a more complex trajectory: starting at 21% in 2016, rising thereafter, but falling again in 2022—an election year—to just 34%, before slightly recovering.

Crises and periods of uncertainty: We analyzed publication frequency in HRTC to evaluate surges in content during two key periods: (1) the COVID-19 pandemic (2020–2021) and (2) the 2022 general elections. As shown in Figure 2, both periods corresponded with sharp increases in activity—rising from 3,184 posts in January 2020 to 17,322 in January 2021, and peaking at 141,848 in January 2022. Importantly, post-election publication volume stabilized at a significantly higher baseline than pre-pandemic levels (e.g., 42,376 posts in January 2024 vs. 3,184 in January 2020). These findings support the notion that crises and electoral uncertainty act as catalysts for information disorder.

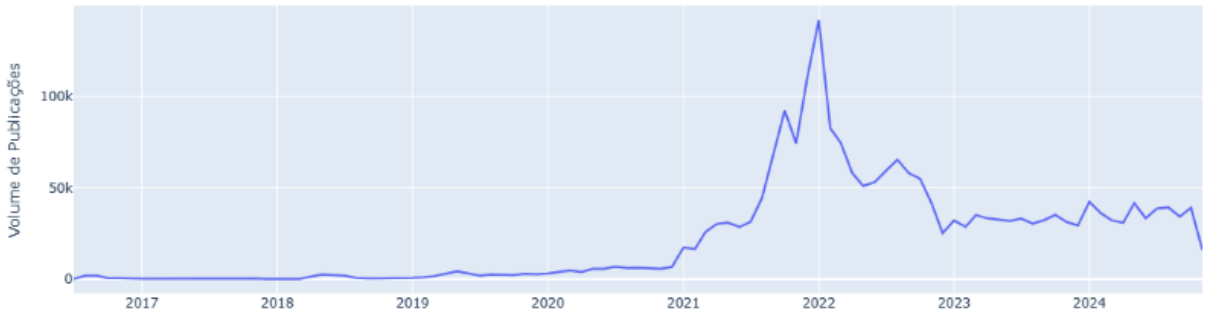


Fig. 2 - Monthly Publications in Health-related Telegram Communities (HRTC)

High levels of political polarization and ideology: To assess this factor, we conducted keyword-based semantic filtering within the HRTC dataset. More than 21% of posts (475,830) included terms linked to political affiliation or ideological bias. As shown in Figure 3, prominent keywords included "against covid," "covid vaccine," "government," "Brazil," and "United States"—frequently used in narratives alleging that authorities were concealing effective treatments or promoting globalist agendas. These narratives spiked notably during the 2022 election period (Figure 4), reinforcing the connection between political polarization and disinformation, and echoing the earlier findings on the role of Crises and periods of uncertainty.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



Fig. 3 - Word Cloud illustrating Political Polarization and Ideology Terms in HRTC

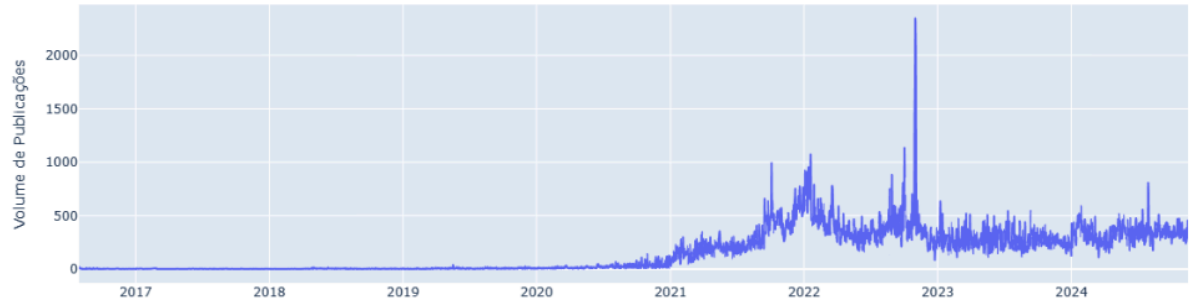


Fig. 4 - Daily Publications Including Terms Associated with Political Polarization and Ideology in Health-related Telegram Communities (HRTC)

High levels of affective polarization: We also examined how anti-vaccine content conveyed hostility toward perceived out-groups, using keyword-based filtering focused on political ideologies, social identities, and polarizing narratives. Over 13% of posts (293,522) in HRTC reflected affective polarization, frequently referencing the "new world order"—often linked to the "covid vaccine" and framed as part of a global plan to undermine "family" values (Figure 5). The term "Time" also appeared as a rhetorical device to create urgency and mobilize audiences. Like political polarization, affective polarization intensified around the 2022 elections (Figure 6), underscoring its role in reinforcing disinformation narratives.

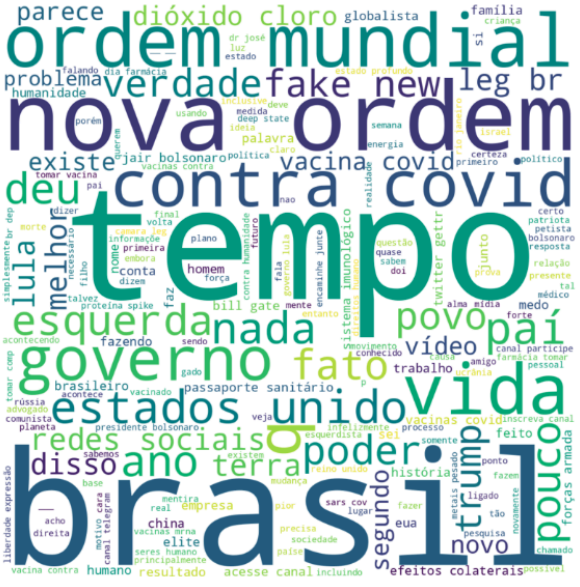


Fig. 5 - Word Cloud illustrating Affective Polarization Terms

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

in HRTC

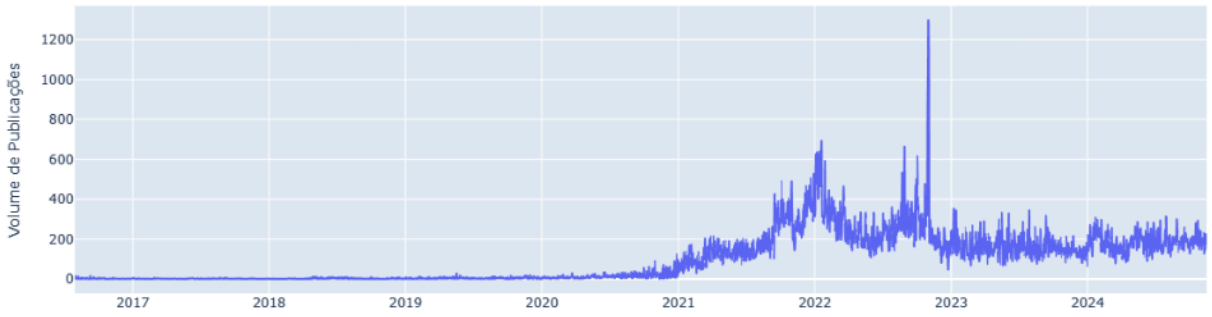


Fig. 6 - Daily Publications Including Terms Associated with Affective Polarization in Health-related Telegram Communities (HRTC)

Populism: Considering that assessing populism at scale would require a tailored methodological approach—such as discourse analysis or computational text classification—, no dedicated empirical experiment was conducted for this factor. Nonetheless, discourse patterns in the HRTC dataset suggest a populist framing. The term "elite" appeared 9,817 times, often within narratives portraying a powerful group allegedly suppressing natural or miraculous cures while coercing the public into accepting harmful vaccines. This rhetorical style aligns with the anti-elitist sentiment characteristic of populist discourse.

Social tensions: Disinformation often exploits social divisions, identity-based grievances, and cultural tensions to heighten emotional resonance and deepen polarization (Bjola & Papadakis, 2020; Vićić & Gartzke, 2024). To examine this dynamic, we analyzed the intersection of anti-vaccine narratives with moral and identity-based agendas in HRTC posts. Keywords were grouped into categories such as Racism and Ethnic Issues, Homophobia and Gender, Machismo and Women, Human Rights, Morality and Cultural Values, and Violence and Crime. Nearly 8% of posts (175,286) included terms associated with these themes. As illustrated in Figure 7, frequently occurring words such as "woman," "life," "family," and "thank God" suggest efforts to frame vaccine resistance within moral or religious discourses—indicating how disinformation narratives in Brazil are often intertwined with broader cultural and ideological fault lines.



Fig. 7 - Word Cloud illustrating Terms associated with Social Tensions in HRTC

Historical traumas and grievances: No quantitative experiment was conducted for this factor, as our methodological approach does not allow for the depth and specificity required to capture such nuanced dynamics on Telegram. Analyzing historical trauma would likely require isolating particular events and tracing their resonance within defined subgroups—an approach that is difficult to implement on a fragmented, pseudonymous platform like Telegram. Nevertheless, prior research supports the enabling role of historical grievances in the spread of disinformation. For example, vaccine resistance in Acre, Brazil, has been linked to local incidents of alleged harm from HPV vaccines (Pinheiro, 2022), while vaccine hesitancy among African-American communities in the U.S. is often rooted in a legacy of structural racism and unethical medical practices (Willis et al., 2021).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Geopolitical tensions: To study this factor, we analyzed how frequently anti-vaccine content was framed through political or geopolitical narratives, such as foreign influence or threats to national sovereignty. Unlike other analyses, we reversed our usual method by identifying health-related terms within "Globalism" and Geopolitics focused Telegram communities. Keywords were grouped into four categories: Pandemic and Vaccination; Off-Label Treatments; Anti-Vaccine Narratives; and Institutions and Authorities. Results show that over 15% of posts (104,297) in these communities connected anti-vaccine discourse to geopolitical frames—such as portraying mandatory vaccination as part of a "communist" or "fascist" agenda. Terms like "plandemic," "deep state," and "vachina" (a portmanteau of vaccine and China) were common, illustrating how global political tensions are embedded within localized disinformation narratives (Figure 8).



Fig. 8 - Word Cloud illustrating Terms associated with health in "Globalism" and Geopolitics Telegram Communities

Economic hardships: This factor was not empirically tested due to the lack of user demographic data. Without socioeconomic indicators, we can not assess how financial precarity may enhance susceptibility to disinformation.

Religion: Religious thinking—particularly in its dogmatic or fundamentalist forms—has been widely identified as an enabling factor of disinformation (Czech, 2022; Hidalgo, 2022; Yendell & Herbert, 2022). Among the sociopolitical vulnerabilities analyzed in HRTC, religious framing emerged as the most prominent. A comprehensive keyword-based thematic analysis—including terms related to Christianity, Afro-Brazilian religions, Orientalism, Judaism, and Islam—found that over 26% of posts (586,786) contained one or more religious references. The volume of such content increased significantly after the onset of the COVID-19 pandemic (Figure 9). As with the Political polarization and ideology analysis, some of the most frequent keywords were "chlorine dioxide," "against covid," and "covid vaccine" (Figure 10). These terms often appeared in narratives portraying chlorine dioxide as a "miraculous" alternative to vaccines, framed within faith-based appeals.

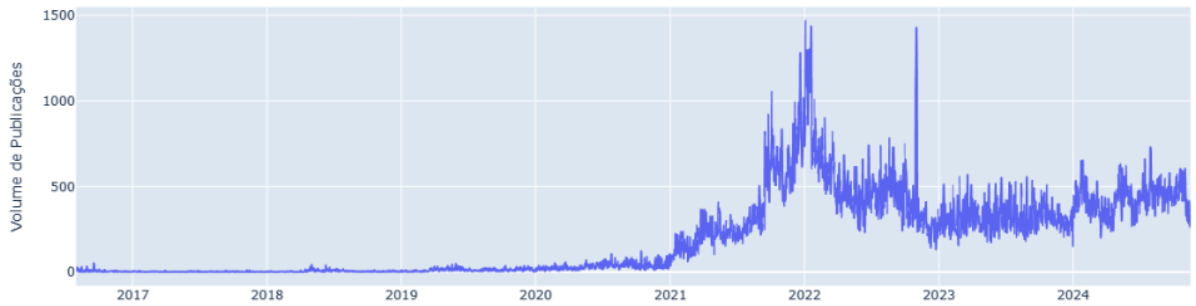


Fig. 9 - Daily Publications Including Terms Associated with Religion in Health-related Telegram Communities (HRTC)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

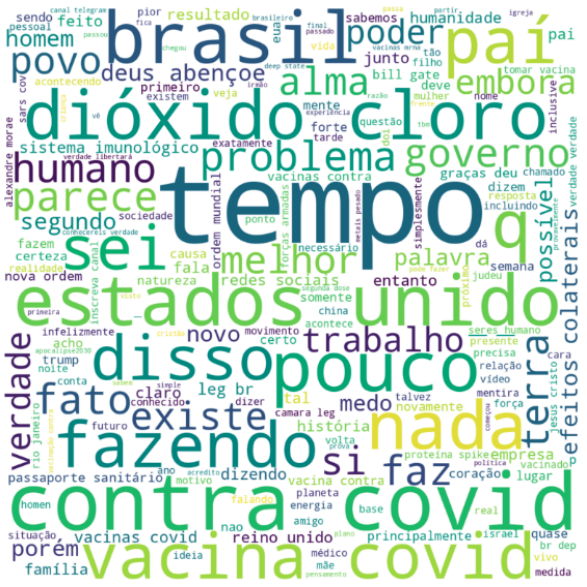


Fig. 10 - Word Cloud illustrating Terms associated with Religion in HRTC

Informational Ecosystem Enabling Factors

Infodemic: To assess the scale and dispersion of health-related disinformation, we analyzed the presence of health-related terms across the full dataset of over 10 million posts (Figure 11). Nearly 13% (1,356,611) contained health misinformation, often framed through conspiracy theory narratives. As shown in Figure 12, these posts were distributed across a wide range of communities. While anti-vaccine groups predictably accounted for the largest share, health-related disinformation was present across all thematic categories of conspiracy-oriented Telegram channels. This suggests that such content is not confined to niche spaces but circulates broadly across disinformation ecosystems. The sheer volume and diversity of topics—ranging from "covid vaccine" to "new world order," "deep state," "Lula government," and "Nazi communist"—highlight how these narratives converge and proliferate within an overloaded and chaotic digital environment.

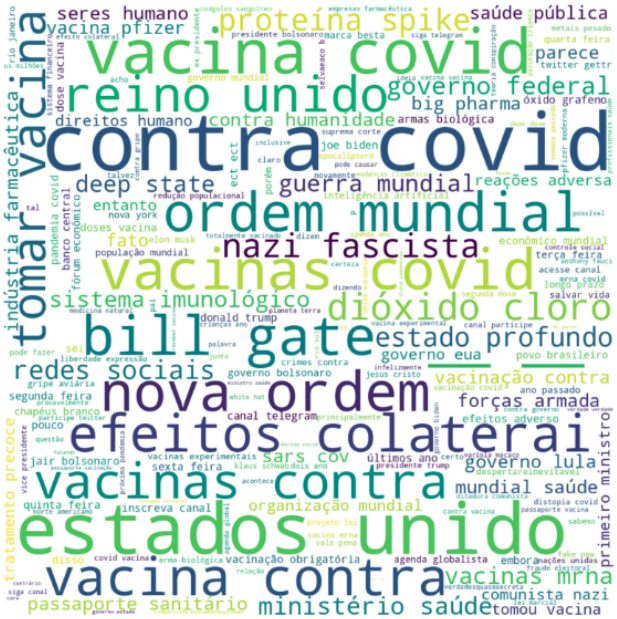


Fig. 11 - Word Cloud illustrating Terms associated with Health in all Communities from the Database

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Conspiracy Theory	Volume of Health-Related Posts	Percentage of Health-Related Posts	Conspiracy Theory	Volume of Health-Related Posts	Percentage of Health-Related Posts
Anti-vaccine (Antivax)	363,745	24.28%	UFO and Universe	34,313	5.28%
New World Order (NWO)	256,611	13.83%	Climate Change	34,253	15.32%
General Conspiracies	217,708	9.83%	Revisionism and Hate Speech	17,797	7.87%
Off-label Medications	133,489	18.03%	Anti-Woke and Gender	12,324	6.32%
Globalism	104,297	15.16%	Flat Earth	10,826	3.80%
Apocalypse and Survival	80,119	10.50%	Anti-Science	10,014	6.92%
Occultism and Esotericism	39,977	5.02%	Reptilians and Creatures	3,723	6.39%
QAnon	37,415	9.40%			

Fig. 12 - Volume of Health Disinformation Publications in all Communities from the Database

Attention Economy: No empirical analysis was conducted for this factor, given that it is structurally embedded in platform logic and opaque by algorithmic design. Nonetheless, other aspects presented here—particularly the dominance of virality over interaction—offer indirect evidence of engagement-driven visibility.

New Monetization Models: Aligned with the logic outlined in the previous factor, we did not conduct an empirical analysis of monetization dynamics. Additionally, emerging monetization models—such as those used by disinformation websites that mimic legitimate outlets—fall outside the scope of the Telegram communities analyzed in this study.

Decline of Mainstream Journalism and Disintermediation: To explore the diminishing role of traditional journalism and the rise of alternative content flows, we analyzed the proportion of links shared within HRTC that pointed to social media versus other web domains. Social media platforms accounted for 53% of all shared links (453,531), while 47% (407,225) linked to websites such as blogs or news portals (Figure 13). This pattern underscores the shift away from traditional gatekeepers, with platforms now serving as primary conduits for information exposure and circulation.

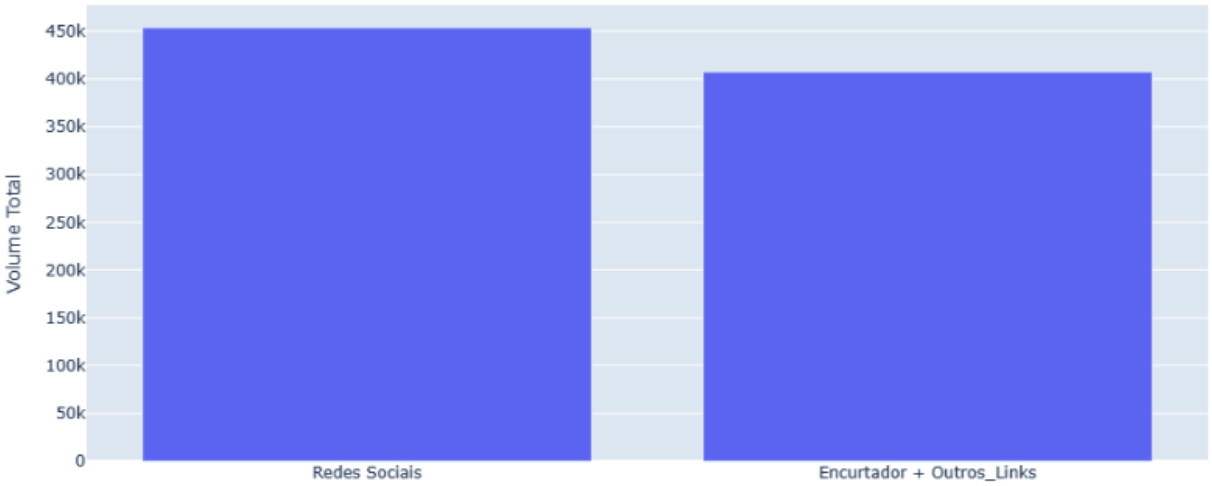


Fig. 13 - Volume of Publications with Links to Social Media and Shorten URLS / Other links in Health-related Telegram Communities (HRTC)

Media consumption habits: As noted in the literature review, the relationship between media consumption habits and information disorder is nuanced and multifaceted. Our findings reflect this complexity, with media consumption patterns in HRTC pointing to a fragmented, multi-platform ecosystem spanning both algorithmically mediated platforms (YouTube, Instagram, TikTok, Facebook, etc.) and private messaging apps like Telegram and WhatsApp. As shown in Figure 15, Telegram and YouTube were the most frequently linked platforms (164,083 and 157,184 links, respectively), together accounting for over 920 million views and 7.6 million shares. This suggests that health disinformation is primarily consumed through audiovisual and closed-loop channels—emphasizing intentional engagement within ideologically cohesive communities, rather than incidental exposure to diverse perspectives.

Fragmentation into partisan niches and audiences: Niche partisan outlets and websites tend to reinforce pre-existing beliefs rather than broaden the debate, fostering echo chambers and facilitating the spread of disinformation (Mauk & Grömping, 2024; Krafft & Donovan, 2020). To examine this dynamic, we mapped and classified the most frequently shared domains—excluding links to social media platforms—into four categories: mainstream media, partisan media, institutional websites, and e-commerce/other. The results (Figure 14) show that 75% of the most circulated domains belong to partisan media outlets, while the remaining 25% are distributed among institutional or government websites, mainstream news sources, and off-label e-commerce platforms. Notably, only five of these domains were associated with traditional media outlets (e.g., Globo and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Revista Oeste) or mainstream institutions (e.g., Instituto Butantan, PubMed, and the Brazilian Senate). The overwhelming prevalence of partisan and alternative sources suggests that information consumption in these health-related communities is shaped primarily by ideological segmentation, with users gravitating toward content that affirms their existing views.

Media Type	Domain	Frequency	Views	Shares	Media Type	Domain	Frequency	Views	Shares
Partisan Media	jornaldacidadeonline.com.br	11,643	6,298,965	28,908	Mainstream Media	g1.globo.com	3,385	3,722,605	36,827
Partisan Media	planetaprisao.com.br	9,88	6,437,356	89,643	Partisan Media	redemption.news	3,022	265,924	1,624
Partisan Media	terrabrasilnoticias.com	7,173	6,079,189	35,368	Partisan Media	reversaohumana.com.br	2,784	194,68	4,088
Partisan Media	pleno.news	6,256	3,538,826	14,758	Partisan Media	contrafatos.com.br	2,74	5,306,061	52,829
Partisan Media	tribunanacional.com.br	5,621	2,704,518	46,68	Institutional Site	www12.senado.leg.br	2,642	4,314,811	51,54
Institutional Site	butantan.gov.br	4,846	48,683	759	Partisan Media	starday.com.br	2,429	7,106,531	42,527
Partisan Media	verdadeconspurada.com.br	3,892	1,692,526	19,586	Partisan Media	revistaoeste.com	2,338	3,148,659	21,619
E-commerce	farmaciaviva.com.br	3,612	743,143	10,708	Partisan Media	gazetabrasil.com.br	2,329	1,792,147	12,172
Others	pubmed.ncbi.nlm.nih.gov	3,459	2,339,241	44,62	Partisan Media	redemption3301.blogspot.com	2,247	96,308	1,297
Partisan Media	childrenshealthdefense.org	3,404	6,292,476	78,15	Partisan Media	atrombetanews.com.br	2,152	71,549	553

Fig. 14 - Top #20 Domains Circulated in Health-related Telegram Communities (HRTC)

Endogenous vulnerabilities of digital media: We explored how Telegram's platform structure itself enables disinformation diffusion by analyzing outbound links in HRTC posts. While many links led to external platforms like YouTube, the majority redirected users to other Telegram groups—demonstrating a self-reinforcing architecture that keeps users within a closed information loop (Figure 15). Engagement metrics further emphasize this dynamic: of the recorded interactions, shares (202,134,432) vastly outnumbered comments (155,986) and reactions (563,849). This suggests that disinformation spreads primarily through passive replication rather than critical dialogue. Users act less as evaluators of content and more as amplifiers within a high-velocity, closed-circuit network.

Platform	Volume	Views	Reactions	Shares	Comments
Telegram	164,083	544,756,218	290,369	5,251,922	80,865
YouTube	157,184	376,059,835	79,73	2,425,423	36,583
Instagram	23,875	23,588,897	65,607	254,351	20,618
Twitter	19,4	39,781,885	56,49	579,712	14,339
Facebook	7,94	7,529,877	36,948	84,492	12,837
WhatsApp	4,649	4,475,881	1,755	21,735	619
TikTok	343	1,717,883	399	5,819	127
LinkedIn	205	1,418,588	117	23,682	16
Kwai	7	132	3	1	0

Fig. 15 - Volume of posts with links to Social Media in Health-related Telegram Communities (HRTC)

Digital divide and unequal access: We did not conduct empirical testing for this factor, as it requires demographic and access-related data beyond the scope of this dataset. However, prior literature strongly links limited digital access and literacy with increased exposure to second-hand, unverifiable information—particularly in regions with high reliance on interpersonal or offline information flows.

4. Discussion

Based on the 18 enabling factors identified in the systematic literature and explored in the empirical analysis, Tables 1 and 2 present a systematization of the analysis, integrating both theoretical and empirical insights. Notably, we found empirical evidence for 11 out of the 18 factors identified in the literature, suggesting that (1) socio-political and ecosystem vulnerabilities indeed contribute to information disorder, and (2) they are significantly present in anti-vaccine discourse in Brazilian Telegram communities. Although the feedback dynamics between vulnerabilities and disinformation were not the primary focus of this article, our findings underscore the importance of adopting a holistic and systemic approach to the problem.

Indeed, we observe that certain socio-political vulnerabilities may simultaneously function both as facilitators and consequences of disinformation. For example, lack of trust in institutions is widely recognized as a factor facilitating the spread of disinformation, yet it is also one of the most frequently cited outcomes of sustained exposure to disinformation (Dowling & Legrand, 2023; Kweon, 2023). Similarly, while high levels of political polarization intensify the circulation of false or misleading content, enhanced polarization is also a deliberate outcome of many orchestrated disinformation campaigns. Other vulnerabilities, while not displaying the same cyclical pattern, still illustrate how enabling vulnerabilities are leveraged by agents of information disorder. For instance, our findings suggest that both social and geopolitical tensions are used to frame anti-vaccine discourse

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

in Brazil.

Turning to the informational ecosystem enabling factors, the findings confirm that a weakened information environment can both enable and sustain disinformation. Overall, the infodemic — the overwhelming volume of information in today's digital societies — which blurs the line between credible and misleading content (Maati et al., 2023), acts both as a condition for and an impact of information disorder. As anticipated, the decline of mainstream journalism and disintermediation — driven by the rise of digital platforms and changes in media consumption behavior — together with platforms' affordances both contribute to information disorder.

Tab. 1 - Overview of Socio-political Enabling Factors.

Enabling Factors	Reference in the Literature	Empirical Finding
Lack or Loss of Trust	Loss of trust in the government (Islam et al., 2023; Dowling & Legrand, 2023), in public institutions (Koc-Michalska et al., 2023), and in the media (Freiling et al., 2023) enables information disorder.	No direct test conducted; presence of 2.5M users in conspiracy communities indicates trust erosion. Edelman Barometer data shows fluctuating trust in government and media (2016–2024).
Crises and Periods of Uncertainty	Crises –such as the COVID-19 pandemic– and moments of uncertainty –particularly election periods– act as catalysts for information disorder (Kweon, 2023; Pickel et al., 2022; Edwards III, 2020; Karekwaivanane, 2019).	Temporal analysis shows peaks of publications in 2021 and 2022, suggesting that the COVID-19 pandemic and the 2022 elections amplified the information disorder context in Brazil.
High Levels of Political and Ideological Polarization	Political polarization intensifies the spread of disinformation (Faris et al., 2017; Jungherr & Rauchfleisch, 2024; De Zuniga et al., 2023), with conservatives being more susceptible (Guess et al., 2020).	21.4% of HRTC posts (475,830) included politically polarized terms, linking health discussions to narratives that a "communist" government was hiding treatments, such as the "miracle cure" or the "dioxide of chlorine." Peaks align with the 2022 elections.
High Levels of Affective Polarization	Emotional identification with political groups and hostility toward opponents increase susceptibility to disinformation (Jenke, 2022; Ndahinda & Mugabe, 2024).	13.2% of HRTC posts (293,522) connected health topics to conspiracy narratives such as the "new world order," linking them to the destruction of traditional values such as "family" and "children".
Populism	Populist governments encourage the spread of disinformation, and belief in conspiracy theories increases support for populism (Arceneaux & Truex, 2023; Serani, 2023).	No empirical test was conducted, but the word "elite" was found 9,817 times in HRTC), with narratives often portraying an elite that allegedly hides miraculous medicines and cures while coercing people into vaccination.
Social Tensions	Amid disputes over narratives, disinformation exploits race, gender, and identity divisions (Bjola & Papadakis, 2020; Vićić & Gartzke, 2024).	7.9% of HRTC posts evoked "moral agendas", and terms such as "minorities," and "culture war".
Historical Traumas and grievances	Disinformation narratives use past historical traumas and social tensions to spread and legitimize disinformation (Nguyen et al., 2023; Perl et al., 2018).	No empirical test conducted.
Geopolitical Tensions	Disinformation narratives can exploit geopolitical conflicts to promote agendas of conspiracy based on prejudices and stereotypes (Zhao et al., 2024; Dawson & Innes, 2019).	In geopolitical and "globalist" communities, 15.2% (104,297 posts) linked health-related disinformation to theories such as the "plandemic".
Economic Hardships	Economic crisis and unemployment are exploited to fuel disinformation narratives (Kermani, 2023; Hughes & Waismel-Manor, 2021).	No empirical test conducted.
Religion	Authoritarian religiosity and	26.4% of HRTC posts (586,786) used

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

	fundamentalism increase belief in conspiracy theories, reinforcing resistance to scientific evidence (Yendell & Herbert, 2022; Czech, 2022).	religious framings, e.g. “miracle cures,” often Christian or syncretic narratives.

Tab. 2 - Overview of Informational Ecosystem Enabling Factors.

Enabling Factors	Reference in the Literature	Empirical Finding
Infodemic	Volume of information makes it difficult to distinguish between reliable and misleading content, and this confusion creates more space for disinformation (Maati et al., 2023).	13% (1.36M) of full dataset posts contained health disinfo, interwoven with other conspiracies like flat earth and "New World Order" conspiracies.
Attention Economy	Algorithms—acting as gatekeepers—prioritize sensationalism and emotionally charged narratives over accuracy, systematically favoring divisive content that drives traffic (Torreblanca, 2023; Bolton, 2021; Wu, 2016).	No empirical test conducted.
New Monetization Models	Advertising-driven revenue models incentivize misleading or sensationalist content disguised as legitimate news, exploiting algorithms to attract clicks and blurring the line between fact and fiction (Wu, 2016; Torreblanca, 2023).	No empirical test conducted.
Decline of Mainstream Journalism and Disintermediation	The rise of social digital media and the loss of traditional gatekeepers have expanded the spread of unverified content (Dahlgren, 2018; Torreblanca, 2023).	53% of HRTC posts links direct users to social media platforms, versus 47% to external portals, highlighting the predominance of social media platforms in information circulation.
Media Consumption Habits	The usage patterns of both direct and indirect exposure shape users’ vulnerability to disinformation, though the relationship remains contested in the literature.	Fragmented and multi-media ecosystem, dominated by Telegram and YouTube. The prominence of long-form and intra-platform sharing suggests intentional, ideologically-aligned consumption, rather than incidental exposure.
Fragmentation into Partisan Niches and Audiences	Vehicles and niche partisan portals reinforce pre-existing beliefs instead of pluralizing the debate, forming echo chambers and engaging in disinformation (Mauk & Grömping, 2024; Krafft & Donovan, 2020).	Within HRTC, 75% of top domains shared are partisan media; only 25% link to mainstream or institutional sources.
Endogenous Vulnerabilities of Digital Media	The speed, scale, and personalization of social digital media make individuals more susceptible to disinformation (Chernobrov, 2022; Torreblanca, 2023).	Most-shared links were Telegram invites; 202M shares vastly exceed reactions/comments, suggesting virality through passive transmission, and demonstrating how disinformation networks reinforce themselves endogenously.
Digital Divide and Unequal Access	Indirect exposure among digitally excluded populations increases reliance on interpersonal (dis)information flows (Gadjanova et al., 2022).	No empirical test conducted.

5. Conclusion and Limitations

This study examined which socio-political and informational ecosystem vulnerabilities contribute to information

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

disorder and how they manifest in anti-vaccine Telegram communities in Brazil. Using a mixed-methods approach that combines a systematic literature review with large-scale empirical analysis, we identified 18 enabling factors and found empirical evidence of 11 of them in over 10 million Telegram posts. The results demonstrate that socio-political enabling factors—such as institutional distrust, high levels of polarization, and social tensions—and ecosystem information factors are strategically exploited within anti-vaccine discourse. Certain vulnerabilities are not only structural but cyclical: for example, loss of trust in institutions facilitates the spread of disinformation, which in turn further erodes trust. The study also finds that crises and periods of uncertainty, specially the COVID-19 pandemic and election cycles, serve as catalysts for the infodemic, accelerating the circulation of false and misleading content. From the perspective of the informational ecosystem, the study confirms that platforms like Telegram enable the amplification of disinformation due in particular to endogenous digital vulnerabilities and disintermediation. This is exacerbated by the declining trust in mainstream journalism and increasing fragmentation into partisan niches and audiences.

Importantly, this work contributes to a growing body of scholarship that reframes disinformation not simply as a problem of "truth" or technological advancements, but as a structural phenomenon embedded in broader socio-political and media systems. Addressing information disorder requires acknowledging the contextual vulnerabilities present in a given setting, understanding how they intersect, and identifying the full range of stakeholders needed to develop sustainable, multi-level responses. Our findings suggest that effective responses must go beyond fact-checking and digital literacy. Sustainable interventions must address the structural conditions—both socio-political and informational—that allow disinformation to take root and flourish. This may include rebuilding institutional trust and developing platform governance strategies that recognize contextual vulnerabilities that enable disinformation, but further research is needed.

Certain limitations must be acknowledged. First, by focusing exclusively on Telegram, the findings reflect the dynamics of a single platform characterized by minimal moderation and high user anonymity. While this choice enables in-depth analysis of a key disinformation hub in Brazil, it limits generalizability to other platforms. Second, the study does not include psychological or individual-level variables—such as cognitive bias or conspiratorial thinking—which may further influence user susceptibility. While this aligns with our focus on systemic vulnerabilities, future research could integrate micro-level analyses to better understand how personal factors interact with broader socio-technical enabling factors. Third, this article does not evaluate nor propose policy solutions. Instead, our findings lay the groundwork for future studies to propose policy interventions addressing the identified enabling factors –beyond the prominent measures such as media literacy– that could address information disorder from a more systematic perspective. Future research should explore how information disorder operates across multiple platforms, how it intersects with offline behaviors, and how structural and individual-level vulnerabilities interact.

Funding or Grant

The authors acknowledge the support of the Brazilian National Council for Scientific and Technological Development (CNPq) for the Technological and Industrial Development Fellowship (DTI), process no. 380088/2025-8 and process no. 381825/2025-6, granted to the first and second authors of this study.

Data/Software Access Statement

TelegramScrap, an open-source tool developed by one of the authors, was used for Telegram data collection and analysis. The tool is publicly available with documentation for replication: https://github.com/ergoncugler/web-scraping-telegram.

Contributor Statement

Julie Ricard: Conceptualisation, Methodology, Literature Review, Writing-Original Draft, Writing – Review & Editing, Supervision. Ergon Cugler: Methodology, Software, Visualisation, Writing-Original Draft, Ivette Yañez and Leticia Hora: Literature Review, Writing-Original Draft, Writing – Review & Editing.

Use of AI

During the preparation of this work, the author(s) used Google Translate in order to translate content from Portuguese to English. Authors also used GPT 4.o to summarize findings for systematization tables. After using these, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

Conflict Of Interest (COI)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

There is no conflict of interest.

References

Arceneaux, K., & Truex, R. (2023). Donald Trump and the lie. Perspectives on Politics, 21(3), 863-879. https://doi.org/10.1017/S1537592722000901

Balfour, L. (2020). A discussion of Russell Muirhead and Nancy L. Rosenblum's A lot of people are saying: The new conspiracism and the assault on democracy. Perspectives on Politics, 18(4), 1156-1157. https://doi.org/10.1017/S1537592720003503

Bjola, C., & Papadakis, K. (2020). Digital propaganda, counterpublics and the disruption of the public sphere: The Finnish approach to building digital resilience. Cambridge Review of International Affairs, 33(5), 638-666. https://doi.org/10.1080/09557571.2019.1704221

Bolton, D. (2021). Targeting ontological security: Information warfare in the modern age. Political Psychology, 42(1), 127-142. https://doi.org/10.1111/pops.12691

Casarões, G., & Magalhães, D. (2024). The hydroxychloroquine alliance: How far-right leaders and alt-science preachers came together to promote a miracle drug. Revista de Administração Pública, 55, 197-214. https://doi.org/10.1590/0034-761220200556

Celliers, M., & Hattingh, M. (2020). A systematic review on fake news themes reported in literature. In IFIP WG 6.11 Conference on e-Business, e-Services, and e-Society, I3E 2020, Proceedings, Part II (pp. 223-234). Springer International Publishing.

Chernobrov, D. (2022). Diasporas as cyberwarriors: Infopolitics, participatory warfare and the 2020 Karabakh war. International Affairs, 98(2), 631-651. https://doi.org/10.1093/ia/iiac015

Czech, F. (2022). Links between conspiracy thinking and attitudes toward democracy and religion: Survey data from Poland. Politics and Governance, 10(4), 192-202. https://doi.org/10.17645/pag.v10i4.5832

Dawson, A., & Innes, M. (2019). How Russia's Internet Research Agency built its disinformation campaign. The Political Quarterly, 90(2), 245-256. https://doi.org/10.1111/1467-923X.12690

De Zúñiga, H. G., Marné, H. M., & Carty, E. (2023). Abating dissonant public spheres: Exploring the effects of affective, ideological and perceived societal political polarization on social media political persuasion. Political Communication, 40(3), 327-345. https://doi.org/10.1080/10584609.2022.2139310

Dowling, M.-E., & Legrand, T. (2023). "I do not consent": Political legitimacy, misinformation, and the compliance challenge in Australia's Covid-19 policy response. Policy and Society, 42(3), 319-333. https://doi.org/10.1093/polsoc/puad018

Edelman. (2025). Edelman Trust Barometer. https://www.edelman.com/trust/2025/trust-barometer

Edwards III, G. C. (2020). The bully in the pulpit. Presidential Studies Quarterly, 50(2), 286-324. https://doi.org/10.1111/psq.12644

Enders, A. M., & Smallpage, S. M. (2019). Informational cues, partisan-motivated reasoning, and the manipulation of conspiracy beliefs. Political Communication, 36(1), 83-102. https://doi.org/10.1080/10584609.2018.1493006

Faris, R., Roberts, H., Etling, B., Bourassa, N., Zuckerman, E., & Benkler, Y. (2017). Partisanship, propaganda, and disinformation: Online media and the 2016 U.S. presidential election (Berkman Klein Center Research Publication 2017-6). https://ssrn.com/abstract=3019414

Freiling, I., Stubenvoll, M., & Matthes, J. (2023). Support for misinformation regulation on social media: It is the perceived harm of misinformation that matters, not the perceived amount. Policy & Internet, 15(4), 731-749. https://doi.org/10.1002/poi3.360

Gadjanova, E., Lynch, G., & Saibu, G. (2022). Misinformation across digital divides: Theory and evidence from northern Ghana. African Affairs, 121(483), 161-195. https://doi.org/10.1093/afraf/adac009

Guess, A. M., Nyhan, B., & Reifler, J. (2020). Exposure to untrustworthy websites in the 2016 US election. Nature Human Behaviour, 4(5), 472-480. https://doi.org/10.1038/s41562-020-0833-x

Gunther, R., Beck, P. A., & Nisbet, E. C. (2019). "Fake news" and the defection of 2012 Obama voters in the 2016 presidential election. Electoral Studies, 61, 102030. https://doi.org/10.1016/j.electstud.2019.03.006

Heckler, N., & Ronquillo, J. C. (2019). Racist fake news in United States' history: Lessons for public administration. Public Integrity, 21(5), 477-490. https://doi.org/10.1080/10999922.2019.1626696

Hidalgo, O. F. (2022). Religions and conspiracy theories as the authoritarian "other" of democracy? Politics and Governance, 10(4), 146-156. https://doi.org/10.17645/pag.v10i4.5826

Hughes, H. C., & Waismel-Manor, I. (2021). The Macedonian fake news industry and the 2016 US election. PS: Political Science & Politics, 54(1), 19-23. https://doi.org/10.1017/S1049096520000992

Islam, M. S., Mahmud, R., & Ahmed, B. (2023). Trust in government during COVID-19 pandemic in Bangladesh: An analysis of social media users' perception of misinformation and knowledge about government measures. International Journal of Public Administration, 46(8), 570-586. https://doi.org/10.1080/01900692.2021.2004605

Jenke, L. (2024). Affective polarization and misinformation belief. Political Behavior, 46(2), 825-884. https://doi.org/10.1007/s11109-022-09851-w

Jiang, Y. (2023). The impact of political ideology, knowledge and participation on electoral conspiracy endorsement. Frontiers in Political Science, 5. https://doi.org/10.3389/fpos.2023.1069468

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Jungherr, A., & Rauchfleisch, A. (2024). Negative downstream effects of alarmist disinformation discourse: Evidence from the United States. Political Behavior, 46(4), 2123-2143. https://doi.org/10.1007/s11109-024-09911-3

Kapantai, E., Christopoulou, A., Berberidis, C., & Peristeras, V. (2021). A systematic literature review on disinformation: Toward a unified taxonomical framework. New Media & Society, 23(5), 1301-1326. https://doi.org/10.1177/1461444820959296

Karekwaivanane, G. H. (2019). 'Tapanduka Zvamuchese': Facebook, 'unruly publics', and Zimbabwean politics. Journal of Eastern African Studies, 13(1), 54-71. https://doi.org/10.1080/17531055.2018.1547257

Keller, F. B., Schoch, D., Stier, S., & Yang, J. (2020). Political astroturfing on Twitter: How to coordinate a disinformation campaign. Political Communication, 37(2), 256-280. https://doi.org/10.1080/10584609.2019.1661888

Kermani, H. (2023). #MahsaAmini: Iranian Twitter activism in times of computational propaganda. Social Movement Studies, 1-11. https://doi.org/10.1080/14742837.2023.2180354

Koc-Michalska, K., Lilleker, D. G., Mamonova, M., & Gibson, R. (2023). (Digital) campaigning in dissonant public spheres. Political Communication, 40(3), 255-262. https://doi.org/10.1080/10584609.2023.2173872

Krafft, P. M., & Donovan, J. (2020). Disinformation by design: The use of evidence collages and platform filtering in a media manipulation campaign. Political Communication, 37(2), 194-214. https://doi.org/10.1080/10584609.2019.1686094

Kweon, Y., & Choi, B. (2023). Fueling conspiracy beliefs: Political conservatism and the backlash against COVID-19 containment policies. Governance. https://doi.org/10.1111/gove.12808

Lôbo, E., & Bolzan de Morais, J. L. (2021). New technologies, social media and democracy. Opinión Jurídica, 20(41), 253-274. https://doi.org/10.22395/ojum.v20n41a9

Lombana-Bermúdez, A., Palacios Cruz, G., Valcárcel, J., & López, G. (2021). Echo chambers, disinformation and discrediting campaigns in Colombia. Política y gobierno, 29(1). http://www.politicaygobierno.cide.edu/index.php/pyg/article/view/1494

Maati, A., Orsini, A., Swigart, L., & Rohlinger, D. A. (2023). Information, doubt, and democracy: How digitization spurs democratic decay. Democratization, 1-21. https://doi.org/10.1080/13510347.2023.2234831

Martini, S., Torcal, M., & Orriols, L. (2022). Paranoid styles and innumeracy: Implications of a conspiracy mindset on Europeans' misperceptions about immigrants. Italian Political Science Review, 52(1), 66-82. https://doi.org/10.1017/ipo.2021.26

Massari, O. (2018). Dal partito di massa alla partitocrazia senza partiti. Rivista Nomos Le Attualità Nel Diritto, Antecipazioni convegni, 3, 10. http://www.nomos-leattualitaneldiritto.it/wp-content/uploads/2019/01/Massari-contributo-su-Zangara-3.2018.pdf

Mauk, M., & Grömping, M. (2024). Online disinformation predicts inaccurate beliefs about election fairness among both winners and losers. Comparative Political Studies, 57(6), 965-998. https://doi.org/10.1177/00104140231193008

Ndahinda, F. M., & Mugabe, A. S. (2024). Streaming hate: Exploring the harm of anti-Banyamulenge and anti-Tutsi hate speech on Congolese social media. Journal of Genocide Research, 26(1), 48-72. https://doi.org/10.1080/14623528.2022.2078578

Nguyễn, S., Nguyen, E., Fernández Campbell, A., & Tran, M. (2023). "We never really talked about politics": Race and ethnicity as foundational forces structuring information disorder within the Vietnamese diaspora. Political Communication, 40(4), 415-439. https://doi.org/10.1080/10584609.2023.2201940

Partheymüller, J., Kritzinger, S., & Plescia, C. (2022). Misinformedness about the European Union and the preference to vote to leave or remain. JCMS: Journal of Common Market Studies, 60(5), 1449-1469. https://doi.org/10.1111/jcms.13316

Perl, A., Howlett, M., & Ramesh, M. (2018). Policy-making and truthiness: Can existing policy models cope with politicized evidence and willful ignorance in a "post-fact" world? Policy Sciences, 51(4), 581-600. https://doi.org/10.1007/s11077-018-9334-4

Pickel, G., Pickel, S., & Yendell, A. (2022). Covid-19-related conspiracy myths, beliefs, and democracy-endangering consequences. Politics and Governance, 10(4), 177-191. https://doi.org/10.17645/pag.v10i4.5798

Pinheiro, C., Benazzi, S., Ferrari, B., Esteves, B., & Kugler, H. (2022). Roots of the anti-vaccine movement in Brazil. Questão de Ciência. https://doi.org/10.1590/0037-8682-0592-2021

Ricard, J., Yañez, I., & Hora, L. (2025). A framework for information disorder: Modeling mechanisms and implications based on a systematic literature review. arXiv. https://doi.org/10.48550/arXiv.2504.12537

Serani, D. (2022). The Covid pandemic enters the ballot box: The impact of conspiracy theories on Italians' voting behavior during the COVID-19 crisis. Italian Political Science Review, 53(1), 50-67. https://doi.org/10.1017/ipo.2021.56

Silva, E. C. M. (2023). TelegramScrap: A comprehensive tool for scraping Telegram data. arXiv. https://doi.org/10.48550/arXiv.2412.16786

Stabile, B., Grant, A., Purohit, H., & Harris, K. (2019). Sex, lies, and stereotypes: Gendered implications of fake news for women in politics. Public Integrity, 21(5), 491-502. https://doi.org/10.1080/10999922.2019.1626695

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Vićić, J., & Gartzke, E. (2024). Cyber-enabled influence operations as a 'center of gravity' in cyberconflict: The example of Russian foreign interference in the 2016 US federal election. Journal of Peace Research, 61(1), 10-27. https://doi.org/10.1177/00223433231225814

Willis, D. E., Andersen, J. A., Bryant-Moore, K., Selig, J. P., Long, C. R., Felix, H. C., McElfish, P. A. (2021). COVID-19 vaccine hesitancy: Race/ethnicity, trust, and fear. Clinical and Translational Science, 14(6), 2200-2207.

Yair, O., Cavari, A., & Efrat, A. (2024). Conspiracy thinking and electoral trust during tumultuous times: The case of Israel. International Journal of Public Opinion Research, 36(2). https://doi.org/10.1093/ijpor/edae014

Yendell, A., & Herbert, D. (2022). Religion, conspiracy thinking, and the rejection of democracy: Evidence from the UK. Politics and Governance, 10(4), 229-242. https://doi.org/10.17645/pag.v10i4.5904

Zhao, B., Su, Y., Zhan, J., & Di, Z. (2024). Manufacturing conflict or advocating peace? A study of social bots agenda building in the Twitter discussion of the Russia-Ukraine war. Journal of Information Technology & Politics, 21(2), 176-194. https://doi.org/10.1080/19331681.2023.2189201

Zimmermann, F., & Kohring, M. (2020). Mistrust, disinforming news, and vote choice: A panel survey on the origins and consequences of believing disinformation in the 2017 German parliamentary election. Political Communication, 37(2), 215-237. https://doi.org/10.1080/10584609.2019.1686095

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Social media and deliberation in the period of COVID-19 crisis: transforming political interaction between citizens and Russian authorities in the digital sphere

Daniil Volkovskii [a*], *Olga Filatova* [b]

[a] Université Paris 1 Panthéon-Sorbonne, Paris, France, daniil.volkovskii@etu.univ-paris1.fr, 0000-0002-2674-5794

[b] ITMO University, Saint-Petersburg, Russian Federation, 0000-0001-9568-1002

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Deliberation is a basic term about reaching a decision through balanced discussion, which openly raises the issues of consensus and its achievement through communication. The current article aims at studying the quality of online deliberation between citizens and Russian authorities on social media in the conditions of global health crisis COVID-19. Indeed, the quality of online deliberation between citizens and authorities on public policy issues is traditionally explored in periods of social certainty and mainly in democratic contexts. However, when this problem is considered in times of crisis and out of democratic societies, there is a huge gap in political science. Indeed, studying the quality of deliberation in online sphere becomes more significant and simultaneously complicated in the context of the COVID-19 pandemic. To evaluate the quality of deliberation, we propose a methodology of content analysis based on the theories of democratic deliberation and cumulative deliberation as well. Also, we employ a medium-size case dedicated to discussing state measures of quarantine and self-isolation in the social network VK.com during March-May 2020 in Russia. These conversations were conducted on the state VK.com platform Stopcoronavirus.rf, which is the official information resource of the Russian Government on coronavirus control issues. In total, 5215 comments of both citizens and authorities were analyzed. As a result, the quality of social media deliberation between Russian authorities and citizens is described and assessed in such categories as participatory activity, (ir)rationality, argumentation, constructive politics, interactivity, (in)civility, (dis)agreement and striving for consensus. Generally, the paper contributes to a better understanding the phenomenon of deliberation in non-democratic societies like Russia, going beyond the Western liberal democracies where deliberation is investigated as one of the most important components in the process of making legitimate decisions. Also, our work shows how the digital interaction can be implemented in the conditions of COVID-19 crisis and whether the results of political dialogue between state officials and people on social media can be taken into consideration in the real process of public policymaking in non-democratic societies.

Keywords. Social media, online deliberation, deliberative quality, political interaction, civic engagement, COVID-19, Russia.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.988

1. Introduction

One of the constructive and effective forms of digital interaction between citizens and authorities in democratic societies is online deliberation, which represents a process of public, mutual, purposeful, rational, reasoned, respectful, equal discussion with the predominance of dialogic form of communication and the use of information and communication technologies (ICT), aimed at solving common problems and achieving consensus/cooperation

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

(Volkovskii & Filatova, 2022). Deliberation both between citizens and with authorities on public policy issues can take place on various digital platforms. Recently, the attention of researchers in the field of political communication and e-participation has been focused on social media as spaces where political discussions between citizens and with authorities are actively taking place (Alarabiat, Soares, & Estevez, 2016; Bolgov, Filatova, & Volkovskii, 2024). Research confirms that social media acts as a catalyst for online deliberation (Halpern & Gibbs, 2013), contributes to increasing citizens' involvement in politics (Haro-de-Rosario, Sáez-Martín, & del Carmen Caba-Pérez, 2018), allows to rapidly address current social issues to government structures and involve authorities into communications with different actors of public sphere (Volkovskii, Filatova, Bodrunova, & Bolgov, 2024). To understand how citizens communicate among themselves and with authorities in social media deliberation and how they reach consensus and overcome differences, it is necessary to analyze the quality of deliberation.

The quality of online deliberation between citizens and with authorities on public policy issues is traditionally studied in periods of social certainty (Volkovskii, Filatova, & Bolgov, 2023). However, when this problem is considered in times of crisis (war, terrorism, pandemic), i.e. "a threat that is somehow perceived as existential" (Boin't Hart, & Kuipers, 2018), especially in hybrid and non-democratic countries as China, Singapore, Russia, Belorussia, there is a huge gap in political science. Indeed, studying the quality of deliberation in online sphere becomes more significant and simultaneously complicated in the context of the COVID-19 pandemic. First, the COVID-19 crisis markedly changed the model and content of political communication in general as (1) political leaders, scientific experts became the main figures of communication and key actors in policy responses, while citizens' communications became less considerable for decision-makers; (2) the influence of media increased as they gained more control and power to construct and manipulate the agenda and public opinion; (3) the negative role of social networks associated with dissemination of fake news, myths, conspiracy theories, boosted (Lilleker, Coman, Gregor, & Novelli, 2021). Whereas it is impossible to confirm whether false information was an acute problem or a major result of the raised use of social media, there were, nevertheless, public clashes between political factions, low political trust in government (Lilleker, Coman, Gregor, & Novelli, 2021). Secondly, the COVID-19 pandemic was, definitely, an existential threat that caused a colossal number of human deaths. One of the central roles in leveling the negative impact on people's lives and society's activity was played by the political communication of authorities with citizens, which should have been reduced to the following principle: 'the right message at the right time from the right person can save lives' (Reynolds & Quinn, 2008). Social media allowed the authorities to interact directly and in a deliberative way with people during the COVID-19 pandemic, which could lead to a clearer understanding of the problems people faced and, ultimately, to greater trust in state institutions. In addition to timely and reliable public information spread by government, deliberation between citizens and authorities on social media was also relevant as people could present their problems, propose solutions, and give feedback on certain policy initiatives. Consequently, it becomes highly demanding to study not only the models and methods of political communication between authorities and citizens in times of crisis, but also the quality of deliberation, ways to reach consensus and overcome disagreements. The reason is that they can affect the level of political trust, the quality of digital interaction in general and the resolution of the crisis or the prolongation, aggravation of its impact. Thirdly, some studies on authoritarianism confirm that when citizens face crises that pose a great personal threat, they prefer to trade their democratic rights and freedom for personal security (Altemeyer, 1996; Amat, Arenas, Falcó-Gimeno, & Munoz, 2020). In the face of threat, ruling elites propose certain strategies and implement various methods, including deliberative ones, to restore security and order, which may contribute to the activation and stabilization of authoritarianism (Filsinger & Freitag, 2022). Accordingly, it is important to examine how countries without a long liberal-democratic tradition use deliberation in the digital environment to strengthen the regime, overcome conflicts, and address dissent and the actors expressing it in times of crisis.

Thus, the current article aims at studying the quality of online deliberation between citizens and Russian authorities on social media in the conditions of the COVID-19 crisis. The paper contributes to a better comprehending the phenomenon of deliberation in hybrid/non-democratic regimes, going beyond the Western liberal democracies where deliberation is studied as one of the most considerable components in the process of making a legitimate and balanced decision. Also, our study shows how the digital interaction can be implemented in the conditions of the COVID-19 crisis and whether the results of political dialogue between state officials and people can be taken into consideration in the real process of public policymaking in non-democratic contexts. In order to evaluate the quality of deliberation, we propose a methodology of content analysis based on the theories of democratic deliberation (Habermas, 1996) and cumulative deliberation (Bodrunova, 2021). Deliberation is a basic term about reaching a decision through balanced discussion, which openly raises the issues of consensus and its achievement through communication. S. Bodrunova's concept contradicts J. Habermas's concept only in the way, in which communication participants search for consensus and how public opinion is formed in the online environment: in a cumulative way where participants can express themselves in a free manner without observing the normative principles laid down in the theory of deliberation, or according to the principle of a round table where everyone expresses his/her opinion in compliance with all the principles and rules of deliberation. As a result, we set three dimensions of empirically assessed parameters: (1) participatory (in)equality; (2) (ir)rationality: on/off-topic talk, presence/absence of argumentation, and elements of constructive politics; (3) (non-)dialogicity: interactivity, (in)civility, and (dis)agreement patterns. For this research, we employ a medium-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

size case dedicated to discussing measures of quarantine and self-isolation in the social network VK.com during March-May 2020 in Russia. These conversations were conducted on the state VK.com platform Stopcoronavirus.rf, which is the official information resource of the Russian Government on coronavirus control issues. In total, 5215 comments of both citizens and authorities were analyzed.

Research question: What are the characteristics regarding the quality of deliberation between citizens and Russian authorities on public policy measures on social media in the period of the COVID-19 pandemic?

The remainder of the paper is structured as follows: Section "Theoretical Background" provides a review of theoretical works on online deliberation as a form of e-participation of citizens in politics and usage of social networks in the period of various crises, including both democratic and authoritarian contexts. Section "Empirical Data" describes sampling and its principles, while Section "Methodological Approach" sheds light on the methods. Section "Results" provides the findings according to the RQ. Section "Discussion and Conclusion" summarizes the paper by discussing the results, limitations of research, and future avenues for studies in the field of online deliberation in the conditions of crises.

2. Theoretical Background

2.1 Digital interaction between citizens and authorities via social networks

Overall, there is a wealth of research showing that social networks have led to profound changes in the way people and organizations communicate and share information. A solid overview of research on social media usage by government bodies is presented in the work of N. DePaula and E. Dincelli (2018). It says that early work on social media usage by state authorities saw social networks as "tools for transparency" and "anti-corruption tools" [200], which could be used for "civic co-production" and "mass collaboration" (Linders, 2012; Mossberger, Wu, & Crawford, 2013). The distributed nature of these technologies and their adoption by the general public has shown that social media can be used to disseminate important information about state activities (Bertot, Jaeger, & Grimes, 2010), to maintain a dialogue with citizens (Bonsón, Torres, Royo, & Flores, 2012) and, in general, to enable communication functions that contribute to the public good (Lee & Kwak, 2012). Also, social media are increasingly used in crisis communication (DePaula & Dincelli, 2018), which is more outlined in the section 2.4.

As using social media becomes more popular and necessary among the global population, government agencies are making extensive use of these platforms in their digital activity (DePaula & Dincelli, 2018). Social media have become tools that enable to accomplish the goals of transparency, participation, and collaboration, despite the problems correlating with rise of disinformation on social media, "echo chambers," proliferation of 'algorithmic control', etc. In academic literature, unjustifiably little attention has been paid to the multifaceted nature of state communication and research on how the interaction between government and society takes place in social networks. It happens due to the fact that governments serve more as disseminators of information and are highly regulated bodies, and their approach to social media is determined by political guidelines. However, there are still some studies arguing that social media are not only tools for democratic transparency and citizen participation, but also tools for self-presentation, exchange of symbolic gestures and marketing of products and services. Therefore, most of governments uses social media for symbolic and presentational purposes. The articles by N. DePaul and E. Dincelli (2018) discuss the nature of social media interaction in a governmental context. Considering the recent literature on affective nature of social media and affective nature of politics more broadly, the authors find that reactions on social media are skewed towards affective and symbolic content and, thus, potentially unsuitable for deliberative or rationalized discussions and interactions. However, some research indicate that social media may become a potential platform for deliberative interaction between citizens and government bodies (Nigmatullina, Bodrunova, Rodossky, & Nepiyushchikh, 2023; Volkovskii, Filatova, Bodrunova, & Bolgov, 2024), although there are many factors influencing the quality of deliberation.

.2.2 Deliberation between citizens and authorities in a (non-)democratic context

The concept of deliberation is about equality and avoidance of domination in expressing and sharing individual preferences (Gastil, Black, & Lawra, 2008; Jonga, 2012). It also comprises (1) transparency and accessibility of information flow that may help participants of deliberative process learn and better comprehend a situation and each other (Nabatchi, 2010); (2) adequacy and reliability of information presented in the forms of statistics, surveys, objective measurements that go beyond individual biases (Habermas, 1984). Hence, such characteristics of information and its types can make a discussion more effective for the process of making decisions (Gouran & Hirokawa, 1996). The inclusiveness and responsiveness are key conditions as they allow citizens to perform as both the authors and addressees of certain solutions or proposals. Interestingly, inclusion and mutual respect, on the one hand, are outcomes of deliberation and, on the other one, prerequisites for it (Beauvais, 2020). The core values of deliberation, according to Habermas, are communicative rationality and legitimacy (Habermas, 1984).

Many theorists and empirical researchers have recently joined the thought of aggregation of preferences and processes by which preferences and broader values that shape them are formed in public deliberation (Shapiro,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2003). It seems extremely necessary to highlight the relevance and benefits of deliberation for citizenry, society and government as well. Thanks to deliberating, community's social capital increases, since more people consider deliberation as a civic activity (Fishkin, 1995), constitutional order legitimacy explicitly grows as people have an opportunity to express their views and understand that order by exchanging their opinions (Chambers, 1996; Gutmann & Thompson, 1996), public actions and decisions made both individually and collectively have a greater supporting for responsive government representatives (Gastil, 2000). As a result, citizens become more enlightened about their own and others' needs and experiences, can better resolve deep conflicts and be more involved in political participation, which can be implemented digitally via social media.

Nowadays, enormous amount of research is concentrated on investigating online deliberation and its different aspects as design, technical affordances, results, process, effects. Our recent literature review on online deliberation allowed us to detect a few directions that certainly should be developed in the future (Volkovskii, Filatova, & Bolgov, 2023). The first one correlated with exploring online deliberation and its quality in the conditions various crises (pandemic, war, natural or technogenic catastrophes, ecological crisis). The second venue was about understanding what online deliberation represents and what negative effects it may have on citizens and civic engagement. Indeed, there is a tone of definitions, and the majority of researchers concentrates on studying good sides of online deliberation, while negative consequences are remaining unexplored enough. The third direction touched citizens' motivation and intentions to participate in online deliberation, tools and benefits proposed by government agencies to increase a level of civic engagement. One more direction can be correlated with studying the quality of online deliberation between citizens and government bodies towards valuable socio-political questions in non-democratic countries or hybrid regimes. As for Russia, there are some empirical works indicating on involvement of authorities into deliberation with citizens on social media (Nigmatullina, Bodrunova, Rodossky, & Nepiyushchikh, 2023; Volkovskii, Filatova, Bodrunova, & Bolgov, 2024). Some recent empirical results about authorities' responses to citizens' complaints or opposing positions towards the state in deliberative process reveal that a mechanical and bureaucratic way of communicating with citizens in comment sections significantly reduces the quality of deliberating as well as the level of civic trust towards government agencies and citizens' motivation to discuss particular problems and solutions with state authorities on social media (Enikeeva, Kulnazarova, Rafikov, & Shutman, 2023). Although some Russian studies show that discussions between citizens and authorities on the social media's state pages are more reasoned and polite compared to discussions on unofficial Internet forums or on the social media pages of Russian mass media (Filatova & Volkovskii, 2021; Volkovskii & Filatova, 2020, 2021, 2022; Volkovskii, Filatova, & Bolgov, 2022), it is not enough to understand the phenomenon of digital deliberation in a non-democratic context. In order to know what deliberation represents in countries without a long liberal-democratic tradition and why it is employed by authorities there, it is necessary to refer to the concept of authoritarian deliberation broadly elaborated in the Chinese political science.

Deliberative democracy theorists believe that deliberation is incompatible with authoritarian regimes because of imbalance in the distribution of power between civil society and ruling elites in governance and decision-making (He & Warren, 2011), but deliberation exists not only in democratic societies. This idea is reflected in the concept of deliberative authoritarianism, which presents a combination of deliberation and the permanence of power concentration (He & Warren, 2011). Thus, Baogang He introduced the term of authoritarian deliberation, referring to the Chinese political context as Chinese public discourse in decision-making is dominated by non-competitively elected leaders (He, 2006). Accordingly, the boundaries of political discourse are set by the state party, but this discourse is of deliberative nature, since citizens can collectively discuss problems, argue their positions, and propose solutions. Through deliberative practices, the government collects information about public discontent and political sentiment and uses it to build institutions for control and effective governance (Nathan, 2003). The combination of authoritarian governance and deliberative mechanisms has been studied and explored in detail in China where deliberation functions as an information resource through which authorities shape public policy and gain support from those they target, while having a monopoly on decision-making. In authoritarian regimes, it is the political elites that establish the subject and space for deliberative process. In China, for example, elites control discursive spheres and agendas, limiting public deliberation to pre-selected governance issues and avoiding non-approved venues and topics that could delegitimize the regime. In such a context, citizens have limited powers in specific areas of governance, ranging from negative powers of protest and obstruction to positive powers of some kinds of voice (in organized deliberative forums) (He & Warren, 2017). For the regime, too, this has consequences, namely there is a weakening of the autocrat's control over political discourse, but in exchange for other priorities – its own stability and survival.

Why might the development of deliberative interaction between citizens and with authorities be encouraged in authoritarian regimes? First, deliberation can co-opt political dissent and maintain social order. Second, deliberation can produce information about society and politics, allowing autocrats to avoid lapses in governance. Given the rapid development and innovation of the electronic sphere, authoritarian methods may become obsolete and conflict with the information resources needed for governance (He & Warren, 2017). Therefore, in this regard, more attention is paid to social networks that may function both as a catalyst for online deliberation and political disagreement (Volkovskii, Filatova, Bodrunova, & Bolgov, 2024). Thus, social media can be intensively utilized by authorities to monitor citizens' discontent and eliminate their dissents with government and its politics through

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

different methods, including online deliberation. Third, public deliberative practices promote transparency, thereby protecting the bureaucratic sector from allegations of malfeasance or corruption. Officials can learn to use the transparency and inclusiveness in decision-making that deliberation affords them to avoid or, at least, refute claims against them when decisions are unpopular with the public and address the needs of elites rather than citizens (He & Warren, 2017). Fourth, the deliberative process implies collective responsibility when it comes to losses and managerial lapses. Thus, by shifting the responsibility for its political failure to other actors (citizens or oppositional forces), the leadership can avoid being blamed by population. Deliberation acts as a political cover for actors making decisions. Based on the mentioned theses, we can conclude that deliberation can generate such a politically important resource for hybrid or authoritarian regimes as legitimacy, allowing autocrats to cleverly avoid conflicts and formation of protest moods in society. These conclusions may refer to the Russian context as well explaining why and how deliberation on social media can be used, but more empirical research is required.

2.3 Deliberation and social media in the context of the COVID-19 crisis

Social media are increasingly being used by authorities and health experts to disseminate health information to the public (Gough et al., 2017), especially during various health crises (Graham, Elizabeth, & Sejin, 2015). Given the speed at which information can be communicated to wide audiences, social media are particularly useful for rapid dissemination of data updates and warnings during crises (Eriksson & Olsson, 2016). Previous research on use of social media by authorities to raise public awareness of epidemics has been conducted in the context of the Zika fever outbreak (Vijaykumar, Meurzec, Jayasundar, Pagliari, & Fernandopulle, 2017), Ebola hemorrhagic fever (Strekalova, 2017), and the H1N1 swine flu pandemic (Liu & Kim, 2011). The COVID-19 pandemic was a major public health concern for policymakers and citizens around the world. Thus, the usage of social media by state officials reached unprecedented levels during the COVID-19 pandemic to maintain trust in scientific expertise (van Dijck & Alinejad, 2020). Although there is still insufficient knowledge about the extent to which the public trusts health experts and authorities, it is hypothesized that government communication during crises is most effective when it contains and broadcasts scientific and technical information (Herovic, Sellnow, & Sellnow, 2020). Social media platforms played a significant role in government communication with citizens as the pandemic led to a narrowing of the topical agenda on these platforms (Rauchfleisch, Vogler, & Eisenegger, 2021).

Social media generated a space for citizens, communities to interact and actively participate in sharing and refining relevant messages (Hyland-Wood, Gardner, Leask, & Ecker, 2021). Social media allowed public bodies to interact with people in a direct and deliberative way, which could lead to a clearer understanding of the issues people were facing and, ultimately, increased trust in government institutions. Rational and high-quality deliberation was essential for governments and administrations to effectively and legitimately address the extreme challenges posed by the COVID-19 crisis (Lavazza & Farina, 2020; Parry, Asenbaum, & Ercan, 2020). The policies, proposed by governments in response to the global health crisis, were based on assumptions about public opinion and constraints to which people must conform (Sibony, 2020). Although the COVID-19 pandemic increased reliance on scientific and technical expertise in problem solving and policymaking, such expertise could not resolve the moral and political dimensions of policymaking (Elstub et al., 2021). This could be done in a deliberative way (Brown, 2014). As citizens demanded quick action and decision making from authorities, the pandemic posed several challenges for online deliberation (Elstub et al., 2021): (1) whether digital environment was suitable for online deliberation or not; (2) predominance of emotional aspect over rational one; (3) growing incivility vs decreasing civility and tolerance between deliberators. Considering these challenges, it becomes clearer that reaching consensus in such conditions was more than ever a harsh task.

3. Empirical Data

3.1 The description of chosen case and period

On March 29, 2020, the Government of Moscow introduced a self-isolation regime due to the threat of rapid spread of coronavirus. By March 31, the authorities of 67 subjects of the Russian Federation decided to introduce a self-isolation regime for all residents on the territory of the regions. Self-isolation was defined as a strict recommendation to every Russian not to leave home for no particular reason, while emergency and quarantine regimes were not introduced. Air travel with other countries, including land checkpoints, was completely closed, except for flights to take people out. On April 15, e-passes for travel within a city were introduced in Moscow and in Moscow region: 1) working pass (issued once for the entire duration of restrictions), 2) for travel to medical institutions (one pass for each trip without restrictions), 3) one-time pass (for personal travel for one day not more than twice a week). However, on the very first day of the passes' validity, colossal queues were formed at the entrance to the subway, those standing in them did not observe any social distance, which caused mass dissatisfaction of Moscow citizens with the measures taken. On the other hand, all the above-mentioned measures made it possible to reduce the rate of spread of the virus and to prepare for the treatment of a large number of sick people. During the period of self-isolation, an overwhelming number of medical facilities throughout the country were adapted to treat patients with the infection, and doctors were retrained. Russia's closed-door schedule was extended until May 11 and lifted on May 12. In terms of the strength and severity of the COVID-19 crisis, it was one of the most severe phases of the crisis for Russian society as it was characterized by the most radical and high-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

profile measures to combat the epidemic in Russia.

Social networks and the Internet became the main platforms where many people could publicly express their opinions and arguments, spreading them to a mass audience, familiarize themselves with various positions, including those different from the official one, and find both like-minded and opposing supporters. Many COVID-19 dissidents appeared who did not believe in the existence of COVID-19 and tried to convince the public otherwise, spreading myths and conspiracy theories, claiming that the crisis was created in the interests of WHO, billionaires and large pharmaceutical companies. In parallel, a group of COVID-19 alarmists emerged. They, on the contrary, declared all actions of the Russian authorities insufficient, incompetent and demanded a "Chinese version" with a complete ban on leaving the house for everyone and stopping of public transportation. Incivility and dissent existed not only in the online sphere, but also in public places, as cases of violence were recorded both against those who refused to wear a mask and those who demanded that others observe the measures.

3.2 The description of selected platform and discussions

Due to the problem of spreading fakes in mid-March 2020, the State Center for informing citizens about the situation with COVID-19 in Russia offered an official online resource for the public on the coronavirus pandemic (Stopcoronavirus.rf). In our work, we selected VK.com social network as it is more popular among Russians and more employed by Russian authorities than other networks. The platform Stopcoronavirus.rf in the social network VK.com was founded on March 16, 2020 by the Russian Government to inform citizens about coronavirus situation in Russia and measures proposed by authorities and experts to combat it. This group became the most popular government platform on COVID-19 in VK.com since the crisis began. Its number of subscribers amounted to about 502 thousand users from different regions of Russia and other countries. Since its founding, government bodies published posts about the coronavirus, offering citizens open access to commenting, so that people could communicate with Russian authorities online throughout all the period of COVID-19. The first post about COVID-19 in the community was published on March 16, 2020.

Online conversations were selected for empirical analysis based on the following factors: (1) they were conducted on a state platforms in VK.com between March 30, 2020 and May 11, 2021; (2) they dealt with COVID-19 pandemic issues, including regulatory measures; (3) open access to commenting on posts by both citizens and authorities; (4) the presence of responses (feedback) from Russian authorities to citizens' comments in online discussions; (5) the presence of at least one expression of dissent from citizens or authorities; (6) the number of comments in one discussion was at least 100 as they were automatically gathered . Totally, 5215 comments collected via programme software were manually analysed by two coders to determine the quality of online deliberation in this period.

It is worth noting that the community prescribed the rules of citizens' communication in the group, non-compliance with which was sanctioned by deleting the comment or blocking the user for repeated violations. In turn, moderation and proposed rules influenced the results of the deliberative analysis: mainly on such parameters as uncivil communication in relation to citizens and authorities, citizens' disagreement with state measures and authorities in general.

4. Methodological Approach

The study employs several approaches to assess the deliberative quality of online discussions. First, the Discourse Quality Index, widely used in modern deliberative research, which includes such criteria as participation, level of argumentation, argumentation content, respect, counterarguments, and constructive politics (Steenbergen, Bächtiger, Spörndli, et al., 2003). Second, an analytical approach to assessing discourse quality created by Yu. G. Misnikov (2011) who described seven thematically different discursive parameters to guide the coding of online discussion posts: participatory equality, argumentation, communication culture, assertion efficacy, interactivity, dialogicity, and thematic diversity. Thirdly, the concept of cumulative deliberation proposed by Russian professor S. Bodrunova (2021). This conceptual framework points to several non-deliberative features of user communication such as irrationality, simultaneity (and lack of order), non-dialogicity, potential inequality, permissible emotionality and even uncivil (within the law) speech, and non-consensual goal setting. Besides mentioned discourse analysis approaches, J. Stromer-Galley's approach is used to analyse agreement, disagreement and their types in the categories of argumentation and (in)civility (2007, 2009, 2015). These methodological approaches are combined to comprehensively assess the quality of deliberation. As a result, three dimensions are identified: 1) (non-)equal participation; 2) (ir)rationality: discourse on/off-topic; presence/absence and type of argumentation; elements of constructive politics; 3) (non-)dialogicity: interactivity; (in)civility and (dis)agreement.

(Un)equal participation. This parameter contains several coding categories describing the number of comments left by participants in a discussion thread. These were formulated based on the experience of previous studies (Filatova & Volkovskii, 2020, 2021): inactive (1 post), moderately active (2-3), active (4-5), very active (6-9) and hyperactive (10 or more).

(Ir)rationality. On/off-topic comments reflex whether communicators follow the topic determined in the beginning of talk or prefer discussing other themes out of the main one. The category of argumentation is borrowed from the work of Fischer and co-authors (2021), where several types of arguments were described and empirically

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

applied (see Table 1). This approach fits well with this work because it allows to establish an explicit difference in the types of arguments offered by the government corpus and ordinary citizens (inductive, deductive, casual, analogical reasoning, expressing uncertainty, questioning).

Table 1. Argumentation and its categories proposed by Fischer and his colleagues (2021)

Category	Description
Inductive	Personal examples, experiences, stories, and hypothetical examples can be used to inductively make a point
Deductive	Evoking expertise, statistics, or authoritative texts from one side, often to challenge the reasoning of another side
Casual	The reasoning is not always sound in the 'if/then' relationships in causal arguments: many participants may rely on a correlational relationship, not an actual cause-effect relationship. Correlational relationships imply an association, but with multiple potential causes
Analogy	Analogies compare two targets towards one context
Expressing uncertainty	The expression of uncertainty is a central source of pressure for participants undecided on the measure. Expressing uncertainty means that the reasoning is unauthoritative in nature as the group came to a decision
Question	A common communicative tactic participants use to express reasoning. Questions about evidence allow participants to add their opinion to the discourse in a nonthreatening, though sometimes confrontational, way

The measurement of constructive politics is of high relevance as it gives an opportunity to discover who constructs the political discourse and who proposes constructive solutions to tackle the issues and build consensus. The authors of DQI (2003) capture three codes which are also implemented in our research: (1) positional politics which means no compromise or consensus building between speakers who strongly belong to their own positions; (2) alternative proposal which does not cover the current agenda but fits another one; (3) mediating proposal that fits the current agenda.

(Non-)dialogicity. Interactivity means an interaction between users, which can be marked by two indicators (Filatova & Volkovskii, 2020): 1) mentioning one participant by another in a conversation (either by name or a link to a comment), 2) without mentioning the name of individual, but only by reference to the comment. The category of (in)civility is adopted from works of Misnikov as it has been successfully tested in our several recent works (Volkovskii & Bodrunova, 2023; Volkovskii & Filatova, 2023). The characteristics are distributed in two categories as we analyze comments of both government and citizenry. If we consider DQI (2003), there is a category of respect that can be similar to term of civility. However, there are three general codes (no respect; implicit respect; explicit respect) that make analysis of communication culture very narrow and unpresentable.

The categories close to constructive politics are agreement and disagreement. The works by Stromer-Galley (2007, 2009) proposed a systematic way to measure what happens during discussions. The article presented a simple procedure for coding and analyzing agreement and disagreement. Agreement was understood as a signal of support with something said by a previous speaker. Agreement includes a comment containing explicit or implicit agreement with the statements of other users. Disagreement is understood as a statement that signals a contradiction with something said by a previous speaker, including a moderator. Messages are encoded as disagreement when they (1) diverge from general tone of discussion (considering a previous message in topic as a basic one), which indicates a heterogeneity in the topic; (2) clearly diverge from another commentator in the form of a name tag or response. Therefore, disagreement is encoded if at least one of two conditions is seen.

The methodology may contain the following components of analysis of agreement and disagreement, which are presented below:

(1) analyzing the presence and absence of agreement and disagreement, their frequency;

(2) the actor who expresses agreement or disagreement (citizens, authorities);

(3) the subject/object towards which agreement or disagreement is expressed (person, authority, policy measure);

(4) analyzing a type of disagreement in terms of two categories:

- argumentation (justified or unjustified);
- communication culture (civil (soft and bold) or uncivil).

Also, we distinguish different categories of agreement and disagreement based on components 2 and 3:

(1) (dis)agreement of citizens with citizens;

(2) (dis)agreement of citizens with authorities;

(3) (dis)agreement of citizens with policy measures;

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

(4) (dis)agreement of citizens with a topic of post and information;

(5) abstract disagreement of citizens (with citizens, authorities, world, etc.).

(6) (dis)agreement of authorities with citizens.

5. Results

(Un)equal participation. Analyzing participation of Russian authorities in communication with citizens, a colossally low number of comments was recorded (16 out of 5215, which was 0.31%). At the same time, a number of citizens' comments deleted by community moderators without explaining a specific reason (1.5%) was higher than a number of comments left by authorities. In turn, these comments could contain elements of disrespectful attitude towards authorities and disagreements about self-isolation and quarantine regime. This result indicates that Russian authorities preferred to solve problems in a non-deliberative way, removing user comments that could undermine the image of the authorities. It can be a trait of authoritarian deliberative practice.

(Ir)rationality. Overall, there was a low rate in the parameter of comments on topic, which was only 25.1%. However, not only the percentage of comments on topic was low, but also the overall level of arguments in discussions, which amounted to 9.11% (see Table 2). At the same time, arguments were predominantly made by citizens rather than by state officials. Thus, 9.03% was left by citizens, of which mostly were arguments of inductive character, i.e. personal examples, situations from life, reflections (6.44%). After inductive arguments, deductive arguments were used, i.e. references to statistics, normative-legal documents, studies of scientists, media and expert interviews (0.91%). The authorities used only deductive argumentation in their answers to citizens' comments (0.08%). The use of other types of argumentation was not recorded.

Table 2. Argumentation expressed by citizens and Russian authorities in online discussions (%)

Category	%	Types of arguments					
		Inductive	Deductive	Causal	Analogical	Expressing uncertainty	Questioning
General figures	9,11	6,44	1	0,59	0,58	0,19	0,31
Government's argumentation	0,08	0	0,08	0	0	0	0
Citizens' argumentation	9,03	6,44	0,92	0,59	0,58	0,19	0,31

As for constructive politics, Russian authorities preferred to keep silent and did not give practically any suggestions for solving problematic situations (0.04%), while, in comparison with authorities, citizens were very active in policy construction (3.22%) (see Table 3). The mediated suggestions that received the most from citizens were the ones that addressed the problems related to self-isolation and quarantine (1.78%). The number of alternative proposals that did not address the main topic of discussion was 1.44%. Only mediated proposals were recorded from authorities.

Table 3. Constructive politics in online discussions between citizens and Russian authorities (%)

Category	Types of constructive politics	
	Alternative politics	Mediating politics
General figures	1,44	1,82
Government	0	0,04
Citizenry	1,44	1,78

(Non-)dialogicity. The overall level of interactivity was quite high and amounted to 74.86%. However, the level of civility was not as high as the level of interaction of participants. The level of civility was only 0.21% and only towards other citizens (see Table 4). At the same time, the general level of uncivil attitude in the discussions was higher than the civil one. The rudest statements and insults from citizens (2.12%) were recorded in relation to other people (1.02%), then to the Russian authorities (0.33%), then in relation to the measures taken (0.1%) (see Table 4). In addition, citizens spoke negatively about other issues that could concern those who came from abroad and brought the infection (0.67%). It is important to note that this intolerant communication was abstract and indirectly addressed as this category of citizens was not present in the discussions. The authorities responded to citizens' comments in a neutral tone. In general, taking into account our previous research (Volkovskii & Bodrunova, 2023; Volkovskii & Filatova, 2023), rather low levels of disrespectful communication of citizens were recorded on the platform, since the rules of communication were prescribed in the community, comments were moderated by administrators, and the open presence of bots and trolls was not detected by citizens. This result indicates that moderation and rules of communication matter and may influence a deliberative process.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Table 4. Civility and incivility in online discussions between citizens and Russian authorities (%)

Category	%	Types			
		Towards topic	Towards citizens	Towards authorities	Towards other issues
General figures for civility	0,21	0	0,21	0	0
Civil tone of government	0	0	0	0	0
Civil tone of citizens	0,21	0	0,21	0	0
General figures for incivility	2,12	0,2	1,03	0,33	0,67
Uncivil tone of government	0	0	0	0	0
Uncivil tone of citizens	2,12	0,1	1,02	0,33	0,67

Regarding agreement and disagreement, the overall level of agreement (2.64%) was higher than the level of disagreement (0.36%) in the discussions (see Table 5). Most of the citizens agreed with each other (2.49%), while some agreed with the measures taken by government (0.15%). Agreement of citizens with authorities was not detected, whereas agreement of authorities with citizens was observed. It may reveal that authorities tried to raise their level of legitimacy and citizens' trust by confirming the views and arguments of people. As for disagreement, citizens mostly disagreed with each other (0.21%), while the level of citizens' disagreement with measures was the same as the level of other citizens' agreement with measures (0.15%). This may indicate that there were different views on these measures in society, but we cannot know the authentic indicators as they may be distorted. It was already mentioned earlier that Russian authorities deleted 78 comments from 5215 citizens, although these comments could have disagreements of citizens with other citizens, policy or authorities, which, in turn, could affect the interpretation of results. There was no direct disagreement between citizens and authorities, as well as no open disagreement between authorities and citizens. As for types of disagreement expressed by citizens, we detected a common communication pattern: unjustified, neutral/civil, bold disagreement (see Table 6).

Table 5. Agreement and disagreement in online discussions between citizens and Russian authorities (%)

Category of agreement	(%)	Category of disagreement	(%)
Agreement of citizens with measures	0,15	Disagreement of citizens with measures	0,15
Agreement of citizens with authorities	0	Disagreement of citizens with authorities	0
Agreement of citizens with citizens	**2,49**	Disagreement of citizens with citizens	**0,21**
Agreement of authorities with citizens	0,04	Disagreement of authorities with citizens	0
General figures	**2,64**	General figures	**0,36**

Table 6. Type of disagreement in online discussions between citizens and Russian authorities (%)

Type of disagreement	(%)
Justified	0,12
Unjustified	**0,25**
Neutral/civil	**0,35**
Uncivil	0,02
Soft	0,06
Bold	**0,29**

5. Discussion and Conclusion

The results of current analysis showed that during one of the most acute phases of the COVID-19 crisis, Russian authorities preferred to delete citizens' comments by implementing automatic moderation rather than responding to them. In other words, the priority was given to a non-deliberative strategy that may be close to censorship measures rather than a deliberative approach, which may indicate a tendency towards authoritarian practices of control over public sphere and deliberative process rather than a democratic one. This is a curious observation that motivates to continue conducting studies on ways, in which Russian authorities control deliberative process and public sphere in the digital environment, especially in social networks where they communicate directly with citizens. If we consider the problem in a global context, it is important to understand what practices of authoritarian control are used by non-democratic regimes in the online milieu and how they affect construction of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the digital public sphere both in times of crisis and social stability. Research in this area is mainly presented in Chinese political science where the concepts of authoritarian deliberation, consultative authoritarianism and deliberative authoritarianism are studied in detail (He, 2014; He & Warren, 2011, 2017). As for Russian research, there is still no empirical evidence based on the concept of authoritarian deliberation. Our study tries to analyze the modern deliberative process in Russia through prism of this concept, however, more theoretical review and empirical results are necessary to confirm the authoritarian character of deliberation in Russia.

Summarizing our results, we can see that the quality of online deliberation on the Stopcoronavirus.rf platform was clearly low: a low percentage of comments on topic, a low percentage of argumentation, a low percentage of civility, a high percentage of incivility, and a low percentage of striving for consensus. This outcome is confirmed by our previous studies on the quality of deliberation in social networks (Filatova & Volkovskii, 2021; Volkovskii & Filatova, 2021, 2022; Volkovskii, Filatova, & Bolgov, 2022), as well as by literature that we used in the theoretical part (Elstub et al., 2021). Indeed, the levels of rationality, argumentation, and polite communication are falling, while the levels of intolerance and irrationality are rising. However, the issue of growing disagreements between citizens and authorities during the crisis remains controversial as our research has not detected this. We can assume that the political context influences the degree and form of disagreement expressed by citizens regarding authorities and their policies. To better understand this issue, it is worth referring to the concept of authoritarian publics proposed by F. Toepfl (2020), who distingushes three types of publics: uncritical publics, policy-critical publics, leadership-critical publics. One of his studies, which deals with exploring authoritarian public sphere in various undemocratic countries, reveals what types of publics exist (Toepfl & Litvinenko, 2021). In Russia, all three types of publics are present, but uncritical public prevails over two others. In contrast, in China, two types of publics are identified (uncrticical and policy-critical), while, in North Korea, only one type of public is determined (uncritical). Based on these data, it is possible to assume that, after all, the crisis has a lesser effect on the level of political disagreement in society than the political context, in which this society finds itself. On the one hand, our results can facilitate the development of Toepfl's concept as we determine different types of disagreement and, accordingly, various types of critisizing publics showing the ways how disagreement can be publicly expressed and worked by state officials. On the other hand, this encourages us to conduct research involving various cultural and political contexts.

There is a significant question raised by our research: is online deliberation with Russian authorities real or is it an imitation of deliberation controlled by the authorities to monitor public opinion? The answer is ambigious as it depends on a theoretical context, through which we get the asnwer. From positions of democratic deliberation and deliberative democracy, the deliberative process on the platform of the Russian Government in the social network VK.com can be described as symbolic, that is, online deliberation is imitative in nature and is aimed at fulfilling the tasks and testimony required by the authorities, not citizens, although deliberation is a citizen–oriented process (Abdullah & Rahman, 2015). In our empirical analysis, the imitation nature of deliberation was indicated by the parameter of constructive policy: citizens offered more solutions, both alternative and mediated, and also sought consensus more actively than Russian authorities. Online discussions did not capture the true desire of authorities to solve the problems of Russian population as communication of Russian authorities was aimed at calming and distracting citizens. It is obvious that the proposals of citizens regarding self-isolation and quarantine measures were not taken into account by Russian authorities when developing the policy. However, from positions of authoritarian deliberation and deliberative authoritarianism explaining the objectives that can be accomplished by authorities thanks to deliberation, we cannot indicate on symbolism of deliberative practice as it potentially may satisfy the goals Russian authorities may pursue: cooptation of people expressing disagreement or elimination of public complaints, stabilizing the regime and legitimazing the public policy in the period of the COVID-19 crisis. Definitely, more research has to be conducted in order to continue this discussion.

As for limitations of our research, we can list a few of them. First, we take one country case, although the practice of deliberation exists in other countries, both authoritarian and democratic ones. Secondly, the discussions in only one Russian social network VK.com are analyzed, although deliberative process took place in other Russian social networks (Odnoklassniki) and messengers (Telegram). In this regard, it is hard to generalize the data obtained and formulate the general theoretical principles, which could be used in subsequent studies. Nevertheless, in our opinion, this study has an important applied sense for Russian political science and for the field of deliberative studies in a global context, especially in times of authoritarian renaissance. Thirdly, the number of platforms could be expanded to understand which authorities communicated with citizens and how. Fourth, research methodology. The number of parameters for analyzing the deliberative quality of discussions can be expanded, and their characteristics can be detailed. The data analysis was carried out manually, although it can be automated and performed by a computer program or with the help of artificial intelligence in the future. Research in this area is already underway by scientists (Shin & Rask, 2021), including our efforts (Filatova, Volkovskii, & Begen, 2020). This will speed up the process of data collection and analysis, letting avoid human errors and false interpretations.

Acknowledgement

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **Funding or Grant:** The research was supported by the Russian Science Foundation and St. Petersburg Science Foundation Grant No. 23-18-20079 "The Social Efficacy of Electronic Interaction between Citizens and the Government: The Case of Urban Digital Services in St. Petersburg".
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

1. Abdullah, N.N. & Rahman, M.F.A. (2015). The Use of Deliberative Democracy in Public Policy Making Process. Public Policy and Administration Research, 5(3), 221–229.
2. Alarabiat, A., Soares, D.S., & Estevez, E. (2016) Electronic participation with a special reference to social media-a literature review.Electronic Participation: 8th IFIP WG 8.5 International Conference, EPart 2016, Guimarães, Portugal, September 5-8. Proceedings, 41-52.
3. Altemeyer, B. (1996). Authoritarian specter. Cambridge, Mass: Harvard University Press.
4. Amat, F., Arenas, A., Falcó-Gimeno, A., & Munoz, J. (2020). Pandemics meet democracy: Experimental evidence from the COVID-19 crisis in Spain.
5. Beauvais, E. (2020). Deliberation and Non-Deliberative Communication. Journal of Deliberative Democracy, 16(1), 4–13.
6. Bertot, J.C., Jaeger, P.T., & Grimes, J.M. (2010). Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies. Government Information Quarterly, Vol. 27 (3), 264-271.
7. Bodrunova, S. S. (2021). Practices of cumulative deliberation: A meta-review of the recent research findings. In A. V. Chugunov, M. Janssen, I. Khodachek, Y. Misnikov, & D. Trutnev (Eds.), Proceedings of electronic governance and open society: Challenges in Eurasia (EGOSE'2021). Communications in computer and information science (Vol. 1529, pp. 89–104). Springer.
8. Boin, A., 't Hart, P., & Kuipers, S. (2018). The crisis approach / H. Rodriguez, E. Quarantelli, & R. Dynes (Eds.). Handbook of disaster research. New York: Springer, 24.
9. Bolgov, R., Filatova, O., & Volkovskii, D. (2024). E-Participation as a Research Domain: Analysis of Publication Patterns and Current Tendencies. In.: Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance (ICEGOV '24). Association for Computing Machinery, New York, NY, USA, 158–165.
10. Bonsón, E., Torres, L., Royo, S., & Flores, F. (2012). Local E-Government 2.0: Social Media and Corporate Transparency in Municipalities, Sector Público, Spain.
11. Brown, M. (2014). Expertise and Deliberative Democracy. In Deliberative Democracy: Issues and Cases, edited by S. Elstub, and P. Mclaverty. Edinburgh: Edinburgh University Press.
12. Chambers, S. (1996). Reasonable Democracy. Ithaca, NY: Cornell Univ. Press.
13. DePaula, N., & Dincelli, E. (2018). Information strategies and affective reactions: How citizens interact with government social media content. First Monday, 23(4).
14. Elstub, S., et al. (2021). The Resilience of Pandemic Digital Deliberation: An Analysis of Online Synchronous Forums. Javnost - The Public, 28:3, 237– 255.
15. Enikeeva, E.M, Kulnazarova, A.V., Rafikov, A.I., & Shutman, D.V. (2023). The Impact of Digital Tools on Conflictive Communications in the "Government-Society System": St. Petersburg Experience. In Communication Strategies in Digital Society Seminar, Saint Petersburg, Russian Federation, 147-150.
16. Eriksson, M., & Olsson, E.K. (2016). Facebook and Twitter in crisis communication: A comparative study of crisis communication professionals and citizens. Journal of contingencies and crisis management, 24 (4), 198–208.
17. Filatova, O., Volkovskii, D., & Begen P. (2020). Usage of Artificial Intelligence in Internet Discourse Analysis: from Manual Mechanisms of Data Processing to Electronic Ones. In.: Proceedings of the 22nd Conference on Scientific Services & Internet (SSI-2020) Novorossiysk-Abrau (online), Russia, September 21-25, 352-360.
18. Filatova, O. & Volkovskii, D. (2021). Key Parameters of Internet Discussions: Testing the Methodology of Discourse Analysis. In.: Chugunov, A.V. et.al (ed.) Digital Transformation and Global Society (DTGS 2020). Proceedings of the 5th International Conference, St. Petersburg, Russia, 32-46.
19. Filatova, O. & Volkovskii, D. (2020). The online discourse as a form of e-Participation: the experience of internet discourse research. In.: Proceedings of the 13 the International Conference on Theory and Practice of Electronic Governance (ICEGOV 2020). Athens, Greece, 326-333.
20. Filsinger, M. & Freitag, M. (2022). Pandemic threat and authoritarian attitudes in Europe: An empirical analysis of the exposure to COVID-19. Eur Union Polit, 23(3), 417–36.
21. Fischer, K. et al. (2021). A Typology of Reasoning in Deliberative Processes: A Study of the 2010 Oregon Citizens' Initiative Review. Journal of Deliberative Democracy, 18(2), 1-13.
22. Fishkin, J. (1995). The Voice of the People. New Haven, CT: Yale Univ. Press.
23. Gastil, J., Black, & Lawra, W. (2008). Public deliberation as the organizing principle of political communication research. Journal of Public Deliberation, 4 (1).
24. Gastil, J. (2000). By Popular Demand. Berkeley: Univ. Calif. Press, 20-25.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

25. Gough, A., Hunter, R.F., Ajao, O., Jurek, A., McKeown, G., Hong. J., et al. (2017). Tweet for behavior change: Using social media for the dissemination of public health messages. JMIR Public Health Surveill, 3(1).
26. Gouran, D.S., & Hirokawa, R.Y. (1996). Functional theory and communication in decision making and problem-solving groups: An expanded view. In R.Y. Hirokawa and M.S. POOLE (eds.), Communication and group decision making (2nd edition). Thousand Oaks, CA: Sage, 55-80.
27. Graham, M.W., Elizabeth, J.A., & Sejin, P. (2015). The role of social media in local government crisis communications. Public Relations Review, 41(3), 386–394.
28. Gutmann, A., & Thompson, D. (1996). Democracy and Disagreement. Cambridge, MA: Harvard Univ. Press.
29. Habermas, J. (1996). Between Facts and Norms. Contributions to a Discourse Theory of Law and Democracy. Cambridge: MIT Press.
30. Habermas, J. (1984). Theory of communicative action. Boston: Beacon Press.
31. Halpern, D., & Gibbs, J. (2013). Social media as a catalyst for online deliberation? Exploring the affordances of Facebook and YouTube for political expression. Computers in Human Behavior, 29, 1159–1168.
32. Haro-de-Rosario, A., Sáez-Martín, A., & del Carmen Caba-Pérez, M. (2018). Using social media to enhance citizen engagement with local government: Twitter or Facebook? New Media & Society, 20(1), 29-49.
33. He, B. (2014). Deliberative culture and politics: the persistence of authoritarian deliberation in China. Political Theory, 42, 58–81.
34. He, B. & Warren, M.E. (2017). Authoritarian Deliberation in China. Daedalus, 146(3), 155–166.
35. He, B. & Warren, M.E. (2011). Authoritarian Deliberation: The Deliberative Turn in Chinese Political Development. Perspectives on Politics, Vol. 9, №2, 269–289.
36. He, B. (2006). Western theories of deliberative democracy and the Chinese practice of complex deliberative governance. In.: E. Leib & B. He (Eds.), The search for deliberation democracy in China. New York: Palgrave MacMillan.
37. Herovic, E., Sellnow, T.M., & Sellnow, D.D. (2020). Challenges and opportunities for pre-crisis emergency risk communication: Lessons learned from the earth-quake community. Journal of Risk Research, 23(3), 349–364.
38. Hyland-Wood, B., Gardner, J., Leask, J., & Ecker, U.K. (2021). Toward effective government communication strategies in the era of COVID-19. Humanities and Social Sciences Communications, 8(1), 1–11.
39. Jonga, W. (2012). Prioritizing political banditry than good governance: Rethinking urban governance in Zimbabwe. International Journal of Humanities and Social Science, 2 (24), 117-135.
40. Lavazza, A., & Farina, M. (2020). The Role of Experts in the Covid-19 Pandemic and the Limits of Their Epistemic Authority in Democracy. Frontiers in Public Health, 8:356.
41. Lee, G. & Kwak, Y.H. (2012). An Open Government Maturity Model for social media-based public engagement. Government information quarterly, 29 (4), 492-503.
42. Lilleker, D., Coman, I.A., Gregor, M., & Novelli, E. (2021). Political communication and COVID-19: Governance and rhetoric in global comparative perspective. In Political Communication and COVID-19: Governance and Rhetoric in Times of Crisis, 333–350.
43. Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. Government Information Quarterly, Vol. 29 (4), 446-454.
44. Liu, B., & Kim, S. (2011). How organizations framed the 2009 H1N1 pandemic via social and traditional media: Implications for U.S. Health communicators. Public Relations Review, 37(3), 233–244.
45. Misnikov, Y. (2011). Public Activism Online in Russia: Citizens' Participation in Web-based Interactive PoliticalDebate in the Context of Civil Society. Development and Transition to Democracy. PhD thesis.
46. Mossberger, K., Wu, Y., & Crawford J. (2013). Connecting citizens and local governments? Social media and interactivity in major U.S. cities. Government Information Quarterly, Vol. 30 (4), 351-358.
47. Nabatchi, T. (2010). Addressing the citizenship and democratic deficits: the potential of deliberative democracy for public administration. The American Review of Public Administration, 40 (4), 376-399.
48. Nigmatullina, K., Bodrunova, S., Rodossky, N., & Nepiyushchikh, D. (2023). Discourse of Complaining on Social Networks in Russia: Cumulative Opinions vs. Decentering of Institutions. In.: Networks in the Global World VI: Proceedings of NetGloW 2022, 3–20.
49. Parry, L.J., Asenbaum, H., & Ercan, S.A. (2020). Democracy in Flux: A Systemic View on the Impact of COVID-19. Transforming Government: People, Process and Policy, 15 (2), 197– 205.
50. Rauchfleisch, A., Vogler, D., & Eisenegger, M. (2021). Public Sphere in Crisis Mode: How the COVID-19 Pandemic Influenced Public Discourse and User Behaviour in the Swiss Twitter-sphere. Javnost - The Public, 28:2, 129-148.
51. Reynolds, B. & Quinn, S.C. (2008). Effective communication during an influenza pandemic: The value of using a crisis and emergency risk communication framework. Health Promotion Practice, 9(4) Supplement, 13–17.
52. Shapiro, I. (2003). The State of Democratic Theory, Princeton: Princeton University Press.
53. Shin, B. & Rask, M. (2021). Assessment of online deliberative quality: new indicators using network analysis and time-series analysis. Sustainability, 13.
54. Sibony, A-L. (2020). The UK COVID-19 Response: A Behavioural Irony? European Journal of Risk Regulation, 11(2), 350–357.
55. Steenbergen, M., Bächtiger, A., Spörndli, M., et al. (2003). Measuring Political Deliberation: A Discourse Quality Index. Comp Eur Polit, 1, 21–48.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

56. Strekalova, Y. (2017). Health risk information engagement and amplification on social media. Health Education & Behavior, 44(2), 332–339.
57. Stromer-Galley, J., Bryant, L., & Bimber, B. (2015). Context and medium matter: Expressing disagreements online and face-to-face in political deliberations. Journal of Public Deliberation, 11(1), 1.
58. Stromer-Galley, J. (2007). Measuring deliberation's content: A coding scheme. Journal of Public Deliberation, 3, 1-35.
59. Stromer–Galley, J. & Muhlberger, P. (2009). Agreement and disagreement in group deliberation: Effects on deliberation satisfaction, future engagement, and decision legitimacy. Political Communication, 26(2), 173-192.
60. Toepfl, F. (2020). Comparing Authoritarian Publics: The Benefits and Risks of Three Types of Publics for Autocrats, Communication Theory, Volume 30, Issue 2, 105–125.
61. Toepfl, F. & Litvinenko, A. (2021). Critically Commenting Publics as Authoritarian Input Institutions: How Citizens Comment Beneath their News in Azerbaijan, Russia, and Turkmenistan. Journalism Studies, 22(4), 475–495.
62. van Dijck, J., & Alinejad, D. (2020). Social media and trust in scientific expertise: Debating the Covid-19 pandemic in The Netherlands. Social Media + Society, 6(4).
63. Vijaykumar, S., Meurzec, R., Jayasundar, K., Pagliari, C., & Fernandopulle, Y. (2017). What's buzzing on your feed? Health authorities' use of Facebook to combat Zika in Singapore. J Am Med Informatics Assoc, 24 (6)
64. Volkovskii, D. & Bodrunova, S. (2023). Incivility balanced? Civil vs. uncivil speech in online political discussions as dependent on political parallelism. In: Comito, C., Talia, D. (eds) Pervasive Knowledge and Collective Intelligence on Web and Social Media. PerSOM 2022. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 494. Springer, Cham.
65. Volkovskii, D., Filatova, O., Bodrunova, S., & Bolgov, R. (2024). Does government hear citizenry? The quality of deliberative practice between authorities and citizens on social media in Russia. In Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance (ICEGOV '24). Association for Computing Machinery, New York, USA, 327–336.
66. Volkovskii, D., Filatova, O. & Bolgov, R. (2023). Automated Detection of Different Publication Patterns of Online Deliberation as a Research Domain. In.: Social Computing and Social Media: 15th International Conference, SCSM 2023, Held as Part of the 25th HCI International Conference, HCII 2023, Copenhagen, Denmark, July 23–28, 2023, Proceedings, Part I. Cham: Springer Nature, 146-163.
67. Volkovskii, D., Filatova, O. & Bolgov, R. (2022). Social media deliberation: civil or uncivil, reasoned or unreasoned? In.: Central and Eastern European eDem and eGov Days (CEEeGov), September 22, 23, 2022, Budapest, Hungary. ACM, New York, NY, USA, 1–6.
68. Volkovskii, D. & Filatova, O. (2022) Influence of Media Type on Political E-Discourse: Analysis of Russian and American Discussions on Social Media'. In.: Electronic Governance and Open Society. Challenges in Eurasia - 8th International Conference, EGOSE 2021, Proceedings. Chugunov, A. V., Janssen, M., Khodachek, I., Misnikov, Y. & Trutnev, D. (eds.). Springer Nature, 119-131 (Communications in Computer and Information Science; vol. 1529 CCIS).
69. Volkovskii, D. & Filatova, O. (2023). Low civility and high incivility in Russian online deliberation: a case of political talk in VKontakte social network. KOME, 11(1), 95–109.
70. Volkovskii, D. & Filatova, O. (2021). Online deliberation on social media as a form of public dialogue in Russia. In.: IMS 2021 – International Conference "Internet and Modern Society", June 24-26, 2021, St. Petersburg, Russia, 146-156.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Using Generative AI for Identifying Electoral Irregularities on Social Media

Sidney Moura [a*] *Edney Santos* [b], *Pablo* Sampaio [c], *Kellyton Brito* [d].

[a] Universidade Federal Rural de Pernambuco, Recife, Pernambuco, sidney.moura@ufrpe.br, ORCID 0009-0002-2527-3200

[b] Universidade Federal Rural de Pernambuco, Recife, Pernambuco, edney.santos@ufrpe.br, ORCID 0009-0002-6784-8789

[c] Universidade Federal Rural de Pernambuco, Recife, Pernambuco, pablo.sampaio@ufrpe.br, ORCID 0000-0001-8254-560X

[d] Universidade Federal Rural de Pernambuco, Recife, Pernambuco, kellyton.brito@ufrpe.br, ORCID 0000-0002-6883-8657

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. The increasing use of social media (SM) in political campaigns has raised concerns about electoral irregularities, such as unauthorized voter solicitation and the use of sound trucks. Monitoring and enforcing electoral regulations manually are time-consuming and prone to inconsistencies, highlighting the need for automated solutions. A major challenge in automating the detection of electoral violations is the lack of sufficient labeled data. Additionally, the effectiveness of Generative AI in addressing this issue remains underexplored, especially regarding its ability to create synthetic data and enhance detection accuracy. In this context, this study aims to assess the potential of Generative AI in identifying electoral irregularities on SM, focusing on two common violations in the 2024 Brazilian municipal elections: voter solicitation and the use of sound trucks. The goal is to evaluate whether synthetic image generation, combined with AI-based visual analysis, can improve the identification of such infractions. We first generate synthetic images using Imagen 3, Stable Diffusion, and FLUX, identifying Imagen 3 as the most effective in producing realistic and visually coherent images. Then, we test the ability of three AI models—Gemini 2.0 Flash, Llama 3.2 Vision, and PaliGemma 2—to detect electoral violations in both real and synthetic images. To enhance detection accuracy, we apply different prompting strategies, including basic, chain-of-thought, and detailed prompts. Our findings show that Gemini 2.0 Flash performs best, particularly when using detailed prompts. Also, synthetic images help mitigate data scarcity, improving model training and evaluation. Overall, the study demonstrates that Generative AI, combined with optimized prompt engineering, can significantly enhance the accuracy of detecting electoral irregularities.

Keywords. Generative AI, electoral irregularities, SM, election monitoring, online campaigns
Research paper, DOI: https://doi.org/10.59490/dgo.2025.990

1. Introduction

Since the emergence of social media (SM) platforms, these communication tools have served dual purposes - facilitating personal interactions while functioning as professional instruments for commercial profiles and advertising (Kent & Li, 2020). The political domain has become deeply embedded in these digital spaces. Brazil's 2018 presidential elections demonstrated social media's remarkable capacity to influence and even predict electoral outcomes (Brito & Adeodato, 2023). Subsequent academic research has focused on correlating political figures' social media engagement with electoral performance (Brito & Adeodato, 2022).

While not the sole determinant of electoral success, social media's impact on voters is undeniable. Political campaigns employ targeted strategies to promote candidates and platforms, aiming to persuade voters and secure electoral support (Gomes, 2001). However, such campaigns must comply with electoral legislation. The scale of Brazil's 2024 municipal elections - with over 460,000 candidates - presents unprecedented monitoring challenges. According to the Superior Electoral Court (TSE), nearly 90,000 complaints about irregular campaign materials were filed during this election cycle(Superior Electoral Court, 2024), highlighting the limitations of manual oversight by a single

institution.

This study addresses these challenges by employing Generative AI to identify electoral violations in social media content. Our methodology progresses through three phases: comprehensive data collection, synthetic data generation, and image analysis using Large Language Models (LLMs) - an approach that fills a significant gap in existing literature (Grimmer & Stewart, 2013).

We implemented three LLM models (Gemini, Llama, and PaliGemma) to analyse campaign materials from prominent political figures including President Lula, former President Jair Bolsonaro, and Olinda mayoral candidates Mirella Almeida and Vinicius Castello. While our research began with authentic campaign posts, the limited availability of violation examples from the TSE's open data portal necessitated supplementing our dataset with synthetic images generated by Imagen 3, ensuring robust machine learning analysis (Clemmensen & Kjærsgaard, 2022).

The remainder of this paper is structured as follows: Section 2 reviews relevant literature, Section 3 details our methodological approach, Section 4 presents our findings, Section 5 discusses these results, and Section 6 concludes with recommendations for future research in this emerging field of electoral monitoring technology.

2. Background and related works

This section presents the fundamental concepts and reviews the main works related to the detection of infractions in electoral campaigns, presenting topics for contextualization of the study. Four topics will be detailed, such as: Use of social networks in the political context, Applications of Generative AI in SM and government, Prompt engineering and review of related works.

2.1 Use of social media in a political context

In recent years, SM has been consolidating itself as essential tools in various fields, transforming itself into communication channels between politicians and the public (Howard & Kollanyi, 2016). Studies indicate that positive perceptions acquired through SM can indirectly increase political participation outside of SM (Kwak et al., 2018). Therefore, the adoption of SM as political tools can enhance the electoral process in beneficial ways, reducing barriers between the public and information.

On the other hand, the internet and SM present significant counterpoints and difficulties. SM enhances the dissemination of hate speech and fake news (Lazer et al., 2018). Furthermore, research shows that platforms such as Twitter (currently X), where abusive interactions between users are common, marginalize moderation. By analysing thousands of interactions in several countries, Falkenberg concluded that the platform contributes to political abuse, in addition to personifying moderators as enemies and intensifying political polarization (Falkenberg et al., 2024).

The way SM is used can also influence election results (Brito & Adeodato, 2022), even allowing for attempts to predict them through sentiment analysis and engagement metrics(Brito & Adeodato, 2023). In the Brazilian context, the 2018 elections serve as an example, in which former president Jair Messias Bolsonaro achieved high engagement on SM—his campaign's focus—and successfully won the presidency (Brito et al., 2019).

2.2 Applications of generative AI in social media and government

In SM, generative AI has been widely used for content personalization, automated post moderation, and the creation of increasingly sophisticated chatbots. Platforms like Facebook, Twitter, and Instagram employ advanced machine learning models to generate personalized recommendations, filter hate speech, and even create synthetic content, such as images and texts, to boost user engagement (Ferrara et al., 2016; Ian Goodfellow et al., 2016). Additionally, there is growing concern about the use of AI to generate deepfakes and spread disinformation, sparking debates on the regulation and governance of these technologies in the digital environment (Danielle K. Citron & Robert Chesney, 2019).

In the government sector, generative AI has been explored to optimize communication with citizens, automate bureaucratic processes, and even assist in the development of public policies. Intelligent chatbots are used to provide information on public services, while AI models can analyse large volumes of data to identify patterns in social policies, predict demands, and improve administrative efficiency (Sun & Medaglia, 2019). Furthermore, during election periods, AI has been used to monitor political campaigns and detect potential irregularities in advertisements, as seen in initiatives aimed at automating the oversight of online electoral content (Woolley & Howard, 2018). Straub points out that the use of AI by these institutions can go beyond technological issues but may also involve normative divergence, where deviations in social perceptions and ethical and legal acceptability can occur. Furthermore, the literature on the use of AI in this context remains highly fragmented, reflecting the complexity of the topic.

Despite its significant potential, the implementation of generative AI in both SM and government faces considerable challenges. Issues such as data privacy, algorithmic bias, and the need for transparency in automated decision-making are critical topics that require multidisciplinary debate (Hongladarom, 2023; Roy, 2017). Moreover, AI

regulation is still in its early stages in many countries, necessitating a balance between technological innovation and ethical oversight to ensure that the application of these tools does not compromise fundamental rights or democratic integrity (Floridi et al., 2018).

Thus, the intersection of generative AI, SM, and public governance remains a dynamic and evolving field of research, demanding interdisciplinary approaches to understand its impacts and develop effective strategies for its responsible use.

2.3 Prompt engineering

Prompt engineering is a critical discipline in the study and application of generative AI models. As demonstrated in our study and corroborated by the work of Knoth et al. (2024), the formulation of prompts can be the difference between superficial results and deep, contextualized analyses. Moreover, prompt engineering sometimes requires a deeper understanding of the domain in which it is being applied. The construction of prompts may demand knowledge in linguistics, psychology, and computer science (Haupt et al., 2024).

This variation aligns with the findings of Knoth et al. (2024), who highlight the importance of carefully formulating prompts to maximize the effectiveness of generative AI models. Previous studies, such as those by Ettinger (2020), have already demonstrated that language models are highly sensitive to the input they receive and that small changes in structure, tone, or vocabulary can lead to significantly different responses. This sensitivity reinforces the need to consider prompt variation as a critical factor in generative AI studies, as it directly influences the quality, accuracy, and relevance of the generated outputs. Therefore, prompt construction should be approached with attention to linguistic, contextual, and technical nuances, considering that different formulations may serve distinct objectives or yield varying results.

2.4 Related works

Studies such as those by Ajayi & S.a. Adesote (2016) and Olesya Tkacheva (2013) demonstrate how digital platforms and innovative approaches are redefining citizen participation in detecting irregularities. In Nigeria, the combination of mobile devices and social media enabled ordinary citizens to document and expose fraud during the 2011 elections, creating a new paradigm of transparency. In Russia, crowdsourcing emerged as a democratic alternative to the traditional media monopoly in electoral monitoring, decentralizing oversight power.

In Brazil, initiatives like the TSE's Pardal system represent important advances, but they still rely on manual analyses that result in delays and subjectivity in evaluating complaints. This technical limitation contrasts with the current scenario, where the sophistication of fraud demands swift and precise responses. Meanwhile, research such as that by Santana et al. (2024) explores the potential of visual analysis but remains limited to image categorization, lacking the capability to identify critical elements such as evidence of illegalities in electoral campaigns on social media.

Simultaneously, the emergence of generative AI introduces new complex challenges. Works like those by Schmitt & Flechais (2023)and Ferrara (2024) highlight the dual role of these technologies: while they can be powerful tools against disinformation when used by democratic institutions, they also become dangerous instruments in the hands of bad actors, capable of producing convincing deepfakes and large-scale disinformation campaigns.

This multifaceted scenario reveals an urgent need: to develop automated systems specialized in detecting specific electoral irregularities, combining the speed of computational analysis with the thematic precision that existing studies have yet to achieve. While solutions like Pardal remain manual and approaches like Santana's are too generic, there is clear room for innovations that can fill this critical gap in preserving electoral integrity.

3. Methodology

The objective of this work is to detect possible electoral infractions on politicians' social networks, using generative artificial intelligence in image analysis, with the purpose of automating the process of detection and initial screening of images to then be validated by humans. To achieve this goal, we defined the following research questions:

RQ1 - Which generative AI models and prompting strategies work best to generate images that represent scenarios of possible electoral infraction?

Given the difficulty of finding datasets with electoral irregularities, the first research question focuses on creating synthetic images for this purpose. As presented in section 2.3, the variation in prompts and models significantly impacts the results generated.

RQ2 - Which generative AI models and prompting strategies are most efficient in identifying electoral infractions in different contexts, such as real and synthetic images?

Aiming to identify the efficiency of models and prompts in detecting electoral violations. Various generative AI

models, combined with different prompt strategies, will be evaluated to determine which approaches are the most accurate and reliable in analysing both real and synthetic images.

RQ3 - Does the use of more detailed prompts in generative AI models positively impact the accuracy of detecting infractions in images?

This research question provides an additional outcome by discussing the impact of more detailed prompts on detection results. It will investigate whether including more specific and contextualized descriptions in the prompts improves the models' ability to identify electoral violations with greater accuracy.

To answer the research questions, we structured and proposed a methodology composed of 3 main steps. The steps are: (i) Data collection; (ii) Generation of synthetic images using Artificial Intelligence; (iii) Automated Analysis.

3.1 Data collection

The data collection involved gathering images of potential electoral violations shared on social media between August and October 2024. This timeframe covered both the municipal campaign (focusing on the two main candidates from Olinda, Pernambuco) and the presidential campaign, analysing content from candidates Lula and Bolsonaro during both election rounds. The goal was to compile a representative and diverse database for validating the artificial intelligence models.

The analysis was based on posts from the social media platform Instagram, which was selected due to its prominence in visual content sharing and widespread use in political campaigns. The images were collected manually through screenshots, a method that allowed for direct and precise selection of relevant material.

The post selection criteria focused on two specific electoral violations: (i) irregular vote solicitation, covering instances such as inducing votes through illegal promises or benefits; and (ii) improper use of sound trucks, including excessive promotion or usage outside legally permitted timeframes. Thus, the analysed images represent concrete cases of these violations, enabling a targeted and well-supported assessment.

A total of 450 images were collected, distributed evenly among the following categories: (i) Images with possible voter request violations: 150 images that contained banners, pamphlets, posts or content that could be interpreted as a direct voter request, such as “vote for” or “elect [candidate’s name]” (ii) Images without violations: 150 images that contained items related to the political context, but with no apparent evidence of possible violation of electoral legislation (iii) Images with possible violations involving sound trucks: 150 images of events, marches and motorcades in a political context containing sound trucks, which could be interpreted as possible irregular propaganda.

During the collection process, we identified a limitation regarding the availability of images that could be interpreted as a possible violation containing sound trucks. This scenario may occur due to the low visual record of these practices on social networks. To overcome this difficulty, we chose to complement the database with synthetic images, generated through generative artificial intelligence models, as described in the following subsection.

3.2 Synthetic data generation

Because of the difficulty in obtaining sufficient images related to violations involving sound trucks, it was necessary to complement the database using synthetic images. This step aims to create images that represent realistic scenarios, capable of simulating possible violations. We divided the generation process into three main steps: (i) Selection of AI models capable of generating images, (ii) definition of prompt strategies, and (iii) validation of the generated images.

Three Generative AI models were tested: Imagen 3, Stable Diffusion, and FLUX. These models were chosen based on their popularity and ability to generate realistic images. Among the choices, we kept only one private model (Imagen 3), due to the high cost of APIs aimed at generating images such as OpenAI's DALL-E 3. Each model was tested and ranked based on its ability to create visually consistent images that met the context of possible violations provided in the prompts, and were free of bugs, distortions, or artifacts.

To guide the generation of images, three prompt strategies adapted to the image generation context were tested for each model: (i) Zero-shot: a basic command describing the image, without adding prior context or examples. (ii) Chain-of-thought: starting with a simple initial description and then adding layers of details and context to enrich the analysis. (iii) Detailed prompt, containing, in addition to the image description text, creative restrictions such as artistic style, and technical restrictions such as field of view, lighting, and camera angle.

Each model generated 20 images per prompt, totalling 180 images. These images were manually classified according to visual coherence, whether they characterized a possible violation of the law and the absence of errors, such as distortions and artifacts. After analysing the generated images, the Imagen 3 model, together with the Zero- shot prompt strategy, presented the most satisfactory results. Thus, the use of this approach allowed the selection of the

model for the creation of the 150 final synthetic images related to possible violations involving sound trucks.

The following presents the prompts employed for each of the three image generation techniques.

```
Create a picture of a political rally in Brazil. The scene should feature a moving vehicle equipped with loudspeakers,
with a charismatic (female) Brazilian politician above the vehicle delivering an enthusiastic speech to a crowd of
voters on a city street. The main focus should be on the politician, who should be clearly visible, and on the
interaction with the crowd. The image should capture the moving vehicle, the loudspeakers, the politician's
expression, and the crowd, conveying an atmosphere of enthusiasm and energy.
```

Fig. 1 – Zero-shot prompt.

```
- Create an image of a political rally in Brazil.
- Include a  moving vehicle equipped with loudspeakers.
- Position a charismatic (female) Brazilian politician on top of this vehicle, giving an enthusiastic speech.
- Include a crowd of voters surrounding the vehicle on a city street.
- Focus on the politician and his interaction with the crowd.
- Capture the movement of the vehicle, the speakers, the politician's expression, and the emotions of the crowd.
- Create an atmosphere of excitement and energy.
```

Fig. 2 – Chain-of-thought prompt.

```
Artistic Style: Realistic photography with vibrant and dynamic tone.

Creative Restrictions:
- Mandatory: A charismatic (female) Brazilian politician, on top of a vehicle with loudspeakers, addressing a crowd on a city street. The
politician must be in focus.
- Prohibited: Fantasy or science fiction elements.

Technical Parameters:
- Depth of field: Shallow, with a soft blur in the background to highlight the politician.
- Lighting: Natural daylight, with vibrant colors and soft shadows.
- Camera angle: Eye level, with a slight downward angle to include the politician and the crowd in the same scene.

Main Prompt:

Create an image that follows the restrictions and technical parameters above, within the vibrant realistic photography style. The moving
vehicle, the speakers, the politician's expression and the crowd's emotions must be well captured, conveying an atmosphere of enthusiasm and
energy. Generate variations of the scene with different angles and times of day, while maintaining technical constraints and parameters.
```

Fig. 3 – Artistic Style + Creative restriction + Technical parameters prompt.

3.3 Image analysis

This stage aims to evaluate the performance of generative artificial intelligence models in detecting potential electoral infractions on SM. The problem was treated as a binary classification task, meaning the models were trained to classify images into two categories: "with infraction" or "without infraction." To do this, three models were tested: Gemini 2.0 Flash, Llama 3.2 Vision, and PaliGemma 2, selected for their advanced visual analysis capabilities across various scenarios.

We employed three open-source AI models with complementary technical characteristics: PaliGemma 2, Gemini 2.0 Flash, and LLaMA 3.2 Vision. Our selection criteria considered not only model accessibility but also their distinct architectures, enabling robust comparative analyses. We chose Google's PaliGemma 2 (Steiner et al., 2024) for its specialized image analysis capabilities as an optimized vision-language model (VLM). From the same developer, we selected Gemini 2.0 Flash (Shrestha Basu Mallick & Logan Kilpatrick, 2025), a more computationally efficient multimodal model, allowing us to contrast different approaches within the same development ecosystem.

For external comparison, we included Meta's LLaMA 3.2 Vision (Grattafiori et al., 2024), an open-weight model that, while also designed for visual processing, features a distinct architecture with three specialized components: image encoder, image adapter, and video adapter. This combination enabled us to analyze both different implementations of models with similar purposes (PaliGemma 2 and LLaMA 3.2 Vision) and contrast same-developer models with different specializations (PaliGemma 2 and Gemini 2.0 Flash).

This diverse selection was intentional, encompassing models ranging from highly specialized computer vision solutions to more generic multimodal architectures, all within the scope of technologies accessible to the research community. Our approach allowed us to evaluate how different architectures and specializations impact the detection of electoral violations in visual content - the primary focus of our study.

Two prompt strategies were employed (written in English, the primary language of these AI models): (i) Simple prompt: containing only the fundamental elements of electoral legislation applicable to the image category; (ii) Detailed prompt: including, beyond the legal requirements, an elaborated description contextualizing potential cases

and scenarios, highlighting relevant details such as 'Vote request banner featuring the candidate's name and number.'

Below we present two English-language prompts used to detect irregular use of vote solicitation.

Example of a simple prompt:

```
You are an intelligence expert specializing in identifying possible electoral infractions related to explicit requests for votes, according
to Brazilian legislation. Analyze the image provided and determine if there are elements that indicate a possible direct or indirect
request for votes, in violation of the legislation.
Consider the following rules:
Explicit request for votes:
- Visible phrases or messages that contain direct references to the request for votes, such as 'Vote for [candidate's name or number]'.
Prohibited period:
- Any explicit request for votes is prohibited outside the period authorized by the Electoral Court, especially on election day.
Based on these conditions, answer with a single term:
Yes, if the image provided contains evidence of a request for votes in violation of electoral rules.
No, if the image does not present elements that indicate an infraction.
Note: Consider only the visual aspects of the image and not speculate beyond what is explicitly visible. Answer only with one word yes or
no, without a period or line breaks
```

Fig. 4 – Simple prompt.

And also the example of the more detailed prompt:

```
You are an intelligence specialist in identifying possible electoral infractions related to explicit or indirect requests for votes,
according to the rules of Brazilian electoral legislation. Analyze the image provided based on the following criteria:
Explicit request for votes:
- Are there direct phrases such as 'Vote for [candidate's name or number]' or 'I'm counting on your vote'?
- Do the advertising material or elements in the image display the candidate's name, number or slogan associated with a message asking
for votes?
Context of the propaganda:
- Is the request for votes being made in prohibited places, such as polling stations, schools or public offices?
- Is there evidence of the distribution of promotional materials (flyers, stickers or gifts) containing requests for votes in prohibited
contexts?
Prohibited period:
- Does the image suggest that the request for votes is taking place on election day, when any form of propaganda or request for votes is
strictly prohibited?
- Are there characteristics in the image (such as date or setting) that indicate disrespect for the period authorized for campaigns?
Abuse of power or illicit solicitation:
- Is the request for votes being made in exchange for benefits, such as money, gifts or promises of advantages, constituting illicit
solicitation of votes?
Answer with a single term:
Yes, if the image provided presents any of the elements above, indicating a possible electoral infraction related to the request for
votes.
No, if no element observed in the image constitutes an electoral infraction.
Note: Consider only the visual aspects of the image and not speculate beyond what is explicitly visible. Answer only with one word yes or
no, without a period or line breaks
```

Fig. 5 – Detailed prompt.

To evaluate the models' performance, we conducted tests using both prompt strategies on two specific categories of electoral images, as defined by the TSE (Superior Electoral Court) Resolution. The first category involved vote solicitations, regulated by Article 3 of said resolution, which establishes the legal parameters for explicit vote requests during campaigns. The second category concerned sound trucks - vehicles equipped with powerful sound systems designed to reach large distances and attract public attention, whose usage is specifically governed by §3 of Article 5 of the same resolution.

For each test, we employed a carefully balanced set of 300 images - 150 that potentially constituted violations of the aforementioned provisions and another 150 that were fully compliant with electoral regulations. As evaluation metrics, we used four well-established measures in AI system analysis: Precision, Recall, Accuracy, and F1-Score. The entire classification and evaluation process was anchored to the cited electoral legislation articles, thereby ensuring the legal relevance of our analyses and conclusions.

For those not familiar with machine learning, here is a brief explanation of the metrics used: (i) Precision: measures the proportion of correct classifications among all the positive predictions made by the model. For example, if the model identified 100 images as "with infraction," Precision indicates how many of those actually had infractions;

(ii) Recall: measures the proportion of real positive cases that were correctly identified by the model. For example, if there are 150 images with infractions, Recall indicates how many of those the model was able to detect; (iii) Accuracy: measures the proportion of correct classifications (both positive and negative) in relation to the total number of images analysed; (iv) F1-Score: is a robust metric that combines Precision and Recall, balancing the two. It is particularly useful when there is an imbalance between classes (e.g., many images without infractions and few with infractions).

All these metrics range from 0% to 100%, with 100% being the ideal value, indicating that the model made all the correct classifications. The F1-Score is particularly important because it takes into account both Precision and Recall, making it a more reliable measure for evaluating performance in imbalanced scenarios.

4. Results

The results presented in the section are organized to answer the research questions defined previously, addressing the main findings of the study.

4.1 Research Question 1

When exploring the use of Generative AI to create synthetic images that represent possible electoral violations, more specifically in the scenario of sound trucks, three generative AI models were evaluated: Imagen 3, Stable Diffusion and FLUX, with a focus on image quality and a balance between closed and open-source models.

The models were evaluated on three main criteria: visual coherence, whether it characterizes a possible violation and visual bugs or artifacts. The table (Table 1) below summarizes the performance of the models in each of these aspects.

Model	Visual Coherence (%)	Absense of artifacts (%)	Possible Infrigement (%)
Imagens 3	98,33%	98,33%	100%
FLUX	98,33%	81,67%	100%
Stable DIffusion	90%	66,67%	98,33%

Tab. 1 - Image generation verification metrics

Google's proprietary model, Imagen 3, excelled in all criteria, with the highest score for coherence (98.33%) and absence of artifacts (98.33%), demonstrating a high level of realism. The FLUX model presented good quality but fell below Imagen 3 in the absence of artifacts category, while Stable Diffusion obtained the lowest scores, being considerably inferior in the absence of artifacts category.

In addition to the model tests, we used three prompting strategies, detailed in the methodology section, to observe how each approach can influence the quality of the generated images. The following table (Table 2) distills the impact of each prompt on the previous categories, visual coherence, absence of artifacts and possible violation.

Model	Prompt Strategy	Visual Coherence (%)	Absense of artifacts (%)	Possible Infrigement (%)
Imagen 3	Zero-shot	100%	100%	100%
Imagen 3	Chain-of-thought	100%	100%	100%
Imagen 3	Detailed-prompt	95%	95%	100%
FLUX	Zero-shot	95%	75%	100%
FLUX	Chain-of-thought	100%	80%	100%
FLUX	Detailed-prompt	100%	90%	100%
Stable Diffusion	Zero-shot	75%	60%	95%
Stable Diffusion	Chain-of-thought	95%	75%	100%
Stable Diffusion	Detailed-prompt	100%	65%	100%

Tab. 2 - Image generation verification metrics per prompt

As illustrated above, the different prompting strategies did not have a significant impact on the Imagen 3 model, which remained consistent throughout the tests. The FLUX model performed well in terms of visual coherence and significantly improved in the absence of artifacts as we used more detailed prompts, going from 75% with the zero-shot prompt to 90% with the detailed prompt. Finally, the Stable Diffusion model performed worst overall, although coherence improved when using the detailed prompt, the absence of artifacts worsened as the model received more instructions.

Also shown below is an example of a synthetic image, as illustrated in Fig. 1, which displays an image generated by the Imagen 3 model.



Fig. 6 - Synthetic image artificially generated by model Image 3

We also have examples of natural images that were collected from the social media accounts of the respective politicians, such as Mirella Almeida in **Fig. 7** and Vinicius Castello in **Fig. 8**.



Fig. 7 - Campaign image of candidate Mirella Almeida.



Fig. 8 - Political campaign image of candidate Vinicius Castello.

Therefore, generative AI can prove effective in creating synthetic images that simulate real scenarios of electoral infractions in a coherent manner, with each model interacting differently with the prompt strategies. In particular, the Imagen 3 model proved to be the most capable in generating images in the context of the study (Image 1),

contributing to the identification of irregular behavior in electoral campaigns.

4.2 Research Question 2

The analysis of the Visual Generative AI models used to identify violations in the vote-calling and sound truck scenarios showed significant variation in terms of performance. To assess which of the models was most effective, we used accuracy, precision, recall and F1-Score metrics, which allow for a comprehensive analysis of each model's ability to correctly detect violations, in addition to minimizing classification errors.

The models tested were Gemini 2.0 Flash, Llama 3.2 Vision and PaliGemma 2. The table below (Table 3) summarizes the results of each model, highlighting the metrics for the category of violations with sound trucks.

Model	Prompt Strategy	Accuracy	Precision	Recall	F1-Score
Gemini 2.0 Flash	simple	68%	95%	39%	55%
Gemini 2.0 Flash	detailed	99%	98%	100%	99%
Llama 3.2 Vision	simple	59%	97%	19%	32%
Llama 3.2 Vision	detailed	78%	92%	61%	73%
PaliGemma 2	simple	82%	92%	68%	79%
PaliGemma 2	detailed	89%	96%	81%	89%

Tab. 3 - Visual Analytics Verification Metrics – sound trucks

The Gemini 2.0 Flash model achieved the best performance in detecting infractions related to sound trucks. The detailed prompt strategy was essential for obtaining superior metrics; however, since artificially generated images were used from a model of the same family (Imagen 3), this factor may have influenced the results.

Llama 3.2 Vision presented low results using simple prompt, with 59% accuracy and an F1-Score of 32%. However, when providing the greater context of the detailed prompt, there were significant improvements, with accuracy rising to 78% and F1-Score to 73%. The PaliGemma 2 model presented significant results with both simple and detailed prompts, presenting F1-Scores of 79% and 89% respectively. As an open-source model from the Google family, the possibility of overfitting in PaliGemma 2 should also be considered.

Model	Prompt Strategy	Accuracy	Precision	Recall	F1-Score
Gemini 2.0 Flash	simple	82%	90%	72%	80%
Gemini 2.0 Flash	detailed	89%	88%	91%	90%
Llama 3.2 Vision	simple	72%	96%	46%	62%
Llama 3.2 Vision	detailed	82%	94%	67%	79%
PaliGemma 2	simple	63%	93%	28%	43%
PaliGemma 2	detailed	70%	91%	45%	60%

Tab. 4 - Visual Analytics Verification Metrics – vote request

The table above (Table 4) presents the metrics for the vote request infraction category. Again, the Gemini 2.0 Flash model stands out, showing an F1-Score of 80% and 90% for the simple and detailed prompts, respectively. For this type of infraction, only real images were used.

Next, the Llama 3.2 Vision model shows more consistent results for this dataset, increasing from 62% to 79% F1-Score when using the detailed prompt. PaliGemma 2, which performed well for the sound truck infraction, stands out negatively here, with an F1-Score of 43% for the simple prompt and 60% for the detailed prompt.

Based on the results presented, the Gemini 2.0 Flash model was the most effective in identifying electoral violations in both contexts analysed. Despite the possible overfitting observed by the metrics in the sound truck violation, the results based on real images related to the vote request violation showed a positive result.

The superior performance of Gemini 2.0 Flash in terms of accuracy, precision, recall and F1-Score shows that the model can be a good choice for the task of detecting violations in social networks, especially in the domain of images

related to vote request violations. The other models, Llama 3.2 Vision and PaliGemma 2, although effective, have some limitations in the balance between precision and recall, and can be used as an alternative depending on the specific needs of monitoring violations.

4.3 Research Question 3

The generative AI models used for visual verification performed significantly better when analysing images using a detailed prompt, as can be seen in the table below (table 5), which compares the F1-Scores of the analyses performed on the two types of infraction.

Model	Context	F1-Score (Simple Prompt)	F1-Score (Detailed Prompt)
Gemini 2.0 Flash	Vote Request	80%	90%
Llama 3.2 Vision	Vote Request	62%	79%
PaliGemma 2	Vote Request	43%	60%
Gemini 2.0 Flash	Sound Truck	55%	99%
Llama 3.2 Vision	Sound Truck	32%	73%
PaliGemma 2	Sound Truck	79%	89%

Tab. 5 - Visual Analytics Verification Metrics – F1-Score focus

Regardless of the model used, the analysis using a detailed prompt led to an average improvement of approximately 23%. Even eliminating the Gemini 2.0 Flash F1-Score in the sound truck database due to suspected overfitting, the average improvement is still high, reaching 19%. This increase can be related to the fact that the generative AI models were able to better interpret the graphic elements of the generated images, reducing the number of false positives and false negatives.

In addition to the F1-Score, the accuracy values (Table 4) were also higher in the analysis of images using detailed prompts. In the case of the Gemini 2.0 Flash model for the vote request category, the accuracy increased from 82% to 89%. On the other hand, the models showed a tendency for accuracy to drop when using detailed prompts, decreasing by approximately 1% to 2%, which, although not a significant loss, may indicate that extremely detailed prompts or prompts with too much information can make the model more inaccurate.

We can see that the results obtained confirm that the use of more detailed prompts in image analysis positively impacts the F1-Score for detecting electoral violations in images. These findings suggest that, in order to seek to improve monitoring systems for electoral campaigns, it is essential not only to think about training robust AI models, but also to ensure adequate prompt engineering that maximizes the context of these models up to the threshold between too little and too much information.

4.4 Summary of results

The results of this study were organized around the three research questions defined above, providing an analysis of the effectiveness of different prompting strategies and generative AI models in the context of detecting violations. The main findings are presented below.

Research Question 1: The generation of synthetic images through generative AI has proven to be effective in simulating scenarios of electoral violations. Among the models tested (Imagen 3, Stable Diffusion and FLUX), Imagen 3 presented the best performance, achieving 98.33% visual coherence and absence of artifacts. FLUX showed a significant improvement in the absence of bugs and artifacts when using more elaborate prompts. Stable Diffusion, on the other hand, obtained inferior results in all the criteria evaluated.

Research Question 2: In the visual verification for detecting violations, the Gemini 2.0 Flash model was the most effective, standing out in metrics such as accuracy, precision, recall and F1-Score in both scenarios analysed. However, possible overfitting was observed in the analysis of infractions involving sound trucks, due to the use of synthetic images generated by Imagen 3, from the same family of models. Llama 3.2 Vision showed a significant improvement when using more detailed prompts, while PaliGemma 2 showed inconsistent performance, with good results on synthetic images, but inferior performance in the analysis of real images.

Research question 3: The use of more detailed prompts positively impacted the performance of visual verification

models. On average, the F1-Score increased by 23% when using detailed prompts, with improvements highlighted in the vote request category. Furthermore, accuracy values also improved, especially in Gemini 2.0 Flash, which reached 89% accuracy in the analysis of real images. However, a slight drop of 1% to 2% in the accuracy of the models was observed when using detailed prompts, indicating the importance of finding a balance in prompt engineering.

The results highlight that the combination of robust generative AI models and appropriate prompting strategies can bring improvements in the detection of electoral infractions. The findings also suggest the need for special care when working with synthetic data, to avoid problems such as overfitting and ensure greater reliability of analyses in real contexts.

5. Discussions

5.1 Technical implications

The results demonstrate the potential of generative AI in multiple tasks. The creation of synthetic images can complement the dataset for detection, while the AI models showed good effectiveness in analysing potential infractions. These advancements could help regulatory bodies automate the screening of suspicious content, reducing the need for exhaustive manual searches and increasing efficiency in detecting violations. Additionally, prompt optimization proved to be an essential strategy for improving the results obtained through the models.

5.2 Implications for society

The growing use of artificial intelligence (AI) in various sectors of society has raised concerns about the replacement of human labour by machines and the risks associated with automated decision-making. However, the application of AI in electoral monitoring represents a use case that can bring significant contributions to strengthening democracy. By automating the monitoring of illicit and harmful strategies, AI can help ensure that elections focus on the discussion of ideas and public debate, rather than being undermined by illegal practices.

The artificial intelligence models evaluated in this study, while demonstrating satisfactory results, still face significant challenges - particularly in accurately interpreting complex contexts and minimizing false positives that could lead to unjust accusations. These limitations, however, do not overshadow the transformative potential of this technology as an electoral oversight tool.

Since the implementation of the Pardal System in 2014 (Santos, 2023), which marked a turning point in digital electoral monitoring, the volume of visual content requiring analysis has grown exponentially. It is precisely in this scenario that AI emerges as a strategic resource for Brazil's Superior Electoral Court (TSE). By automating and enhancing the screening of this vast image repository, the technology not only accelerates processes but substantially improves oversight capabilities.

The benefits manifest in three complementary dimensions: first, it provides TSE with greater operational capacity to swiftly identify and sanction irregularities with robust evidentiary support; second, it strengthens democratic foundations by ensuring transparency and integrity throughout all stages of the electoral process; and third, it upholds the rule of law by guaranteeing strict compliance with Brazil's electoral legislation.

This convergence between technological innovation and electoral jurisdiction represents more than just methodological modernization - it constitutes an institutional advancement that simultaneously reinforces TSE's administrative efficiency and public trust in the democratic system. As algorithms overcome their current limitations through continuous learning, their role as allies in preserving electoral legitimacy will likely expand, always in accordance with the nation's legal framework.

5.3 Threats to validity

This study presents limitations that must be considered for an appropriate interpretation of the results. One of the main limitations is the focus on only two types of electoral infractions (vote request and sound truck), which does not allow for an evaluation of how well this approach generalizes to other types of infractions or more complex scenarios. Furthermore, the creation of synthetic images may introduce biases into the models used for visual verification, as the same models or architectures were used both to generate and to analyse the images.

Another important limitation is the image dataset used, which may not fully represent the diversity of electoral scenarios encountered in practice, thus limiting the generalization of the results. Additionally, the influence of detailed prompts must also be considered, as different formulations can generate significant variations in the models' performance, raising questions about the reproducibility of the findings. These factors highlight the need for future studies that expand the variety of infractions analysed and use more comprehensive and representative datasets.

5.4 Future works

Future studies could explore strategies to mitigate biases in synthetic images, either by diversifying generative

models or by incorporating more comprehensive real-world databases. Additionally, research into multimodal datasets - encompassing videos, audio recordings, and text alongside images - could provide richer contextual analysis and optimize detection model performance.

As this approach continues to improve and achieves higher accuracy levels, the techniques developed in this study could be deployed to significantly expedite the identification of electoral irregularities during campaign periods. This practical application would yield three key benefits: (1) accelerating electoral-legal processes for faster response to detected violations; (2) reducing the workload burden on analysts conducting manual verification; and (3) minimizing human errors and oversights, thereby enhancing overall system reliability.

6. Conclusions

Among the relevant studies, the work of Ajayi & S.a. Adesote (2016) stands out, exploring the use of social networks to identify irregularities in the Nigerian elections in 2011. The authors show that although the approach used at the time was manual monitoring of social networks, the importance of citizen participation in detecting irregularities was highlighted.

In a similar context, Olesya Tkacheva (2013) investigated the legislative elections in Russia in 2011, highlighting the use of Crowdsourcing as a monitoring tool. Unlike the study by Ajayi & S.a. Adesote (2016), Olesya Tkacheva (2013) emphasizes the independence of traditional media in the electoral surveillance process, in addition to pointing out the limitations of this approach, such as the lack of coordination and the absence of an automated system.

Advances in generative artificial intelligence enable new approaches to monitoring electoral campaigns. In this study, we investigated the use of Generative AI and its capabilities in computer vision to identify possible electoral infractions in images, focusing on cases of voter solicitation and the use of sound trucks. The objective was to evaluate both the feasibility of generating synthetic images and the effectiveness of different AI models in analysing these infractions.

To achieve these objectives, we started by collecting real images and generating synthetic images, using the capabilities of Generative AI to overcome the scarcity of data regarding infractions involving sound trucks. Soon after, different generative AI models with multimodal capabilities were tested in the analysis of these images, varying the prompt engineering strategies. These models were evaluated using metrics such as accuracy, precision, recall and F1-Score, thus allowing a comparative analysis of the performance of the different proposed approaches.

Related to the first research question, the results indicated that Generative AI is effective in generating synthetic images in the context of representing electoral infractions, with the Imagen 3 model being the most suitable. The detailed prompt strategy had a direct impact on the quality of the generated images, especially in open-source models such as FLUX, which showed a significant reduction in artifacts when receiving more precise descriptions.

In the second research question, we evaluated the effectiveness of generative AI models with computer vision capabilities in detecting violations. The Gemini 2.0 Flash model showed the best overall performance, especially in the analysis of real images, which suggests that it is the most reliable option for practical application among the models tested (in addition to Gemini 2.0 Flash, Llama 3.2 Vision and PaliGemma 2). However, we observed possible overfitting effects when testing the same model on synthetic images, reinforcing the need for an adequate balance between real and synthetic data.

Finally, the results related to the third research question demonstrated that the use of more detailed prompt strategies significantly improves the accuracy of detecting violations, presenting an average improvement of 23% in the F1-Score. However, a slight drop in accuracy was identified with more detailed descriptions, between 1% and 2%, suggesting the existence of a threshold between information made available to AI to avoid errors in image classification.

This work contributes to the area of digital monitoring and generative artificial intelligence applied to the electoral process, indicating that AI can assist regulatory bodies in identifying irregularities through images. In addition, the importance of balancing synthetic and real data was highlighted, as well as the need for well-structured prompt engineering. As future work, we suggest tests with multimodal databases, which can combine analysis of videos, audios, texts and images, in addition to exploring methods to reduce biases in synthetic images by exploring the diversification of models used in the image generation stage or using larger real databases.

7. References

Ajayi, A. i., & S.a. Adesote. (2016). The Social Media and Consolidation of Democracy in Nigeria: Uses, Potentials and Challenges . In *http://africajsd.com/wp-content/uploads/2020/07/5-Ajayi-Sola-adegboyega.pdf* (Vol. 6, Issue No.1).

Brito, K., & Adeodato, P. J. L. (2022). Measuring the performances of politicians on social media and

the correlation with major Latin American election results. *Government Information Quarterly*, *39*(4), 101745. https://doi.org/10.1016/j.giq.2022.101745
Brito, K., & Adeodato, P. J. L. (2023). Machine learning for predicting elections in Latin America based on social media engagement and polls. *Government Information Quarterly*, *40*(1), 101782. https://doi.org/10.1016/j.giq.2022.101782
Brito, K., Paula, N., Fernandes, M., & Meira, S. (2019). Social Media and Presidential Campaigns – Preliminary Results of the 2018 Brazilian Presidential Election. *Proceedings of the 20th Annual International Conference on Digital Government Research*, 332–341. https://doi.org/10.1145/3325112.3325252
Clemmensen, L. H., & Kjærsgaard, R. D. (2022). *Data Representativity for Machine Learning and AI Systems*.
Danielle K. Citron, & Robert Chesney. (2019). Deepfakes and the New Disinformation War. *Foreign Affairs*.
Ettinger, A. (2020). What BERT Is Not: Lessons from a New Suite of Psycholinguistic Diagnostics for Language Models. *Transactions of the Association for Computational Linguistics*, *8*, 34–48. https://doi.org/10.1162/tacl_a_00298
Falkenberg, M., Zollo, F., Quattrociocchi, W., Pfeffer, J., & Baronchelli, A. (2024). Patterns of partisan toxicity and engagement reveal the common structure of online political communication across countries. *Nature Communications*, *15*(1), 9560. https://doi.org/10.1038/s41467-024-53868-0
Ferrara, E. (2024). *Charting the Landscape of Nefarious Uses of Generative Artificial Intelligence for Online Election Interference*.
Ferrara, E., Varol, O., Davis, C., Menczer, F., & Flammini, A. (2016). The rise of social bots. *Communications of the ACM*, *59*(7), 96–104. https://doi.org/10.1145/2818717
Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., Luetge, C., Madelin, R., Pagallo, U., Rossi, F., Schafer, B., Valcke, P., & Vayena, E. (2018). AI4People—An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations. *Minds and Machines*, *28*(4), 689–707. https://doi.org/10.1007/s11023-018-9482-5
Gomes, N. D. (2001). *Persuasive forms of political communication: political propaganda and electoral advertising* (Vol. 3). Edipucrs.
Grattafiori, A., Dubey, A., Jauhri, A., Pandey, A., Kadian, A., Al-Dahle, A., Letman, A., Mathur, A., Schelten, A., Vaughan, A., Yang, A., Fan, A., Goyal, A., Hartshorn, A., Yang, A., Mitra, A., Sravankumar, A., Korenev, A., Hinsvark, A., … Ma, Z. (2024). *The Llama 3 Herd of Models*.
Haupt, M. R., Yang, L., Purnat, T., & Mackey, T. (2024). Evaluating the Influence of Role-Playing Prompts on ChatGPT's Misinformation Detection Accuracy: Quantitative Study. *JMIR Infodemiology*, *4*, e60678. https://doi.org/10.2196/60678
Hongladarom, S. (2023). Shoshana Zuboff, The age of surveillance capitalism: the fight for a human future at the new frontier of power. *AI & SOCIETY*, *38*(6), 2359–2361. https://doi.org/10.1007/s00146-020-01100-0
Howard, P. N., & Kollanyi, B. (2016). *Bots, #StrongerIn, and #Brexit: Computational Propaganda during the UK-EU Referendum*.
Ian Goodfellow, Yoshua Bengio, & Aaron Courville. (2016). Deep Learning. *Http://Www.Deeplearningbook.Org*.
Kent, M. L., & Li, C. (2020). Toward a normative social media theory for public relations. *Public Relations Review*, *46*(1), 101857. https://doi.org/10.1016/j.pubrev.2019.101857
Knoth, N., Tolzin, A., Janson, A., & Leimeister, J. M. (2024). AI literacy and its implications for prompt engineering strategies. *Computers and Education: Artificial Intelligence*, *6*, 100225. https://doi.org/10.1016/j.caeai.2024.100225
Kwak, N., Lane, D. S., Weeks, B. E., Kim, D. H., Lee, S. S., & Bachleda, S. (2018). Perceptions of Social Media for Politics: Testing the Slacktivism Hypothesis. *Human Communication Research*, *44*(2), 197–221. https://doi.org/10.1093/hcr/hqx008
Lazer, D. M. J., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., Metzger, M. J., Nyhan, B., Pennycook, G., Rothschild, D., Schudson, M., Sloman, S. A., Sunstein, C. R., Thorson, E. A., Watts, D. J., & Zittrain, J. L. (2018). The science of fake news. *Science*, *359*(6380), 1094–1096. https://doi.org/10.1126/science.aao2998
Olesya Tkacheva. (2013). *Electoral Fraud Social Media and Whistle*. https://ssrn.com/abstract=2334521
Roy, M. (2017). Cathy O'Neil. Weapons of Math Destruction: How Big Data Increases Inequality and

Threatens Democracy. New York: Crown Publishers, 2016. 272p. Hardcover, $26 (ISBN 978-0553418811). *College & Research Libraries*, *78*(3), 403. https://doi.org/10.5860/crl.78.3.403
Santana, J., Santana, M., Sampaio, P., & Brito, K. (2024). Towards a Methodology for Analyzing Visual Elements in Social Media Posts of Politicians. *Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance*, 366–373. https://doi.org/10.1145/3680127.3680218
Santos, É. L. D. (2023). Coronelismo e clientelismo: ecos na sociedade brasileira nas eleições presidenciais (Brasil 2018-2022). In *https://hdl.handle.net/11449/256121*. Faculdade de Ciências Humanas e Sociais, Universidade Estadual Paulista "Júlio de Mesquita Filho."
Schmitt, M., & Flechais, I. (2023). Digital Deception: Generative Artificial Intelligence in Social Engineering and Phishing. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4602790
Shrestha Basu Mallick, & Logan Kilpatrick. (2025, February 5). *Gemini 2.0: Flash, Flash-Lite and Pro*. Https://Developers.Googleblog.Com/En/Gemini-2-Family-Expands/.
Steiner, A., Pinto, A. S., Tschannen, M., Keysers, D., Wang, X., Bitton, Y., Gritsenko, A., Minderer, M., Sherbondy, A., Long, S., Qin, S., Ingle, R., Bugliarello, E., Kazemzadeh, S., Mesnard, T., Alabdulmohsin, I., Beyer, L., & Zhai, X. (2024). *PaliGemma 2: A Family of Versatile VLMs for Transfer*.
Straub, V. J., Morgan, D., Bright, J., & Margetts, H. (2022). *Artificial intelligence in government: Concepts, standards, and a unified framework*.
Sun, T. Q., & Medaglia, R. (2019). Mapping the challenges of Artificial Intelligence in the public sector: Evidence from public healthcare. *Government Information Quarterly*, *36*(2), 368–383. https://doi.org/10.1016/j.giq.2018.09.008
Superior Electoral Court. (2024). *Statistics*. Https://Pardal.Tse.Jus.Br/Pardal-Web/Pages/Estatisticas/Dashboard.Faces.
Woolley, S. C., & Howard, P. N. (2018). *Computational Propaganda* (S. C. Woolley & P. N. Howard, Eds.; Vol. 1). Oxford University Press. https://doi.org/10.1093/oso/9780190931407.001.0001

Track 18: Sustainable and Ethical Public Service Co-Creation

Track Description

The track aimed to provide insights into how these approaches can promote social cohesion, reduce inequalities, and create resilient public administration systems that effectively address diverse societal needs. The growing complexity and evolving requirements of public services pose significant challenges for the public sector, including issues of citizen satisfaction, trust, and limited resources. There is a rising demand for more personalized, citizen-centric services and a shift from viewing policy-making and public service delivery as top-down processes. This track delves into the comprehensive phenomenon of public service co-creation, encompassing both analog and digital forms, in which citizens and stakeholders actively participate in defining, designing, and evaluating public services. The track explores the interplay between traditional methods and digital innovations, including the impact of digital tools and AI in facilitating co-creation. It also examines how digital and AI technologies can enhance public value by improving service quality, broadening opportunities for participation, and ensuring that services align with diverse citizen needs, all while upholding ethical standards and ensuring sustainability.

Track Chairs

N. Rizun, University of Technology, Poland
N. Edelmann, University of Continuing Education Krems, Austria

Contents

AI-enabled co-creation for evidence-based policymaking: A conceptual model 1165
N. Rizun, N. Edelmann, T. Janowski, and A. Revina

Collaborative Governance for the Construction of Public Policies on Social Sustainability 1180
S. Callegaro

Evaluation of Public Services Through the Lens of Digital Ethics 1194
N. Andreasyan, D. Buson, J. Mancera, E. Portmann, and L. Terán

AI-enabled co-creation for evidence-based policymaking: A conceptual model

Nina Rizun [a*], *Noella* Edelmann [b], *Tomasz* Janowski [c], *Aleksandra* Revina [d]

[a] Gdańsk University of Technology, Gdańsk, Poland, nina.rizun@pg.edu.pl, ORCID 0000-0002-4343-9713

[b] University for Continuing Education, Krems, Austria, noella.edelmann@donau-uni.ac.at, ORCID 0000-0001-8386-9585

[c] Gdańsk University of Technology, Gdańsk, Poland and University for Continuing Education, Krems, Austria, tomasz.janowski@pg.edu.pl, ORCID 0000-0001-8950-5782

[d] Brandenburg University of Applied Sciences, Brandenburg an der Havel, Germany, revina@th-brandenburg.de, ORCID 0000-0002-8405-0018

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. This study focuses on developing and validating the key parameters of Artificial Intelligence (AI) -enabled co-creation integrated into evidence-based policymaking. We critically analyzed prior research to ensure a participatory, data-driven, and iterative policymaking process. We identified essential parameters shaping AI-enabled co-creation processes in public sector organizations (PSOs), including legal conformance, sustainability, and ethics. The parameters were validated and refined through a workshop with experts from academia and technology organizations, contributing to the development of a conceptual model structured around four interconnected co-creation phases: 1) co-commissioning; 2) co-designing; 3) co-delivering; and 4) co-assessing. Our study contributes to both theory and practice. Concerning theory, it positions AI-enabled co-creation as a core institutionalized process within evidence-based policymaking rather than a standalone participatory practice. It also introduces a key conceptual distinction between digital co-creation, where digital tools facilitate participatory processes, and digital public service co-creation, where digital solutions are the co-creation outcomes. Concerning practice, the study provides a structured framework for integrating co-creation into policymaking, aligning AI-enabled mechanisms with four identified policy co-creation phases. The framework offers policymakers and public administrators actionable guidance on designing adaptive, stakeholder-driven, AI-supported policy solutions

Keywords. Co-creation, Evidence-based policymaking, Artificial Intelligence, Public sector.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.991

1. Introduction

Several European policy declarations, such as the (Tallinn Declaration, 2017), place users' needs at the center of service design, and encourage the use of digital tools to strengthen the users' participation. In addition, the (Berlin Declaration, 2020) urges policymakers to draw from the lessons learned during the COVID-19 pandemic to achieve a sustainable digital transformation that serves citizens, businesses, and society. These declarations highlight the need for sustainable, ethical, and digital co-creation in policymaking, i.e. creating rules, regulations, and guidelines to address specific issues or achieve defined objectives by governments or other institutions. The increased availability of data, research, and a growing public focus on results have expanded policymakers' ability to assess whether public investments achieve their intended outcomes and to make informed choices. When policymaking is rooted in systematic, evidence-based approaches that leverage available data and research for decision-making, it is referred to as evidence-based policymaking (Evidence-Based Policymaking Collaborative, 2016).

According to (Head, 2010a), reliable knowledge is the key instrument for advising decision-makers, taking decisions, and developing policies, and four key principles to support this approach are: 1) compiling rigorous evidence about what works, including costs and benefits; 2) monitoring and evaluating policy effectiveness; 3)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

using evidence to refine and improve programs; and 4) fostering innovation through experimentation with new approaches. Head (2010a) also notes that integrating evidence into policymaking is a complex and multifaceted process that requires ongoing improvements, and closer integration with research is often "disappointing" (p. 78), i.e. the "hopes of large and rapid improvements in policies and programs […] have not materialized as readily as anticipated" (p.80). He, therefore, suggested that there are four enabling factors that must be included in any evidence-based policymaking process: high-quality information, professionals skilled in data analysis and policy evaluation, political and organizational incentives for using evidence-based analysis and advice, and mutual understanding between policy professionals, researchers and decision-makers.

(Fedorowicz & Aron, 2021) suggest that evidence-based policymaking can be strengthened by increasing the production of evidence, enhancing its use, and applying equity and justice to both evidence generation and decision-making processes. This emphasis on evidence-based policymaking aligns strongly with the concept of co-creation, i.e. shifting the focus of public service reform away from internal efficiency to creating value for citizens and service (Osborne et al., 2016). Co-creation research highlights its benefits for fostering citizen engagement and improving service delivery (Ansell & Torfing, 2021; Eseonu, 2022; Scognamiglio et al., 2023), but the knowledge of the enabling factors that contribute to successful co-creation processes and outcomes within PSOs is limited. Additionally, the role of co-creation within evidence-based policymaking remains underexplored.

At the same time, the increasing integration of digital tools, particularly AI, into co-creation processes introduces further complexities. While AI has the potential to enhance decision-making, stakeholder collaboration, and service delivery, it also raises transparency, fairness, data privacy, and other ethical concerns. These issues are often overlooked, leading to the erosion of public trust, reinforcing societal inequalities, and other risks. To address these challenges, there is a critical need to explore how ethical governance can be embedded within co-creation frameworks. Furthermore, ethical co-creation should not only deliver immediate value but also contribute to long-term societal, economic, and environmental objectives. However, research on co-creation for sustainable policymaking is underdeveloped. There is limited investigation into processes that generate enduring outcomes and their alignment with sustainability objectives and limited research on how AI-enabled co-creation can be systematically embedded into the policymaking cycle by PSOs. Additionally, the absence of standardized guidelines and legal frameworks further complicates realizing ethical and sustainable co-creation.

This study has two objectives to address this gap: to identify and define the key parameters of AI-enabled co-creation for evidence-based policymaking; and to develop a conceptual model that integrates AI-driven co-creation with policymaking processes. To this end, we carried out a critical analysis of previous research to identify and define the key parameters of AI-enabled co-creation in evidence-based policymaking. We also organized an expert workshop involving academic and technology professionals to validate the parameters uncovered by the research analysis and develop the conceptual model of AI-enabled co-creation for evidence-based policymaking.

This work makes some important contributions. First, it advances the understanding of AI-enabled co-creation in evidence-based policymaking by proposing an integrated policymaking process that aligns AI-driven co-creation mechanisms with four interconnected policymaking phases. Second, it highlights AI's role in enhancing evidence collection, stakeholder engagement, and decision-making responsiveness in each phase. Also, the findings emphasize the importance of distinguishing between digital co-creation and the co-creation of digital public services in PSOs, addressing the challenges of integrating AI into these processes and achieving effective outcomes. Third, the study provides a structured framework for policymakers and administrators to design adaptive, user-centered, and data-driven public policies, strengthening participation, trust, and effectiveness of such policies.

The remainder of the paper is structured as follows. Section 2 outlines the theoretical background and concepts underpinning the identification of the conceptual model's key parameters. Section 3 provides information on the research design and methods. Section 4 presents the identification and validation of the key parameters and the development of the conceptual model. Section 5 concludes with the main findings, limitations and research plans.

2. Background and concepts

The public sector is facing an increasing demand for citizens-centered services and policies (Wiktorska-Święcka, 2018), aligned with their specific needs and circumstances (Bovaird & Loeffler, 2012). A shift is becoming visible, policy-making and public service delivery can no longer be seen as unilateral processes (Needham, 2008), and the government should no longer be seen as the sole public service and public value provider (Brandsen et al., 2018). The dominant view of citizens as passive consumers of public sector outcomes has been replaced by a view of citizens as co-creators (Osborne, 2018; Voorberg et al., 2017). This clearly outlines the growing need to allow citizens to actively participate in defining appropriate public services, shaping policy-making processes and influencing their outcomes. As mentioned above, four enabling factors to be included in evidence-based policy-making are high-quality information, skilled professionals, political and organizational incentives, and the mutual understanding between the stakeholders involved (Head, 2010). Co-creation can support this by considering misdirected stakeholder involvement, exclusion of the key actors, and reduced authority among public officials

(Edelmann & Virkar, 2023). Ethical data governance, stakeholder coordination, and transparent accountability are essential to preventing excessive personalization, information overload, and unclear decision-making. Failure to address these issues may undermine future engagement (Edelmann & Mureddu, 2023). Strong political and managerial leadership is crucial to fostering citizen-centric, co-creative governance (Meijer, 2016; Osborne, 2006).

This section addresses the first objective, to identify and define the key parameters underpinning AI-enabled evidence-based policymaking in the context of co-creation. Parameters, a term common in mathematics, computer programming and AI, are the variables in a model, system or function to help define the expected behavior and performance. They can be adjusted, e.g., during a training process to minimize prediction errors. These parameters and the sections covering them are public sector co-creation (Section 2.1), co-creation processes and outcomes (Section 2.2), and five sections on public sector co-creation and: digital tools (Section 2.3), AI (Section 2.4), evidence-based policymaking (Section 2.5), sustainability (Section 2.6), and ethics (Section 2.7).

2.1. Public sector co-creation

The co-creation paradigm is becoming increasingly popular. It aims to transform the public sector from an authority and service provider into an arena for engaging citizens and public and private actors and mobilizing experiences, resources and ideas of a plurality for the design and production of public services and public policy (Osborne, 2018; Ostrom et al., 1978). Co-creation enhances public value by improving service quality, expanding participation, refining information accuracy, and increasing citizen satisfaction (Cordella et al., 2018). It can be structured into several phases, e.g. co-design, co-delivery, and co-evaluation or co-assessment, each having specific characteristics and operational mechanisms (Linders, 2012)(Jaspers & Steen, 2021). Other models introduce four phases: co-commissioning, co-designing, co-delivering and co-assessment (Loeffler & Bovaird, 2019). The co-design phase engages stakeholders in the creation and development of policies or services, including their perspectives in shaping the outcomes. The co-delivery phase fosters greater acceptance of public policies and services by involving stakeholders in their implementation (Sicilia et al., 2016). Lastly, the co-evaluation phase focuses on assessing the effectiveness of services post-delivery or policies/initiatives after the implementation, providing valuable insights for self-learning and adaptation. These phases aim to ensure user-centric experiences, increase trust in public administrations and enhance communication between service providers and users, enabling administrations to gather stakeholder data but also increase service users' willingness to accept and use the service. However, the sustainability of co-creation depends on ensuring adequate financial resources and institutional capacities, which are essential for ensuring continuous stakeholder engagement and their meaningful integration into decision-making (Misuraca et al., 2020; Rodriguez Müller et al., 2021a).

2.2. Co-creation processes and outcomes

A co-creation process allows "two or more public and private actors [to] solve a shared problem, challenge, or task through a constructive exchange of different kinds of knowledge, resources, competences, and ideas that enhance the production of public value […], or services, either through a continuous improvement of outputs or outcomes or through innovative step-changes that transform the understanding of the problem or task at hand and lead to new ways of solving it" (Torfing, et al 2019, p. 802). According to Torfing et al. (2019), co-creation is a process. It can also be seen as an outcome. Co-creation thus leads to the creation of effects that endure, even after the co-creation activity itself has come to an end (Jaspers & Steen, 2021), contributes to the development of collaborative practices in an organization, as well as user acceptance of public services and technologies. Edelmann and Steen (2023) show that according to the stakeholders, the co-creation of digital public services involves identifying technology needs and gaps, supporting innovation, capacity-building, and dissemination. Stakeholders point out that ensuring the sustainability of co-creation requires organizational change regarding technical support arrangements, organizational processes and developing expertise. At the same time, the relationship with external stakeholders must be developed and sustained, and all stakeholders must engage in continuous learning. It is also important to consider the technical or financial risks of co-creation, to address any bias appearing during the co-creation process and in the outcomes achieved (Edelmann & Virkar, 2023; Jacobs et al., 2018).

2.3. Public sector co-creation and digital tools

As analog public services remain widely used, non-digital co-creation tools continue to play a significant role, particularly in the early stages of service and policy design. These tools are especially prevalent for ideation and collaboration (Borum et al., 2014; Inie & Dalsgaard, 2017), leveraging interviews, surveys, focus groups, and meetings (Peters et al., 2021). However, PSOs increasingly adopt digital tools to deliver public services and broaden user engagement in co-creation processes (Edelmann & Pereira, 2024). The digitalization of PSOs offers a potential solution to co-creation, even when users are vulnerable or hard to reach (Jalonen et al., 2021). Digital tools have become integral to co-creation, enabling online debates, collaboration, and crowdsourcing, supporting new digital public services and informing policy-making (Edelmann & Mergel, 2021). These initiatives utilize forums, collaborative websites, SMS, mobile applications, online surveys, and other tools (Rodriguez Müller et al., 2021b). Moreover, digital technologies empower users to create, edit, and evaluate content (Kaplan & Haenlein, 2010), and facilitate interactions, facilitating the sharing of information, opinions, and interests (Khan et al., 2014). Within the

public sector, digital tools foster innovative approaches to processes that deliver public value (Lember, 2017). Their dynamic nature enables citizens to contribute data, participate in creating new products and services, and address resource constraints (Randma-Liiv & Vooglaid, 2019). Enhancing motivation to participate, encouraging contributions, and promoting shared decision-making add value for public stakeholders (Brandsen et al., 2018; Lember et al., 2019). However, digital tools do not deliver effective participation or collaboration alone (Kreijns et al., 2003). Power imbalances, knowledge gaps, digital literacy disparities and other social and organizational barriers hinder co-creation in PSOs (Ståhlbröst & Holst, 2017). Poor channels, inaccessible interfaces, unstructured data, etc. limit engagement (Mejlgade Lab, 2017; Popescul et al., 2024). Ethical concerns over privacy call for user-centered approaches to building trust (Edelmann & Mureddu, 2023). Digitalization may also reduce transparency in administrative processes, replacing human interactions with automated systems, and marginalizing citizens by treating them as data points rather than individuals with needs and rights (European Union, 2024).

2.4. Public sector co-creation and Artificial Intelligence

The use of AI enables public service innovation and citizen involvement in the co-creation process. As Misuraca et al. (2020) highlight, AI-supported co-creation can lead to cost savings, improved service quality, higher user satisfaction, greater inclusivity, and broader societal benefits. Key enablers such as leadership, financial resources, stakeholder engagement, and digital infrastructure (Edelmann & Mureddu, 2023) align with AI's capabilities to enhance public service co-creation. Numerous cases confirm AI's role in enabling co-creation across boundaries, fostering interaction between service providers and service users (Ali et al., 2022; Manser Payne et al., 2021; Rizun et al., 2023). (Rizun et al., 2025) also revealed a disproportionate and fragmented development of AI-supported co-creation, particularly in text analytics (TA) which is predominantly used in the co-design phase. This is due to the effectiveness of TA techniques such as content analysis and pattern recognition, along with question-answering systems that enhance consultation and ideation (Cortés-Cediel et al., 2023; Rodriguez Müller et al., 2021b). TA applications in the co-evaluation phase remain limited, primarily focused on sentiment analysis and feedback prioritization, facing the challenges of explainability, domain adaptation, and human oversight (Ojo et al., 2024). The co-delivery phase, hindered by underdeveloped theoretical and legal frameworks, lack of governmental accountability, and low awareness among practitioners, exhibits the least AI applications (Linders, 2012). Addressing these disparities is crucial for AI to support all co-creation phases, enabling a more holistic and effective public service model. However, challenges regarding data quality, sensitivity, completeness, and accessibility remain. While most studies focus on technical issues, ethical concerns such as bias mitigation, accountability, and transparency remain underexplored. This highlights the urgent need for best practices and regulatory frameworks to ensure that AI-enabled co-creation aligns with ethical principles, fostering trust, security, and governance (European Commission, 2021; van Noordt et al., 2023).

2.5. Public sector co-creation and evidence-based policymaking

Evidence-based policy promotes rigorous analysis of service and policy options to improve decision-making quality (Head, 2010b). While traditional decision-making features "bargaining, entrenched commitments, and the interplay of diverse stakeholder values and interests" (p.77), evidence-based policymaking incorporates "rigorous research evidence into public policy debates and internal public sector processes" (Head, 2010a). Integrating evidence into policymaking requires systematic mechanisms to enhance its effectiveness. In the public sector, evidence-based policymaking relies on two forms of evidence: 1) factual, statistical, and scientific data that assess whether policies and initiatives function effectively; and 2) contextual insights that evaluate how policies work across social groups and environments (Sanderson, 2002). Four evidence-based policymaking principles are: 1) compiling evidence on what works, costs and benefits; 2) monitoring and evaluating policy effectiveness; 3) using evidence to refine and improve programs; and 4) fostering innovation and experimentation in policymaking (Head, 2010). Strengthening evidence-based policymaking requires enhancing evidence production, improving research finding applications, and bringing equity to evidence generation and policy design (Fedorowicz & Aron, 2021). The emphasis on evidence-driven decision-making aligns with co-creation, i.e. stakeholders contributing information, experiences, and expertise collaboratively. In AI-enabled co-creation, citizens design, deliver, and evaluate public initiatives, connecting policymakers and society. Such co-creation serves two roles: 1) generating evidence that reflects real-world policy impact and stakeholder needs; and 2) leveraging AI-powered analytics to support responsive, data-informed governance (BPC Policy Center, 2019). At the co-design stage, co-creation integrates stakeholder perspectives, ensuring that an understanding of societal needs informs policy formulation. AI amplifies this process by analyzing large-scale datasets, forecasting policy impacts, and identifying challenges, allowing to tailor solutions to evidence-based insights**.** During co-delivery, collaboration between governments, organizations, and citizens enables real-time policy adaptation. AI-driven decision support systems help PSOs respond to evolving conditions and stakeholder feedback. During co-evaluation, co-creation fosters a learning cycle, where stakeholder input and AI-powered analytics enhance policy assessment, ensuring that policies remain relevant, responsive, and aligned with evolving priorities (Gertler et al., 2016). Embedding AI in co-creation allows policymakers access to context-specific, real-time insights that support transparent, accountable, and adaptive governance (Mahmoud et al., 2023). AI-driven analytics refines decision-making, justifies policy actions, identifies unintended consequences, and ensures inclusivity (Flores et al., 2022; Ojo & Rizun, 2021). Thus, AI-enabled co-creation enables evidence-

based policymaking, stakeholder engagement and institutional capacity for data-driven decision-making.

2.6. Public sector co-creation and sustainability

The expanding use of AI in PSOs has created opportunities to redefine interactions among public administrations, citizens, and stakeholders, contributing significantly to sustainability goals and fostering better governance. Sustainability is about supporting, maintaining, and preserving what is valuable (Türke, 2012). It endures over time, supported by collaborations, flexible processes, and citizens' involvement in co-creation, which collectively lead to valuable and lasting outcomes (Jaspers & Steen, 2019). The collaborative nature of co-creation fosters long-term value creation, responsiveness to diverse social needs, and enduring societal benefits; it aligns with sustainability (Thomsen, 2013). These principles resonate with the UN 2030 Agenda and the Sustainable Development Goals (SDGs), which emphasize stakeholder engagement, inclusiveness, and resource efficiency as essential pathways to sustainable development (United Nations, 2015). Facilitated by co-creation, evidence-based policymaking enhances sustainability by aligning immediate actions with long-term goals and addressing diverse needs through reliable data and ethical practices (Edelmann et al., 2023; Edelmann & Voigt, 2024). AI can support these efforts but needs an ethical focus to ensure transparency, accountability, inclusiveness, and building trust among the stakeholders (Edelmann & Virkar, 2023; Rizun et al., 2025).

2.7. Public sector co-creation and ethics

Organizations increasingly emphasize a shift from collaborative knowledge to co-creation, as the latter bridges the research-practice gap and increases stakeholder empowerment (Mahmoud et al., 2023). Co-creation should involve the end-users from beginning to end; this will impact the implementation and acceptance of the service by the end-users and increase trust in the provider (PSO). Such collaboration should be not only equitable but also ethical. Relevant frameworks include the Good Practice Principles for Data Ethics in the Public Sector, emphasizing the trustworthy use of data in digital government (OECD, 2021), OECD Principles for Managing Ethics in the Public Service to improve effective public sector governance (OECD, 2016), OECD recommendations aimed at anti-corruption and public sector integrity (OECD, 2022), or the Australian framework for professional conduct and public interest (NSW Public Service Commission, 2022). The European Court of Auditors found out that EU institutions have adequate ethical frameworks but there is no common EU ethical framework to govern the work of the Member States and their representatives. In 2019, the European High-Level Expert Group on AI presented the Ethics Guidelines for Trustworthy AI, highlighting that trustworthy AI should be lawful, ethical, and robust (European Commission, 2019). Whilst public participation is a legal right in Europe, and there are guidelines for conducting such participation, the same cannot be said for co-creation (Banisar et al., 2011; European Environment Agency, 2023; Giannelos et al., 2024; Pevkur et al., 2018).

2.8. Research gap

The analysis of existing literature documented in previous sections uncovered a broad spectrum of studies that: 1) explore the role of co-creation in public service delivery, emphasizing its potential for fostering citizen engagement and improving policy outcomes, and 2) investigate the integration of digital tools, particularly AI, in co-creation, highlighting its capacity to enhance decision-making, collaboration, and efficiency in policymaking. Conceptual insights derived from sections 2.1 to 2.7 are synthesized in Table 1.

Tab. 1 – Conceptual insights on AI-enabled co-creation for evidence-based policymaking

Label	Insight	Section
CI1	Co-creation should be understood as an iterative phase-based process relying on collaboration, feedback loops, and adaptation, generating tangible public value, such as improved service quality, strengthened trust, and greater inclusivity.	2.1
CI2	A comprehensive understanding of co-creation as both a process and an outcome is essential for effective public sector innovation and meaningful stakeholder engagement.	2.2
CI3	The intertwined social, organizational, financial, and technical challenges underscore the need for a systematic approach to integrating digital tools into co-creation processes.	2.3
CI4	Establishing a rigorous legal and regulatory framework that addresses potential risks, ensures that AI applications align with ethical principles and standards, and facilitates a seamless transition to effective AI-enabled public sector co-creation is essential.	2.4
CI5	Co-creation facilitates evidence-based policymaking, leveraging AI's transformative potential to enhance informed decision-making and stakeholder collaboration.	2.5
CI6	Achieving sustainability requires recognizing the continuity of the co-creation processes and outcomes, which address immediate challenges while fostering long-term societal benefits.	2.6
CI7	Whilst co-creation is often regulated by the regional, national and supranational legal frameworks, a dedicated ethical framework to guide co-creation practices is needed.	2.7

However, this analysis also revealed a significant gap in understanding how AI-enabled co-creation operates within PSOs and how it contributes to evidence-based policymaking. While co-creation has gained recognition in public service innovation, its role as a structured, integrating mechanism for participatory, data-informed, and adaptive policymaking remains underexplored. Despite the increased emphasis on evidence-based policymaking, where rigorous research, data availability, and systematic evaluation guide decision-making, the link between AI-driven co-creation and its impact on policy formulation, implementation, and evaluation remains unclear. Additionally, policy initiatives such as the Tallinn Declaration (2017) and the Berlin Declaration (2020) emphasize the importance of user-centered service design, participatory governance, and digital transformation in policymaking. However, existing research lacks a clear framework on how co-creation can systematically shape policies, ensuring that such policies are informed by diverse stakeholder inputs, AI-driven insights, and sustainability considerations.

3. Research design

To address the research gap uncovered in Section 2 and defined in Section. 2.8, this study explores the role of AI-enabled co-creation in PSOs to contribute to evidence-based policymaking. Its objectives are:

O1. To identify and define the key parameters of AI-enabled co-creation for evidence-based policymaking
O2. To develop a conceptual model that integrates these parameters, contributing to a structured framework for understanding co-creation as both a process and an outcome in evidence-based policymaking

The study adopted four steps to meet these objectives.

First, existing literature was critically analyzed to identify and define the key parameters of AI-enabled co-creation for evidence-based policymaking. The outcome is documented in Section 2 and synthesized in the form of seven conceptual insights in Table 1. In turn, these insights will serve as the foundation for defining the key parameters of an AI-enabled co-creation model in Section 4.1.

Second, a workshop involving experts from academia and technology organizations was organized to validate the literature-based parameters; the results are documented in Section 4.2. To help develop the conceptual model for AI-enabled co-creation for evidence-based policymaking, the results are also documented in Section 4.3. The workshop formula was selected to enable small group discussions, guided by a moderator, to gather experts' views on the parameters, the model, and any additional perspectives (Gottesdiener, 2002). The workshop formula is also commonly used in co-creation to reflect a democratic decision-making process (Andersen & Jæger, 1999). Specifically, the workshop was organized online in January 2025, bringing together nine experts from academia and technology organizations. Experts were invited from diverse fields, including public administration, academia, and technology organizations (see Table 2), ensuring a comprehensive, interdisciplinary perspective. A detailed presentation was provided to establish a shared understanding of the parameters and the model among participants. The parameters were based on the systematic literature review and (Rizun et al., 2025).

Third, to facilitate iterative discussions on the model and assess its applicability to real-world scenarios, workshop participants were asked to complete a structured questionnaire via Google Forms, designed based on the workshop presentation. The questionnaire comprised one closed and eight open-ended questions, designed to validate the key parameters of the conceptual model and gather expert insights. It began with a closed question to assess the experts' agreement with Edelmann and Virkar's (2023) definition of sustainability. Next, evidence-based policy was explored based on the outcomes by Head (2010). The experts were asked whether these outcomes fully captured the scope of evidence-based policymaking and invited to propose additional outcomes. Ethics in public sector co-creation was another focal point, with participants identifying the key ethical frameworks applicable to public administration. The questionnaire then addressed digital co-creation, asking respondents to highlight significant issues, suggest appropriate communication channels, identify key stakeholders, and propose potential funding sources for co-creation activities. The role of AI in public sector co-creation was another area of inquiry. Experts were asked to specify functions and processes that could be delegated to AI and to outline perceived challenges and risks associated with AI integration in co-creation efforts.

Fourth, from the workshop, the discussion protocol, memo notes, and expert survey responses were analyzed using thematic analysis (Naeem et al., 2023), a process for deriving conceptual models from qualitative research findings. The insights gathered from the workshop and questionnaire, serving as validation instruments, contributed to refining the model by incorporating experts' perspectives on its key parameters. The thematic analysis followed two stages. First, validating and refining the key parameters that form the foundation of the conceptual model. Second, developing the model by systematically mapping AI-enabled co-creation phases and their mechanisms onto the evidence-based policymaking process and integrating this process with the identified key parameters.

Tab. 2 – Profiles of the workshop participants

ID	Organization	Area of expertise	Years of expertise
E1	academia	Computational analysis, artificial intelligence, policy analysis, public service co-creation	23
E2	academia	Digital government, digital inclusion, sustainable development	20
E3	academia	e-Governance, in particular organizational change and digital transformation in public sector organizations, new ways of working, engagement practices, sustainability	25
E4	academia	New information/computation paradigms, trustworthy software infrastructures, citizen-centered digital services	25
E5	academia	Data modeling ontologies, e-governance, public administration, information systems interoperability	15
E6	academia	Computational linguistics, NLP, ML for text mining, responsible AI, disinformation, propaganda detection	30
E7	academia	Business administration, business process management, linguistics	10
E8	academia	Computer science, decision support systems, data mining, business process management	25
E9	academia	Education internationalization, project management, implementation of international projects	20

4. Results

This section addresses the second objective to develop a conceptual model that integrates identified parameters of AI-enabled co-creation for evidence-based policymaking, contributing to a structured framework that conceptualizes co-creation as both a process and an outcome in this context.

4.1 Conceptual model parameters

Based on the conceptual insights from the literature review (Section 2), five parameters of co-creation for evidence-based policymaking in PSOs were identified, providing the foundation for the conceptual model.

The first is the structure of the public policy and service creation process, represented as a continuous iteration of commissioning, designing, delivering, and evaluating (CI1). Adopting a "co-" approach – co-commissioning, co-designing, co-delivering, and co-evaluating – enriches this process by fostering collaboration, shared expertise, and leveraging diverse perspectives to enhance the quality and legitimacy of public decision-making.

The second parameter is the co-creation impact, emphasizing the tangible and structural effects of the process. Beyond being a key enabler and guiding principle, co-creation drives measurable public sector outcomes (CI2) by shaping overarching institutional and specific co-creation-related results. These include: 1) social impact by addressing the needs of diverse groups, including the vulnerable, by tailoring policies and services to their specific needs; 2) innovation by encouraging creative solutions that incorporate diverse stakeholder insights and leverage advanced technologies like AI; 3) efficiency by streamlining resource allocation and policymaking through participatory and data-informed processes; and 4) organizational transformation by facilitating cultural and structural changes within PSOs to adapt to dynamic societal needs.

The third parameter represents the enablers of evidence-based policymaking – leadership, financial support, stakeholder engagement, and technologies like AI (CI3), essential for operationalizing co-creation. While leadership, financial support, and stakeholder engagement provide the necessary governance, resources, and collaborative mechanisms, AI enhances the process by enabling predictive modeling, trend analysis, and improved stakeholder communication. Together, these enablers ensure that the co-creation process is structured and adaptive, empowering PSOs to address complex policy challenges.

The fourth parameter represents the core principles of co-creation for evidence-based policymaking – ethics (CI4), evidence-based decision-making (CI5), and sustainability (CI6), together ensuring that co-creation is participatory, impactful, and aligned with long-term goals. Ethics safeguards transparency, accountability, and inclusivity, fostering trust among stakeholders and reinforcing the integrity of the co-creation process within public sector governance. Sustainability underscores the continuity and adaptability of co-creation processes, ensuring their longevity and inclusiveness while driving the co-creation of sustainable policy outcomes that address immediate challenges and foster enduring societal benefits. Evidence-based decision-making ensures that co-creation is guided by reliable data and insights, strengthening the effectiveness and legitimacy of the process.

Finally, the fifth parameter makes sure that the entire co-creation framework for evidence-based policymaking in PSOs is underpinned by a strong legal and regulatory foundation (CI7) to ensure compliance, transparency, and accountability, particularly by responsibly integrating AI and other technologies. This foundation provides the structural integrity necessary for co-creation processes to produce meaningful results and flourish.

4.2 Validated conceptual model parameters

This section presents the results of expert validation of the parameters of AI-enabled co-creation for evidence-based policymaking proposed from the literature, allowing us to clarify, enrich and refine such parameters.

Core principle – Sustainability

Experts' insights enriched the definition of sustainability according to Edelmann & Virkar (2023), refining its applicability to AI-enabled public sector co-creation for evidence-based policymaking, leading to the following definition: "Taking into account that sustainability can be understood as meeting the needs of the present generation without compromising the ability of future generations to meet their own needs, sustainability should not only be about environmental and social impact but be adaptable to different contexts, retaining its value over time, leading to new ways of working in organizations, and include any artifacts created for the long term. Thus, sustainable processes and outcomes are those that have long-term benefits, where technology and AI act as key enablers, supporting new ways of working, enhancing efficiency and innovation, and ensuring long-term impact. To achieve sustainability, sustainable outputs must be defined beforehand, while mitigating risks such as bias and discrimination in digital technologies is essential to uphold fairness, inclusivity, and ethical co-creation".

Core principle - Ethics

An ethical co-creation framework must provide core values, standards of conduct, and accountability mechanisms: 1) transparency, accountability, fairness, and inclusion should be binding for all public employees and stakeholders involved in public sector co-creation, regardless of role or contract type; 2) while core values remain universal, ethical guidelines must adapt to different sectors, ensuring academic integrity and fairness in higher education, open engagement and trust in public administration, and data privacy, security, and bias mitigation in AI-enabled co-creation; 3) ethical frameworks must integrate rules of engagement, oversight mechanisms, and evaluation tools to ensure compliance and assess long-term impact; 4) ethical considerations should address both intended and unintended consequences, ensuring that co-creation processes account for future implications and the needs of directly- and indirectly-affected stakeholders (McKenna & Bargh, 1999). Experts also highlighted that existing ethical guidelines from research, innovation and AI could contribute to the ethical framework for co-creation (Dainow & Brey, 2021; Shneiderman, 2020, 2022; Thiebes et al., 2021). For a higher education context, ethical frameworks must focus on academic integrity, respect for intellectual property, fairness, inclusion, social responsibility and equality, and fair treatment of students and staff. The consequences framework, focusing on possible future effects of any course of action with consideration of directly- or indirectly-affected stakeholders (Gebru et al., 2021; Hardebolle et al., 2023; Reijers et al., 2018) may be particularly useful.

Enabler – AI and public sector co-creation

AI serves as a critical enabler for public sector co-creation by enhancing efficiency, automating repetitive tasks, and supporting evidence-based decision-making. Experts highlighted AI's role in: 1) process optimization, i.e. automating, monitoring, controlling, and adapting routine tasks and workflows; 2) data-driven insights, i.e. collecting, processing, and analyzing data, including sentiment analysis and scenario modeling; 3) decision-support mechanisms, i.e. providing evidence-based recommendations and simulating policy impacts; and 4) operational execution, i.e. assisting in communication, coordination, and execution of standardized processes. However, challenges in AI adoption within co-creation persist. Experts raised concerns about: 1) data quality and bias, as AI systems may draw on outdated or low-quality datasets; 2) transparency, security, and privacy risks in AI-driven decision-making; 3) over-reliance on automation, potentially reducing human oversight and accountability; 4) regulatory gaps, with a lack of governance frameworks for AI-based public services; and 5) public skepticism including unfounded fears and ethical concerns regarding AI's role in policymaking.

Enabler – Digital co-creation vs. co-creation of digital public services

Importantly, experts emphasized the need to clearly distinguish between digital co-creation and co-creation of digital public services, which imply different technological applications, stakeholder involvements, and governance structures. Digital co-creation refers to the use of digital technologies to enable co-creation activities. The outcome can be digital or non-digital. Digital co-creation emphasizes collaborative processes empowered by digital platforms, including participatory decision-making, citizen engagement, and collaborative problem-solving (Edelmann & Mergel, 2021; Rodriguez Müller et al., 2021b). This form of co-creation leverages digital tools such as crowdsourcing platforms, online forums, sentiment analysis, and social media to facilitate citizen participation

and improve service responsiveness (Brandsen et al., 2018). Digital co-creation includes five components: 1) technology as an enabler, i.e. digital tools supporting communication, collaboration, and decision-making, but not "prescribing" the nature of co-created public services (Lember, 2017); 2) stakeholder focus, i.e. inclusivity and accessibility for a diverse range of stakeholders (Bovaird & Loeffler, 2012); 3) ethical and governance principles, i.e. the organizations responsible for digital co-creation must adhere to ethical guidelines, ensuring data privacy, security, fairness, explainability, and human oversight (Edelmann et al., 2023); 4) sustainability and fairness, i.e. digital co-creation must support transparent, trust-based, and balanced collaboration, ensure that any biases are mitigated and decision-making is inclusive and participatory; 5) hybrid integration, i.e. digital tools should support virtual or face-to-face co-creation or involve physical co-creation efforts.

Co-creation of digital public services is an outcome-oriented process, where collaborative design, implementation, and refinement of digital solutions drive public sector service delivery and innovation (Linders, 2012). Unlike digital co-creation, where digital tools support participatory processes, the co-creation of digital public services focuses on building digital services. The process involves multi-sector collaborations, including partnerships between governments, private tech companies, and research institutions (Rodriguez Müller et al., 2021b). The services may include AI-powered administrative systems, digital identity verification, open data portals, smart governance platforms, etc. Key components of co-creating digital public services are: 1) technology as the core product, i.e. the results is the development of digital solutions, e.g. AI-driven services, digital governance platforms, and e-government applications (Torfing et al., 2019); 2) service innovation and scalability, i.e. developing new digital solutions that must be sustainable, adaptable, and accessible, ensuring long-term usability and cross-institutional integration (Wirtz et al., 2021); 3) regulatory and legal compliance, i.e. the development requires compliance with legal, ethical, and technical standards, ensuring security, transparency, and interoperability across PSOs (European Commission, 2021); 4) human oversight and trust-building, i.e. while AI-driven automation enhances service efficiency, the human intervention must remain central to validate AI-generated insights, prevent algorithmic biases, and ensure user trust in digital public services. Hence, by distinguishing between digital co-creation and co-creation of digital public services, our study underscores the diverse roles of digital technologies in public sector innovation. While digital co-creation helps engage citizens in service development in the broad sense, co-creation of digital public services focuses on the development and implementation of digital solutions.

Enabler – Co-creation channels of participation and communication

Effective co-creation requires context-sensitive, inclusive communication strategies that integrate traditional and digital channels to accommodate diverse engagement dynamics and stakeholder needs. Experts emphasized that no single channel is inherently superior; rather, the selection must be purpose-driven, contextually relevant, and aligned with accessibility principles. Traditional channels like public meetings, workshops, or printed materials foster deliberative engagement and trust-building in structured settings. Digital channels like social media, crowdsourcing platforms, or electronic coordination tools expand reach, facilitate real-time participation, and enhance analytical capabilities through AI-driven insights. Beyond communication modes, stakeholder composition is fundamental. Co-creation must intentionally engage a diverse ecosystem of citizens, policymakers, private sector actors, NGOs, technology firms, and academic institutions to ensure inclusive governance, equitable representation, and legitimacy. Prioritizing those most affected and investing in co-creation with them strengthens policy responsiveness, trust, and co-ownership of outcomes.

Enabler – Financial aspects of co-creation

Co-creation requires dedicated financial resources, but no additional financial burden should be placed on participants. A sustainable funding model should integrate multiple sources: 1) public funding – local, regional, and national governments should take the lead in financing co-creation initiatives; 2) private sector contributions – partnerships with businesses can provide funding, expertise, and technological support; and 3) international grants and foundations – funding from international organizations, NGOs, and philanthropic institutions can support long-term sustainability. Whilst the public sector should take the lead in implementing public sector co-creation, convincing them of the value and long-term benefits of such investments remains a critical challenge.

4.3 Conceptual model

Based on the workshop-produced insights, the process of AI-enabled co-creation for evidence-based policymaking was adapted from the process proposed by Head (2010) and operationalized to be iterative, participatory and co-created. Each co-creation phase was mapped onto specific evidence-based policy processes, demonstrating how stakeholder engagement, AI-driven analytics, and iterative policy refinement enhance transparency, inclusivity, and adaptability. Integrating AI into co-creation allowed PSOs to develop more informed, accountable, and citizen-centered policy decisions. Table 3 presents this integrated process, demonstrating how AI-enabled co-creation aligns with evidence-based policymaking across four phases: 1) co-commissioning vs. policy initiation; 2) co-designing vs. engaging, evidence-gathering, and policy planning; 3) co-delivery vs. policy delivery; and 4) co-assessment and co-evaluation vs. policy evaluation.

Tab. 3 – The process of AI-enabled co-creation for evidence-based policymaking

Co-creation vs. evidence-based policymaking	Co-creation phase	Evidence-based policy phase
Co-commissioning vs. policy initiation		
	Co-commissioning for early stakeholder involvement and addressing legal and ethical requirements	Identifying policy goals and challenges while aligning with stakeholder needs, assessing organizational readiness and addressing legal prerequisites
Co-designing vs. engaging, evidence gathering, policy planning		
Co-designing vs. engaging	Co-designing to facilitate meaningful participation and shared decision-making	Involving citizens, organizations, and experts in shaping the policy agenda through engagement activities
Co-designing vs. evidence gathering	Ensuring co-designed evidence, integrating diverse perspectives and experiences, and AI-driven analytics	Collecting qualitative and quantitative data to inform policy decisions
Co-designing vs. policy planning	Embedding co-design principles to iteratively shape responsive policies	Developing citizen-centric, sustainable, and inclusive solutions based on stakeholder input and evidence
Co-delivery vs. policy delivery		
	Embeds co-delivery for stakeholder involvement throughout the execution. AI-enabled communication channels enhance accessibility, helping build trust and securing buy-in	Implementing policies with mechanisms for tracking progress and adapting to unforeseen challenges
Co-assessment or co-evaluation vs. policy evaluation		
Co-assessment vs. options and appraisals	Enables co-assessment to ensure stakeholder-driven assessment and mitigate personal and political biases. The integration of AI-driven simulations and scenario modeling.	Assessing policy alternatives for feasibility, impact, and alignment with innovation, public trust, accountability, inclusivity and other outcomes
Co-assessment vs. decision and presentation	Co-creation fosters transparency by involving stakeholders in final decision-making. Digital platforms and explainable AI add credibility and broaden acceptance.	Selecting policy directions and ensuring transparent communication with stakeholders and accountability
Co-evaluation vs. evaluation and review	Institutionalizes co-evaluation to ensure continuous learning and adaptation. AI-driven analytics and engagement ensure adaptability and responsiveness.	Reviewing impact, integrating feedback, and refining policies iteratively

The conceptual model for AI-enabled co-creation for evidence-based policymaking is depicted in Figure 1. The model integrates the five parameters identified and validated throughout the study. It structures the policymaking process as an iteration of four integrated phases aligned with co-creation phases. The model also highlights critical enablers of evidence-based policymaking, including leadership, financial support, stakeholder engagement, and AI-driven tools, while reinforcing evidence-based decision-making, sustainability, ethics, and regulatory compliance as principles. Furthermore, it identifies co-creation outcomes as measurable public sector transformations encompassing social impact, innovation, efficiency, and organizational change.

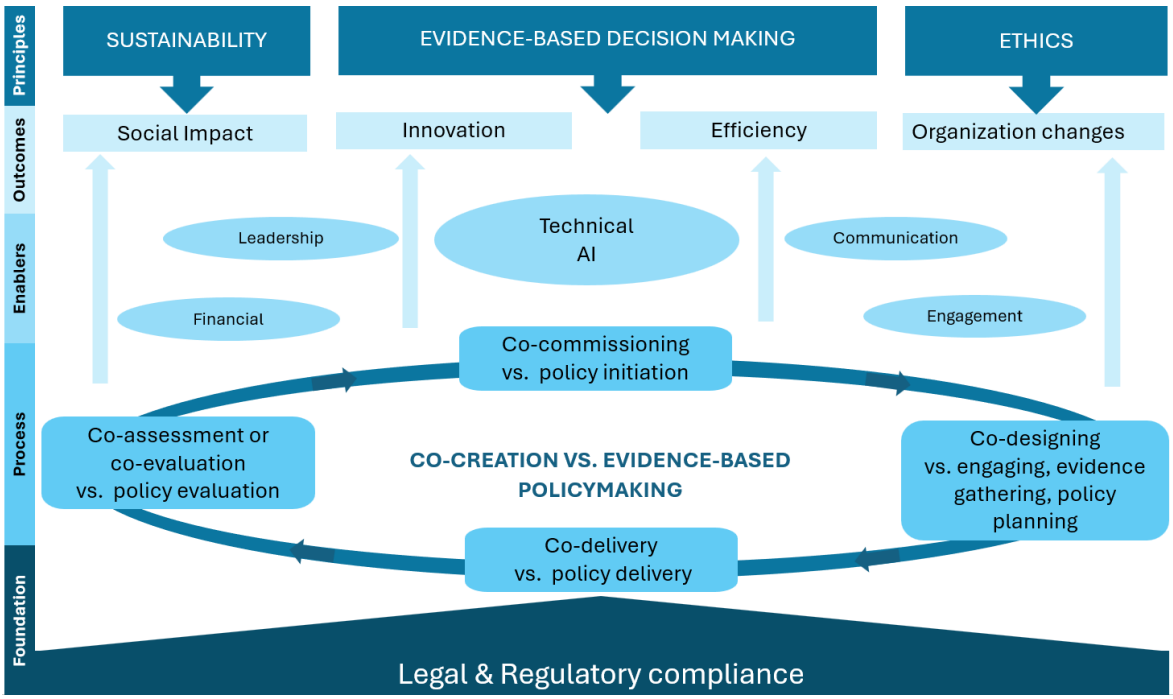


Fig. 1 – The conceptual model of AI-enabled co-creation for evidence-based policymaking

5. Conclusions

The main outcome of this study is the integration of AI-enabled co-creation and evidence-based policymaking within PSOs. The resulting conceptual model embeds co-creation into policy processes across four phases: 1) co-commissioning vs. policy initiation; 2) co-designing vs. engaging, evidence gathering, and policy planning; 3) co-delivery vs. policy delivery; and 4) co-assessment or co-evaluation vs. policy evaluation. The study makes theoretical, methodological, and practical contributions. The theoretical contribution is about advancing the understanding of co-creation as an integral component of evidence-based policymaking, embedding it in the structured and iterative policy process. The result highlights the interdisciplinary and multi-stakeholder nature of co-creation, emphasizing essential parameters such as sustainability, ethics, legal foundations, financial aspects, and digital governance required for its effective implementation in PSOs. The methodological contribution is about proposing a structured policymaking process, integrating AI-enabled co-creation across four interconnected phases, and making a distinction between digital co-creation (where digital tools enable participatory processes) and co-creation of digital public services (where digital solutions are the outcome of co-creation). The practical contribution is about providing a framework for integrating AI-enabled co-creation into policymaking processes, guiding policymakers and public managers in designing adaptive, user-centered, and data-driven public services.

The study has some limitations. First, while the conceptual model was validated through expert insights, further empirical research is needed to test its applicability across different PSO contexts and governance levels. Second, the dynamic nature of AI in co-creation processes presents ongoing challenges regarding ethical safeguards, regulatory compliance, and the evolving capabilities of AI-driven tools, which our model does not fully capture. Additionally, ethical concerns can go beyond AI, considering power dynamics and the risk of superficial participation. If not carefully managed, co-creation efforts may favor certain stakeholders.

Future research could explore strategies to prevent co-creation from becoming a symbolic exercise, ensuring genuine engagement and meaningful collaboration. Another challenge is the availability and quality of data. Similar to other domains, AI's effectiveness in co-creation depends on access to reliable and representative data; unfortunately, public sector data is often fragmented, biased, or difficult to access. Misinformation and security risks present ongoing challenges in digital co-creation. If not carefully monitored, AI tools can spread misinformation. Thus, strengthening security measures, improving misinformation detection, and building trust in AI-driven co-creation should be key priorities moving forward. Lastly, future research could further validate and refine the parameters of the conceptual model, conducting empirical testing and iterative evaluation to ensure its applicability and effectiveness in diverse public sector settings.

Acknowledgement

This work was supported by the European Union through the Erasmus+ Programme, under the project AICOSERV

(AI Technologies for Sustainable Public Service Co-Creation). Project No. 101180346, funded by the European Education and Culture Executive Agency (EACEA).

References

Ali, M., Maratsi, M. I., Euripidis, L., Alexopoulos, C., & Charalabidis, Y. (2022). Analysis of Reviews on Greek Municipalities to Improve Public Service Delivery and Citizen Satisfaction: A Tool for Co-creation and Co-design. *ACM International Conference Proceeding Series*, 296–303. https://doi.org/10.1145/3575879.3576008

Andersen, I. E., & Jæger, B. (1999). Scenario Workshops and Consensus Conferences: Towards More Democratic Decision-Making. *Science and Public Policy*, *26*(5), 331–340.

Ansell, C., & Torfing, J. (2021). *Public Governance as Co-Creation: A Strategy for Revitalizing the Public Sector and Rejuvenating Democracy*. Cambridge University Press.

Banisar, D., Parmar, S., de Silva, L., & Excell, C. (2011). Moving from principles to rights: Rio 2012 and access to information, public participation, and justice. *Sustainable Development Law & Policy*, *12*, 8.

Berlin Declaration. (2020). *Berlin Declaration on Digital Society and Value-based Digital Government | Shaping Europe's digital future*. https://digital-strategy.ec.europa.eu/en/news/berlin-declaration-digital-society-and-value-based-digital-government

Borum, N., Petersson, E., & Frimodt-Møller, S. (2014). The Resilience of Analog Tools in Creative Work Practices. *International Conference on Human-Computer Interaction (HCI 2014)*, *8510*, 23–24.

Bovaird, T., & Loeffler, E. (2012). From Engagement to Co-production: The Contribution of Users and Communities to Outcomes and Public Value. *Voluntas*, *23*(4), 1119–1138. https://doi.org/10.1007/S11266-012-9309-6/TABLES/2

BPC Policy Center. (2019). *Evidence-Based Policymaking Primer Why Base Policies on Evidence?* 8.

Brandsen, T., Steen, T., & Verschuere, B. (2018). Co-creation and co-production in public services: Urgent issues in practice and research. *Co-Production and Co-Creation: Engaging Citizens in Public Services*, 3–8. https://doi.org/10.4324/9781315204956

Cordella, A., Paletti, A., & Shaikh, M. (2018). Renegotiating Public Value with Co-Production. In *In: Tucci, Christopher, L. and Afuah, Allan and Viscusi, Gianluigi, (eds.) Creating and Capturing Value through Crowdsourcing. Oxford Scholarship* (pp. 181-203.). https://doi.org/https://doi.org/10.1093/oso/9780198816225.003.0008

Cortés-Cediel, M. E., Segura-Tinoco, A., Cantador, I., & Rodríguez Bolívar, M. P. (2023). Trends and challenges of e-government chatbots: Advances in exploring open government data and citizen participation content. *Government Information Quarterly*, *40*(4). https://doi.org/10.1016/j.giq.2023.101877

Dainow, B., & Brey, P. (2021). *Ethics by design and ethics of use approaches for artificial intelligence*.

Edelmann, N., Livieri, G., & Tambouris, E. (2023, September). Ethics challenges in public service co-creation. *CEUR Workshop Proceedings EGOV-CeDEM-EPart Conference*.

Edelmann, N., & Mergel, I. (2021). Co-production of digital public services in Austrian public administrations. *Administrative Sciences*, *11*(1). https://doi.org/10.3390/admsci11010022

Edelmann, N., & Mureddu, F. (2023). Public Policies for Digital Co-Creation in Public Services. In *In Elgar Encyclopedia of Services. Edward Elgar Publishing Limited*.

Edelmann, N., & Pereira, J. V. (2024). Public administrators' perception of ethical issues in public sector co-creation processes and outcomes: A meta-synthesis of cases. *Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance*, 14–21.

Edelmann, N., & Virkar, S. (2023). The Impact of Sustainability on Co-Creation of Digital Public Services. *Administrative Sciences*, *13*(2). https://doi.org/10.3390/admsci13020043

Eseonu, T. (2022). Co-creation as social innovation: including 'hard-to-reach' groups in public service delivery. *Public Money & Management*, *42*(5), 306–313. https://doi.org/10.1080/09540962.2021.2017253

European Commission. (2019). *Ethics Guidelines for Trustworthy AI*.

European Commission. (2021). *Ethics By Design and Ethics of Use Approaches for Artificial Intelligence*.

European Environment Agency. (2023). *The case for public participation in sustainability transitions*. https://www.eea.europa.eu/publications/the-case-for-public-participation

European Union. (2024). *Valorisation policies : code of practice on industry-academia co-creation : Commission recommendation*. https://doi.org/10.2777/05455

Evidence-Based Policymaking Collaborative. (2016). Principles of Evidence-Based Policymaking. *Evidence-Based Policymaking Collaborative*, *September*, 1–11.

Fedorowicz, M., & Aron, L. Y. (2021). *Improving Evidence-Based Policymaking : A Review*.

Flores, A. M., Pavan, M. C., & Paraboni, I. (2022). User profiling and satisfaction inference in public information access services. *Journal of Intelligent Information Systems*, *58*(1), 67–89. https://doi.org/10.1007/S10844-021-00661-W/TABLES/10

Gebru, T., Morgenstern, J., Vecchione, B., Vaughan, J. W., Wallach, H., III, H. D., & Crawford, K. (2021). Datasheets for Datasets: Documentation to facilitate communication between dataset creators and consumers. *Communications of the ACM*, *64*(12).

Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., & Vermeersch, C. M. J. (2016). *Impact Evaluation in Practice,*

Second Edition. Inter-American Development Bank and World Bank.
Giannelos, K., Wiarda, M., & Doorn, N. (2024). Challenges to ethical public engagement in research funding: a perspective from practice. *Open Research Europe*, *4*, 179. https://doi.org/10.12688/OPENRESEUROPE.18126.2
Gottesdiener, E. (2002). *Requirements by Collaboration: Workshops for Defining Needs*. Addison-Wesley Professional.
Hardebolle, C., Macko, V., Ramachandran, V., Holzer, A., & Jermann, P. (2023). *Digital Ethics Canvas: A Guide For Ethical Risk Assessment And Mitigation In The Digital Domain*.
Head, B. (2010a). Evidence-based policy : principles and requirements. *Strenghtening Evidence-Based Policy in the Australian Federation - Volume 1: Proceedings.*, *May*, 13–26.
Head, B. (2010b). Reconsidering evidence-based policy: Key issues and challenges. *Policy and Society*, *29*(2), 77–94. https://doi.org/10.1016/j.polsoc.2010.03.001
Inie, N., & Dalsgaard, P. (2017). How Interaction Designers Use Tools to Capture, Manage, and Collaborate on Ideas. *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 2668–2675.
Jacobs, C., Rivett, U., & Chemisto, M. (2018). Developing capacity through co-design: The case of two municipalities in rural South Africa. *Information Technology for Development*, *25*, 204–226. https://doi.org/10.1080/02681102.2018.1476833
Jalonen, H., Kokkola, J., Laihonen, H., Kirjavainen, H., Kaartemo, V., & V"ah"amaa, M. (2021). Reaching hard-to-reach people through digital means--Citizens as initiators of co-creation in public services. *International Journal of Public Sector Management*, *34*, 799–816.
Jaspers, S., & Steen, T. (2019). The sustainability of outcomes in temporary co-production. *International Journal of Public Sector Management*, *33*, 62–77.
Jaspers, S., & Steen, T. (2021). Does co-production lead to the creation of public value? Balancing the dimensions of public value creation in urban mobility planning. *Administration \& Society*, *53*(4), 619–646.
Kaplan, A. M., & Haenlein, M. (2010). Users of the world, unite! The challenges and opportunities of Social Media. *Business Horizons*, *53*(1), 59–68. https://doi.org/10.1016/j.bushor.2009.09.003
Khan, G. F., Swar, B., & Lee, S. K. (2014). Social Media Risks and Benefits. *Http://Dx.Doi.Org/10.1177/0894439314524701*, *32*(5), 606–627. https://doi.org/10.1177/0894439314524701
Kreijns, K., Kirschner, PA., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Comput Hum Behav*, *19(3)*, 335–353.
Lember, V. (2017). The increasing role of digital technologies in co-production. In *In T Brandsen, Steen, T., Verschuere, B. (Ed.), Co-production and co-creation engaging citizens in public services*. New York: Routledge.
Lember, V., Brandsen, T., & Tõnurist, P. (2019). The potential impacts of digital technologies on co-production and co-creation. *Https://Doi.Org/10.1080/14719037.2019.1619807*, *21*(11), 1665–1686. https://doi.org/10.1080/14719037.2019.1619807
Linders, D. (2012). From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Government Information Quarterly*, *29*(4), 446–454. https://doi.org/10.1016/j.giq.2012.06.003
Loeffler, E., & Bovaird, T. (2019). Co-commissioning of public services and outcomes in the UK: Bringing co-production into the strategic commissioning cycle. *Public Money \& Management*, *39*(4), 241–252.
Mahmoud, I., Ferreira, I., Arlati, A., Bradely, S., Lupp, G., & Nunes, N. (2023). Towards a Co-Governance Approach For Nature-Based Solutions. In *Guidelines for Co-Creation and Co-Governance of Nature-Based Solutions: Insights from EU-Funded Projects* (pp. 44–54). European Commission.
Manser Payne, E. H., Dahl, A. J., & Peltier, J. (2021). Digital servitization value co-creation framework for AI services: a research agenda for digital transformation in financial service ecosystems. *Journal of Research in Interactive Marketing*, *15*(2), 200–222.
McKenna, K. Y., & Bargh, J. A. (1999). Causes and consequences of social interaction on the Internet: A conceptual framework. *Media Psychology*, *1*(3), 249–269.
Meijer, A. (2016). Coproduction as a Structural Transformation of the Public Sector. *International Journal of Public Sector Management*, *29*(6), 596–611.
Mejlgade Lab, rum13 \& Å. V. R. (2017). *City As a 1:1 Green Laboratory: Using VR to Involve Citizens in the Greening and Climate Adaptation of Nørre Stenbro*.
Misuraca, G., Barcevicius, E., & Codagnone, C. (2020). *Exploring Digital Government Transformation in the EU – Understanding Public Sector Innovation in a Data-Driven Society*.
Naeem, M., Ozuem, W., Howell, K., & Ranfagni, S. (2023). A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research. *International Journal of Qualitative Methods*, *22*. https://doi.org/10.1177/16094069231205789
Needham, C. (2008). Realising the potential of co-production: Negotiating improvements in public services. *Social Policy and Society*, *7*(2), 221–231.
NSW Public Service Commission. (2022). *The Code of Ethics and Conduct for NSW government sector employees*. *2*, 1–14.

OECD. (2016). *Recommendation of the Council on Improving Ethical Conduct in the Public Service Including Principles for Managing Ethics in the Public Service*. 109–112. https://doi.org/10.1787/9789264256934-9-en
OECD. (2021). *Good Practice Principles for Data Ethics in the Public Sector*. 1–16.
OECD. (2022). *OECD Guidelines for Citizen Participation Processes*. https://www.oecd.org/en/publications/oecd-guidelines-for-citizen-participation-processes_f765caf6-en.html
Ojo, A., & Rizun, N. (2021). What matters most to patients? On the Core Determinants of Patient Experience from Free Text Feedback. *ICIS 2021 Proceedings*, 19.
Ojo, A., Rizun, N., Walsh, G., Isazad, M., & Venosa, M. (2024). Prioritising national healthcare service issues from free text feedback – A computational text analysis & predictive modelling approach. *Decision Support Systems*, *181*(March), 114215. https://doi.org/10.1016/j.dss.2024.114215
Osborne, S. P. (2006). The New Public Governance? *Public Management Review*, *8*(3), 377–387. https://doi.org/10.1080/14719030600853022
Osborne, S. P. (2018). From public service-dominant logic to public service logic: are public service organizations capable of co-production and value co-creation? *Public Management Review*, *20*(2), 225–231. https://doi.org/10.1080/14719037.2017.1350461
Osborne, S. P., Radnor, Z., & Strokosch, K. (2016). Co-Production and the Co-Creation of Value in Public Services: A suitable case for treatment? *Public Management Review*, *18*(5), 639–653. https://doi.org/10.1080/14719037.2015.1111927
Ostrom, E., Parks, R. B., Whitaker, G. P., & Percy, S. L. (1978). The Public Service Production Process: A Framework for Analyzing Police Services - ProQuest. *Policy Studies Journal*, *7*, 381.
Peters, D., Loke, L., & Ahmadpour, N. (2021). Toolkits, cards and games–a review of analogue tools for collaborative ideation. *CoDesign*, *17*(4), 410–434.
Pevkur, A., Barborič, V. H., & Doig, A. (2018). *Draft guide on public ethics prepared by the working group on public ethics*. *November*.
Popescul, D., Murariu, L., Radu, L. D., & Georgescu, M. R. (2024). Digital Co-creation in Socially Sustainable Smart City Projects: Lessons from the European Union and Canada. *IEEE Access*.
Randma-Liiv, T., & Vooglaid, K. M. (2019). *Organizing for e-participation: Learning from European experiences: Work Package 5 – Deliverable D5.2*.
Reijers, W., Koidl, K., Lewis, D., Pandit, H. J., & Gordijn, B. (2018). Discussing ethical impacts in research and innovation: The ethics canvas. *This Changes Everything–ICT and Climate Change: What Can We Do? 13th IFIP TC 9 International Conference on Human Choice and Computers, HCC13 2018, Held at the 24th IFIP World Computer Congress, WCC 2018, Proceedings*, 299–313.
Rizun, N., Revina, A., & Edelmann, N. (2023). Application of Text Analytics in Public Service Co-Creation : Literature Review and Research Framework. In *24th Annual International Conference on Digital Government Research (DGO 2023)*. Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3598469.3598471
Rizun, N., Revina, A., & Edelmann, N. (2025). Text analytics for co-creation in public sector organizations: a literature review-based research framework. *Artificial Intelligence Review*, *58*(125). https://doi.org/https://doi.org/10.1007/s10462-025-11112-1
Rodriguez Müller, A. P., Flores, C. C., Albrecht, V., Steen, T., & Crompvoets, J. (2021a). A scoping review of empirical evidence on (Digital) public services co-creation. *Administrative Sciences*, *11*(4). https://doi.org/10.3390/admsci11040130
Rodriguez Müller, A. P., Flores, C. C., Albrecht, V., Steen, T., & Crompvoets, J. (2021b). A scoping review of empirical evidence on (Digital) public services co-creation. *Administrative Sciences*, *11*(4). https://doi.org/10.3390/admsci11040130
Sanderson, I. (2002). Evaluation Policy Learning and Evidence-Based Policy Making. *Public Administration Vol.*, *80*(1), 1–22.
Scognamiglio, F., Sancino, A., Caló, F., Jacklin-Jarvis, C., & Rees, J. (2023). The public sector and co-creation in turbulent times: A systematic literature review on robust governance in the COVID-19 emergency. *Public Administration*, *101*(1), 53–70. https://doi.org/10.1111/padm.12875
Shneiderman, B. (2020). Bridging the gap between ethics and practice: guidelines for reliable, safe, and trustworthy human-centered AI systems. *ACM Transactions on Interactive Intelligent Systems (TiiS)*, *10*(4), 1–31.
Shneiderman, B. (2022). *Human-centered AI*. Oxford University Press.
Sicilia, M., Guarini, E., Sancino, A., Andreani, M., & Ruffini, R. (2016). Public services management and co-production in multi-level governance settings. *International Review of Administrative Sciences*, *82*(1), 8–27. https://doi.org/10.1177/0020852314566008
Ståhlbröst, A., & Holst, M. (2017). Reflecting on actions in living lab research. *Technology Innovation Management Review*, *7*(2), 27–34.
Tallinn Declaration. (2017). *Tallinn Declaration on eGovernment at the Ministerial Meeting during Estonian Presidency of the Council of the EU on 6 October 2017*.
Thiebes, S., Lins, S., & Sunyaev, A. (2021). Trustworthy artificial intelligence. *Electronic Markets*, *31*, 447–464.
Thomsen, C. (2013). Sustainability (world commission on environment and development definition). In

Encyclopedia of Corporate Social Responsibility (pp. 2358–2363). Springer.
Torfing, J., Sørensen, E., & Røiseland, A. (2019). Transforming the Public Sector Into an Arena for Co-Creation: Barriers, Drivers, Benefits, and Ways Forward. *Administration and Society*, *51*(5), 795–825. https://doi.org/10.1177/0095399716680057
Türke, R.-E. (2012). Sustainable Governance. In S. Grösser & R. Zeier (Eds.), *Systemic Management for Intelligent Organizations* (pp. 237–248). Springer.
United Nations. (2015). *THE 17 GOALS | Sustainable Development*. https://sdgs.un.org/goals
van Noordt, C., Medaglia, R., & Tangi, L. (2023). Policy initiatives for Artificial Intelligence-enabled government: An analysis of national strategies in Europe. In *Public Policy and Administration*. https://doi.org/10.1177/09520767231198411
Voorberg, W., Bekkers, V., Timeus, K., Tonurist, P., & Tummers, L. (2017). Changing public service delivery: Learning in co-creation. *Policy and Society*, *36*(2), 178–194. https://doi.org/10.1080/14494035.2017.1323711
Wiktorska-Święcka, A. (2018). Co-creation of public services in Poland in Statu Nascendi . A case study on senior co- housing policy at the urban level. *Polish Political Science Review*, *6*(2), 26–54. https://doi.org/10.2478/ppsr-2018
Wirtz, B. W., Langer, P. F., & Fenner, C. (2021). Artificial intelligence in the public sector—a research agenda. *International Journal of Public Administration*, *44*(13), 1103–1128.

Collaborative Governance for the Construction of Public Policies on Social Sustainability

Sabrina Callegaro [a]
[a] Management Program, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil, sabrina.callegaro@edu.pucrs.br, ORCID 0000-0003-0624-608X.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Government actors promoting collaborative initiatives for a more inclusive and democratic society must understand that effective strategies for lasting social impact demand significant effort. Collaborative governance relies on the interaction between the government, private sector, and civil society. However, success is not guaranteed by collaboration alone, due to various factors can affect decision-making effectiveness. This article explores the key factors in collaborative governance, with a specific focus on social sustainability, to optimize governance practices. The field research was conducted using a qualitative approach through a case study in Porto Alegre city, Brazil. We conducted semi-structured interviews with 16 stakeholders, analysed documents, and performed direct observations. The study provides valuable insights for public managers and governments on effective strategies for addressing social issues and improving governance, aiming to enhance social sustainability and project efficiency. Additionally, it identifies factors for collaborative governance in the Latin America context.

Keywords. collaborative governance; social sustainability; decision-making; public policy; governance strategies; collaboration
Research paper, DOI: https://doi.org/10.59490/dgo.2025.992

1. Introduction

Collaborative forms of governance are strongly encouraged but require management that enables the proper involvement and representation of different interests from the initial agenda and activities planning (Broccardo, Culasso & Mauro, 2019). The collaborative process becomes an alternative to strengthen decision-making (Naffaa, 2017), whereas the dynamics of collaboration result in collaborative actions involving multiple stakeholders in the definition of policies, regulations, projects, or agendas (Broccardo, Culasso & Mauro, 2019). Although the government actors are interested in promoting collaborative projects to build a more open and democratic society, they should be aware that creating results with transformative and sustainable social impact requires efforts (Temmerman, Veeckman & Ballon, 2021).

The engagement of players from the private sector, society, or the general public in decision-making processes and structures (Bianchi & Rivenbark, 2021), with diverse communication, collaboration, and power delegation (Newig et al., 2017) is one the principles of Collaborative governance, which is defined by processes and structures of decision-making and management of public policies that involve people constructively to achieve a public purpose that would not be accomplished otherwise (Emerson, Nabatchi & Balogh, 2012). In collaborative governance, specific motivations drive participants to become involved, so it is essential to comprehend their impact on decision-making. This involves determining whether participants primarily aim to pursue their own interests or if they are seeking a better collective outcome. Their behavior influences the process throughout (Choi & Robertson, 2014b).

Although studies on Collaborative Governance extensively explore various dimensions such as models, antecedents, processes, outcomes, challenges, institutional structure, leadership, and the diversity of the groups involved (Bianchi, Nasi & Riverbark, 2021; Ansell & Gash, 2008; Emerson, Nabatchi & Balogh, 2012; Thomson & Perry, 2006), there is a significant gap in the literature regarding a deeper understanding of the aspects that influence decision-making in this context. Mosley & Wong (2021) address the legitimacy of the decision-making process, but there is still a lack of detailed analysis on how this process is constructed. Given these studies, it is

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

evident that the literature lacks a more detailed exploration of the specific factors that shape these decisions. This need is further highlighted by the research of Wang & Ran (2021), who emphasize the increasing complexity of the decision-making process in collaborative governance and the importance of understanding the elements that influence it.

This research has Collaborative governance as its subject, and its objective is to identify the related factors of a decision-making process in a social sustainability multi-stakeholder case, executed by the city of Porto Alegre (Brazil). The research question is: which factors can influence the decision-making process of a Collaborative governance focused on social sustainability? To achieve that objective, we applied a case study approach to understand the complex dynamics and interactions in the decision-making process in Porto Alegre City Hall (Brazil). This initiative aimed to create a public policy to qualify both formal and informal recyclable materials collection, as well as to improve solid waste sorting units.

This study contributes to practitioners and academics by providing them with a better understanding of how those involved in the collaborative process make decisions and communicate them, unraveling the Collaborative governance theme regarding the factors related to multi-stakeholder decision-making, and contributing to the development of broader theory in this field. Contributions to theory and knowledge are the factors that influence decision-making regarding collaborative governance in social sustainability with a focus on the Latin American context. It is a subject that heavily relies on context, and most of the main literature comes from the global north. Contributions to practitioners and managers depend on insights into public policies, particularly the steps of problem understanding and agenda definition. Contribution to society relies on a clear explanation of this complex social problem and its proper understanding.

In the next section, we will develop the conceptual foundation for our research by drawing from the literature to formulate propositions. These propositions will be validated or refuted in a case study conducted in Brazil (Cepeda & Martin, 2005). We emphasize the importance of conducting additional research on various forms of collaboration to evaluate the relevance of our theoretical argument and empirical findings. We conclude the article with suggestions for future research.

2. Theoretical basis

2.1 Collaborative Governance

Collaborative governance is a form of shared governance in which authority and responsibility for decision-making depend on an agency that must inform or consult other rights holders and stakeholders when planning or implementing initiatives (Borrini-Feyerabend et al., 2013). This governance model does not refer only to formal decisions and official laws, but also to formal processes and customary laws (Kossmann, 2015), indicating that the initiation and management of Collaborative Governance is not a one-time act, but a continuous process (Ulibarri et al., 2020).

In a collaborative process, public agencies work with other public and private organizations to develop or implement policies and programs (Ulibarri & Scott, 2017). In this way, collaboration increases opportunities for social learning among stakeholders, suggesting that they would be more capable of identifying and correcting incompatibilities with greater collaboration (Ulibarri, 2015). However, collaboration is linked to the process of dealing with varied perspectives, adopting new roles, and assuming multiple responsibilities in complex situations (Bradley & Arlati, 2022).

Governance practices are shaped by the interactions of different social actors, who often have diverse, conflicting, and antagonistic interests, viewpoints, and values, which governance must resolve or reconcile (Gutberlet, Besen & Morais, 2020). Political actors collaborate during decision-making processes in exchange for the exchange of their objectives into policies (Fischer & Sciarini, 2016). These processes can be simple or complex - they can vary according to the outcomes to be achieved and the reflections to be generated throughout the choices. A key question for those interested in developing effective Collaborative governance systems is: "how to facilitate the decision-making dynamics among diverse and interdependent stakeholders facing complex problems?" (Choi & Robertson, 2014a), as they participate in the governance process, often defined interests and histories of conflicts and alliances (Follador et al., 2021).

> Proposition 1: The complexity of the context changes the dynamics of the processes and makes the results unpredictable and difficult to control.

In contexts of multiple stakeholders, such as in collaborative governance, the goal is to bring together key stakeholders in an integrated dynamic of communication and decision-making. This approach is based on the recognition of the importance of equity and accountability in interactions among stakeholders, as pointed out by Almeida, Getschko, & Afonso (2015). Furthermore, Trimble et al. (2022) emphasize the need for well-defined and formalized roles, even if of a consultative nature, to ensure effectiveness and clarity in the decision-making process. This perspective highlights the importance of clear and accountable structures to facilitate productive dialogues

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and equitable decisions in environments with multiple stakeholders.

> Proposition 2: Social problem's systematic understanding demands listening to all actors.

Interaction among stakeholders can create a trusting relationship among them, even if their goals are not fully achieved (Hovardas, 2021). Trust can be used as social capital to establish governance so that decisions can be made consensually (Panday, 2018; Ansell et al., 2020), although it requires the involvement of stakeholders (Kossmann, Behagel & Bailey, 2016). Furthermore, there must be a pre-established and consolidated degree of trust to allow participants to share knowledge among themselves and improve the performance of the collaborative process (Tonelli et al., 2018). It is imperative to dedicate efforts to enhance collaborative efforts and partnerships among all community stakeholders, focusing especially on integrating those who have been traditionally excluded from decision-making processes (Wang & Ran, 2023).

> Proposition 3: Previous trust among stakeholders is fundamental to reducing conflicts during decision-making.

An important characteristic that helps to distinguish Collaborative governance from traditional decision-making mechanisms is the relative balance of formal power among the various participants involved in the decision-making process (Choi & Robertson, 2014a). For Purdy (2012), Collaborative Governance is related to processes that seek to share power in decision-making with stakeholders to develop shared recommendations for effective and lasting solutions to public problems.

In the division of responsibilities and power, the act of governing becomes more complex, especially in the relationship between the democratically elected governmental authority and the social and private actors who grant power in decision-making related to public policies (Ferrarezi & Oliveira, 2012). Collaborative Governance processes must be planned to promote a substantial balance of power among stakeholders during deliberation and decision-making (Choi & Robertson, 2014b).

> Proposition 4: Actors who have centralized power in other spheres or decisions (such as in government) may not behave collaboratively in collective decision-making.

Governance practices are influenced by the interactions of various social actors, who may have conflicting interests. The importance of balance and trust in decision-making is emphasized, which should be facilitated by the development of mechanisms to manage the complexity and diversity of interests in collaborative decision-making. These aspects are essential for the creation of more effective governance systems, especially in the context of increasing social and environmental complexities.

2.2 Social Sustainability and Governance

Social sustainability can be defined as the resolution of basic needs, such as adequate housing and income; individual capacity or opportunity for learning and self-development; social or community capacity for the organizations and networks development, that promotes social interaction (Davidson, 2010). Although it is a well-established concept, the social dimension is the least developed among all concepts of sustainability, as academic research frequently focuses more on the environmental and economic dimensions (Beck & Ferasso, 2023). This can be explained by considering that identifying social impact can have positive and negative social consequences. The scope of social impact is daunting, which may explain why social sustainability the least well-established pillar of sustainability is compared to the more easily quantifiable economic and environmental impacts (Buchan et al., 2024).

Social sustainability should be recognized in a reliable and affordable manner along with general stakeholder support for the data collection and analysis, thus a good governance will promote sustainability in general and address social sustainability in particular (Pashaei Kamali et al., 2018). Collaborative governance projects should be able to build a wider and democratic society, although it requires action taking efforts at all levels, the government level included, to trigger outcomes with transformative and sustainable social impact (Temmerman, Veeckman & Ballon, 2021).

Pashaei Kamali et al. (2018) identified collaboration and participation as a sustainability necessary practice, with the stakeholder's involvement in decision-making process, which is obtained through discussions aimed at resolving conflicts. It is expected that social sustainability issues faced by society will expand the challenges of balancing local, national, and global goals and objectives, requiring a more collaborative approach to public policy development for long-term planning structures and tools (Picavet et al., 2023).

3. Methodological Procedures

The research used a single case study approach (Yin, 2015) to analyze the Todos Somos Porto Alegre program, a Porto Alegre City Hall initiative in Brazil. The program aimed to shift from social assistance to economic and social development by promoting the productive inclusion of self-employed recyclers through labor market training. This case was chosen for its elements of collaborative governance and stakeholder participation in public policy creation.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The study employed an interpretative qualitative approach, capturing participants' perspectives and integrating multiple data sources (Yin, 2016; Cepeda & Martin, 2005). Data collection involved document analysis, direct interviews, and observations, ensuring reliability through triangulation (Martins, 2008). Primary data were obtained from interviews with project participants conducted between October and December 2019 (see Table 1), while secondary data included program reports, meeting minutes, and media articles (see Table 2). Interviews followed a structured script validated by two researchers (Baxter & Jack, 2008) and were conducted in person or remotely via Skype and WhatsApp. Participants were selected based on their roles in the program's creation, formalization, and implementation (2012–2016), ensuring stakeholder representativeness. Sixteen stakeholders were interviewed until reaching saturation (Fontanella, Ricas & Turato, 2008). Interviews were recorded, transcribed in Portuguese, and selectively translated into English, preserving the original meaning.

Tab. 1 - List of interviewed stakeholders.

Institution	Role	Quantity	Approximate time length
City Council: responsible for the Law	Alderman author of the Law 10.531/2008 that institutes, in the city of Porto Alegre, the Gradual Number's Reduction of Animal Traction Vehicles[1] and Human Traction Vehicles Program	01	25 min
Porto Alegre City Hall: executioner of Public Policy	City Department of International Relations Office Chief	01	51 min
	City Department of International Relations Projects Coordinator	01	56 min
	Mayor of Porto Alegre during the Program	01	43 min
Private Company: Program Supporter	Head of Institutional Relations	01	28 min
University: Program follow up	Production and Transport Engineering Professor at UFRGS	01	15 min
Cooperative: Program coordinator	General Coordinator	01	47 min
	Consultation Letter drafting and coordination support in Project 2	01	01h 08 min
	Planning and Execution Program's Structurer	01	40 min
	Project 1 Coordinator	01	01h 25 min
	Project 2 Coordinator	01	01h 17min
	Author of Program's book	01	25 min
	Social Assistant	01	01 h 04 min
Rio Grande do Sul Public Ministry of Labor: actions follow up and support	Chief Prosecutor	01	31 min
Triage Unit: Program beneficiary entity	Triage Unit Leaders and "Fórum dos Catadores" from "Vila Pinto" and "Campo da Tuca" participants.	02	49 min
Total		**16**	**704 min**

The documents, listed in Tab. 2, allowed us to corroborate and increase the data evidence collected from other queried sources, so it provided us the necessary content for this case study contextualization, expanding and

[1] A type of Vehicle that is pulled by animals, such as wagon, carriage, or chariot.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

highlighting the interviewee's speeches and the information gathered where the interviews and the non-participant observation, being frequently used along with other methods of data collection that offered us a more differentiated and dynamic conjuncture assessment that cannot be easily captured by traditional methods (Liu; Maitlis, 2010).

Tab. 2 - List of analysed documents.

Analyzed Documents Report

Document	Document's Purpose	Date
Law 10.531/2008 establishes, in the city of Porto Alegre, the Gradual Number's Reduction of Animal Traction Vehicles and Human Traction Vehicles Program	Establishes, in the City of Porto Alegre, the Gradual Number's Reduction of Animal Traction Vehicles and Human Traction Vehicles Program and provides other measures.	September/2008
Project Opening Term	Beginning formalization of Productive Inclusion Program implementing and Waste Pickers Productive Inclusion and Porto Alegre's Popular Recycling System Restructuring.	August/2012
Kick off Meeting Report	Report on a meeting held at Local Governance City Department of Porto Alegre City Hall.	August/2012
Braskem Social Investment Presentation	Project Presentation Containing: • General Information • Work Balance sheet • *Stakeholders* List • Developed Strategy • CVCA – *Costumer Value Chain Analysis* • Impact Matrix X Complexity	August/2012
The Implementing of Productive Waste Pickers Inclusion Program and The Restructuring of Porto Alegre's Popular Recycling System Work Proposal	Work proposal presented by "Cooperativa Mãos Verdes" containing the expected objectives and results for the program implementation phase.	August/2012
Scope Management Plan	Establishes as the project scope will be managed and sets how will be treated and controlled its changes.	September/2012
Action Plan Schedule	Lists the actions and those responsible for the program implementation with the planned dates.	February/2013
"Todos Somos Porto Alegre" Program's Implementing	Presentation containing an evaluation of the conducted work, the results of the program implementation phase and the next steps.	February/2013
Executive Committee Establishment Report	Executive Committee establishment and its initial referrals.	February/2013
Committee Tasks and Quality Management System (QMS)	Defines the meeting's systematic between the members of the stakeholder's network and the executive and operational teams, during the Program implementation.	March/2013
Productive Inclusion Program Presentation	Porto Alegre City Hall presentation on the "Todos Somos" Program.	June/2013
Meeting report	Reports of the meetings that occurred throughout the program.	2012 to 2016

The interviews were transcribed, coded, and analyzed using NVIVO v12 for Apple. Data from interviews and documents formed a corpus analyzed categorically according to Bardin (2009), enabling objective and systematic data collection. We started with an initial reading of the data to understand the information, followed by a detailed analysis for coding and categorization. The process included highlighting important sections and making brief

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

notes, connecting insights to the codes identified in the interviews and documents.

Afterward, we identified the factors that emerged from the interviews and influenced decision-making, making it possible to verify which factors had already been identified by the theory and which emerged from the analysis of the information (Flick, 2009).

4. Results

4.1 The Program Structure in Porto Alegre

Porto Alegre is the capital and largest city of Rio Grande do Sul, the southernmost state of Brazil. It has a population of approximately 1.5 million inhabitants and about 4.5 million in its metropolitan area, making it the twelfth most populous city in the country. Porto Alegre was founded in 1769 by a group of immigrants from the Azores Islands, Portugal. In 1989, the city became internationally known for being the first to implement participatory budgeting.

Aiming to modernize the city and improve traffic circulation in Porto Alegre, the capital of Rio Grande do Sul, as well as to advance strategies for preparing the city to host international events such as the 2014 FIFA World Cup, the City Hall decided to ban the circulation of wagons and waste pickers' carts in urban areas, in compliance with Law No. 10,531/2008. Additionally, the municipality sought to professionalize the informal waste sorting system by investing in and strengthening waste sorting units, introducing production goals and processing volume targets, and encouraging the formation of consortia and networks for materials processing and commercialization.

Following the approval of Law No. 10,531/2008 and the establishment of the Executive Committee for the Gradual Reduction of Animal Traction Vehicles (ATVs) and Human Traction Vehicles (HTVs) (Decree No. 16,638/10), it became necessary to implement a public policy for the productive inclusion of waste pickers and the restructuring of sorting units in Porto Alegre. To this end, the public policy known as Todos Somos Porto Alegre (a name chosen by the Waste Pickers Forum) was carried out through a 26-month-long program. This initiative involved multiple stakeholders, including City Hall departments, the Brazilian Development Bank (BNDES) as the funding agency, NGOs engaged in outreach to the waste picker population and sorting centers, social and community leaders, private entities, and, crucially, the waste pickers themselves—the primary beneficiaries of the policy.

The program's main premise was to create work alternatives considering the gradual phasing out of ATVs and HTVs. Other key objectives included street-level outreach to waste pickers, offering individualized support and referrals, strengthening the sorting unit network, and providing legal and institutional backing to enhance their operational capacity and production scale. The focus of the program shifted from a social assistance approach to one based on economic and social development, emphasizing income generation and popular education as a productive force.

In terms of governance, the program's strategic and political coordination was led by the Executive Committee, which defined roles and responsibilities for governance functions and oversaw actions to consolidate an integrated support network. This included organizing continuous improvement seminars, and committee meetings, structuring the external evaluation process, and managing the communication plan aligned with governance activities. The support network comprised the Technical-Operational Coordination unit and individual Project Working Groups. These groups worked closely with service providers and operational teams that directly interacted with the target population. In turn, the target population also maintained dialogue with the Integrated Support Network and the Waste Pickers Forum.

A collaborative network was established so that Porto Alegre City Hall, together with other public and private organizations, could develop and implement the public policy, in line with recommendations by Ulibarri and Scott (2017). Based on the formulation of strategies, activities, and goals, Morse and Stephens (2008) emphasized that such processes should begin with a core group of committed stakeholders. Once the outcomes and strategies are defined, the collaboration moves to the implementation phase, in which agreements and action plans are developed through a set of mutually supportive initiatives. To ensure the continuous improvement of the program, executive committee seminars and meetings were held, alongside the development of the external evaluation framework and the management of the integrated communication plan.

4.2 Decisions influencing factors

4.2.1 Complexity

Complexity can be defined as the presence of numerous interconnected and interactive elements that impact the behaviour of a system (Casti,1986). The definition of Casti is particularly relevant in the public context, as it demonstrates the challenge of predicting the outcomes of an action or decision.

In the analysis of the program documents, complexity was evaluated by constructing a complexity matrix. This approach considers the need for a holistic understanding of the different actor profiles, as well as the diverse demands and needs of the population that necessitate a range of actions, projects, and competencies. The importance of developing a personalized service policy to assess and handle each waste picker case, particularly

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

considering significant complexities, is also emphasized.

Complexity was a factor highlighted by the interviewees, considering the context of the Todos Somos Program and the situations experienced, particularly in relation to the withdrawal of the ATVs and HTVs from circulation. The program's increased complexity was associated with the waste picker's carts and wagons, as shown in Figures 1 and 2. This was due to the diverse audience, many of whom relied on carts or wagons to support their families. However, in some cases, these vehicles were also used to sustain drug addiction.

> *We had two problems with Todos Somos, one, the complexity of the waste picker's itself, their profile, people who mostly do not have an organization, many are homeless, there's always an exploitative group behind them, only a few are independent, the majority live in a vicious cycle of drug involvement, not all of them, but most of them, that's a problem. (E01).*

Fig. 1 - A man pulling a Human Traction Vehicle in the city of Porto Alegre.



Fig. 2 - A man riding an Animal Traction Vehicle in the city of Porto Alegre.



Interviewee no. 10 reports that Todos Somos was a complex program, and there was the need to understand the context of waste pickers and screening units to establish the necessary strategies, "*align things with people, could have time to reason and bring ideas, it is not in the heat of fire that a complex decision is made*" (E10).

The living conditions of waste pickers were a complex problem that needed to be addressed in the Todos Somos

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Porto Alegre Program. The families depended on garbage collection work to live, which was also degrading work. The activity involved sorting the collected garbage in informal sorting units or in their homes, which led families to literally live among the garbage, not to mention the use of heavy human traction strollers, pulled up and down the city, often with children inside.

4.2.2 Systemic comprehension

For Maani (2016), systemic understanding is the key that frees mental models and paves the way for accepting exchanges in a multi-stakeholder decision-making process, being the first step towards a systematic understanding of the problem. However, in a decision-making process, in some cases, information is gradually presented, and problems are unstructured (Gontijo & Maia, 2004).

Municipal governments should collect suggestions and opinions from all stakeholders in projects on behalf of cities, however, citizen participation should be simplified (Bolivar, 2018), for example, through forums. Nevertheless, Ulibarri and Scott (2017) pointed out that high-capacity collaborative decision-making forums may not be the most inclusive in terms of incorporating all network players into decision-making, but they are institutions where a subset of key network players is heavily involved (stakeholders offering particularly relevant information, maintaining key resources, and being critical to achieving successful results).

In the analysis of the Todos Somos Program documents, we observed that there were practices, methods, and project management tools, that provided the necessary formalism which allowed the development and management of a program of this nature. The Program adopted a management model, so they could manage all phases of ongoing projects, identify risks, reduce difficulties and resistance at each program stage, and apply production engineering tools aiming the production of social benefits, as reported by one of the interviewees, "this project, in my opinion, was the first time that a method was used to solve a social problem, so the chances of getting it right were good, and if we continued, much better" (E4).

In the Todos Somos Program, the topics discussed in the meetings were recorded in reports and the agenda was previously established, the information was obtained from the working groups and provided support so the decisions could be made, and errors minimized. The structuring and analysis of the information were aspects highlighted by all interviewees regarding the systemic understanding of this issue, being mentioned even by the members of the Waste Pickers Forum. Interviewee 3 highlighted that the Executive Committee, in some situations, participated in the Waste Pickers Forum and held open meetings with waste pickers, due to the lack of self-employed waste pickers' representatives. These mechanisms allowed the collection of information for decision-making and for the program to move forward with the planned actions.

4.2.3 Relationship among stakeholders

In decision-making, all stakeholders need to be involved for the process to be effective (Edmunds and Wollenberg, 2001), though in some moments might have conflict situations, which may be a resource or a liability during collaboration (Ansell & Gash, 2008). There are many conflicting interests among stakeholders, but they must adjust their preferences through deliberation and dialogue (Choi & Robertson, 2014a).
During the interviews, respondents were asked if conflicting situations occurred and how the relationship between those involved in the program and 12 (twelve) of the 16 (sixteen) interviewees reported that conflict situations, such as complaints to the Public Prosecutor's Office, informal recyclers' resistance to joining the Program, conflicts of ideological concepts among stakeholders that generated critical moments during the execution of the Program. Interviewee no. 9 recalls that conflicts and problems occurred daily and were mitigated due to the trust relationship established between those involved in the Program, especially within the Executive Committee and Working Groups. This relationship was possible due to the Executive Committee member's previous history of participation in other social projects, which, as Ansell & Gash (2008) said, contributes to raising the levels of trust among those involved and thus increasing the commitment, as substantiated by Interviewee no. 3 speech.

> *We had a very good team within the government, had a very engaged team within the government, I for example had a team within the government that I had to deal with, that maybe you will talk to. Sometimes there were many difficulties, but they were really aligned people who wanted to make it happen like us, so there was a lot of trust between us, we knew that even if we disagreed on something we were doing it over things we wanted to go the best way possible for the program's sake (E03).*

Interviewee no. 3 reports the trusting relationship established between stakeholders and the belief that they had over the Program's results. These aspects were fundamental to strengthening the relationship between those involved, even with the existence of conflicts that consequently influenced the decision's direction. Interviewee no. 14 notes that there was mistrust over a Public Power conducted the Program, being the role of the government leader responsible for the Todos Somos Program fundamental to promote the collaborative conduction of the program, through conversation and consensus. This aspect corroborates the research of Emerson, Nabatchi & Balogh (2012) that considers the trust positive influence in collaboration, seen as a mechanism for better understanding the problem and being an essential element to achieving consensus and meeting the needs of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

stakeholders, especially in projects aimed at social sustainability (Beck & Ferasso, 2023).

4.2.4 Power

In collaborative governance, decision-making should be focused on collectively and on sharing with decentralized power, so that the involvement of multiple stakeholders allows legitimizing the decisions made (Emerson, Nabatchi & Balogh, 2012). Power should be shared among stakeholders during deliberation and decision-making, to develop shared recommendations for effective and lasting solutions to public problems (Purdy, 2012; Choi & Robertson, 2014b).

Not all interviewees could identify whether there were power relations between stakeholders involved in decision-making. Of the 16 (sixteen) interviewees, only 6 (six) mentioned a Centralized Power occurrence. In the opinion of four (4) interviewees, the power was decentralized, and shared among all those involved, both in the Executive Committee and in the Active Search team, as reported by Interviewee no. 3. In Interviewee 5's statement, when asked if there was anyone who had the final say in decisions, it is possible to observe that authoritarianism did not prevail in the decisions "We have to avoid that, that is authoritarianism, we didn't have that, we avoid it, not out of fear of making decisions, democracy should be the main foundation" (E05).

Interviewees no.10 and no. 4 reported that power was centered on the Government, in this case, the City Hall. However, they highlighted that the government seemed to be always willing to listen to all those involved opinions, with dialogue still prevailing. In the opinion of Interviewee no. 3, the power was centered in the Cooperative that supported the City Hall in the coordination of the Todos Somos Program, due to this stakeholder technical knowledge in relation to the Program and the influence it had in the Executive Committee.

It is important to emphasize that collaborative governance processes should be planned to promote a power balance between stakeholders during debate and decision-making (Choi & Robertson, 2014b).

4.2.5 Administrative Burden

The concept of administrative burden can be understood as the individual perception of policy implementation as a burdensome task. Often, this burden manifests as a repetitive, inevitable, and prolonged experience, imposing substantial challenges within the context of collaborative governance (Burden et al, 2012). Collaborative governance aims at decision-making based on deliberative consensus, however, there were some situations in which administrative burden was present just as required by any traditional model of centralized governance. During the interviews, the respondents were asked about critical situations they experienced during the program execution and what could have occurred otherwise, i.e., what could have been improved. Interviewees no. 2 and no. 11 mentioned the administrative burden situations handled with BNDES, the main financing source of the program, influencing the continuity of the program when Porto Alegre City Hall had a change of management due to the city's election, this aspect is supported by Purdy (2012), who concludes that in Collaborative governance processes that are convened by government agencies, the authority of the government is linked to its rights to establish and apply rules, while the authority of other actors stems from their right to participate in governance or to bring legal actions.

Interviewee no. 3 emphasizes the slowness of government movements, but this slowness is not related to decision-making, but rather to the realization of decisions, i.e., in the interviewee's words the slowness lies in 'putting the decision on the street, the internal processes needed, and the various assessments. This got in our way a lot, mostly when resources should be liberated so we could effectively execute what we had decided, so that was something we needed to improve. "*The situations encountered required the restructuring and reanalysis of information, making necessary some actions, goals, and schedule adjustments in the Program. Interviewee no. 3"*

5. Results discussion

The complexity of the program is manifested by the multiplicity of actors involved and the variety of their interests and living conditions. For example, waste pickers are not a homogeneous group; they have different stories and challenges, and this complexity increases when considering the logistics of their carts and wagons, which are essential for their work, but also involved in broader public and social policy issues.

The Todos Somos program faced the challenging task of reconciling these diverse factors, seeking to balance the needs and expectations of each stakeholder. This task is complicated by the unpredictable nature of these interrelated elements. As a result, strategies and policies that prove effective in one aspect of the program may not be suitable or effective in another, leading to unexpected and difficult to manage outcomes, corroborating Proposition 1 of this study "The complexity of the context changes the dynamics of the processes and makes the results unpredictable and difficult to control".

The emphasis on using practices, methods, and project management tools reflected a conscious effort to address social problems systematically and structured. The interviewees' reports reinforced the idea that the adoption of structured methods in solving social problems significantly increased the chances of success. By involving waste pickers and other relevant stakeholders in the decision-making process, the program not only gained a deeper understanding of the challenges faced but also promoted a sense of ownership and commitment among the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

participants.

The Todos Somos Program exemplifies how the systematic understanding of social problems is intrinsically linked to the inclusion and listening to all actors involved, validating Proposition 2 of this research: “Social problem’s systematic understanding demands listening to all actors”. By integrating project management methodologies with the active participation of a variety of stakeholders, the program was able to effectively address complex social challenges, reinforcing the idea that listening to all actors is essential for the effective resolution of social problems. Effective and well-defined governance strategies likely improve not only social sustainability but also the interconnections of its dimensions (i.e., environmental, economic, and social). However, the stakeholders involved in the decision-making process must have a clear understanding of social issues (Pashaei Kamali et al., 2018).

In the Todos Somos Program context, the importance of trust among stakeholders was highlighted by how conflicts were managed and mitigated. The trust relationship within the Executive Committee and among the Working Groups played a key role in mitigating daily conflicts. This trust did not arise spontaneously; instead, it was built on shared experience and a history of participation in other social projects. As Ansell and Gash (2008) observed, trust contributes to elevating levels of commitment and collaboration among parties, facilitating the resolution of conflicts and more cohesive decision-making.

The initial distrust regarding the public power’s program management was overcome by the program leader's ability to foster constructive dialogues and seek consensus. This aspect aligns with the conclusions of Emerson, Nabatchi & Balogh (2012), who consider trust as an essential mechanism for better understanding problems and achieving consensus, especially in projects focused on social sustainability.

As highlighted in the literature, pre-existing trust among stakeholders is a factor in effective conflict management and the facilitation of collaborative decision-making (Panday, 2018; Ansell et al., 2020; Tonelli et al., 2018). However, in the studied case, trust did not occur previously among stakeholders, but during the execution of the program's actions. Instead, it was established during the implementation process, partially supporting Proposition 3: "Previous trust among stakeholders is fundamental to reduce conflicts during decision-making."

Collaborative governance prioritizes decentralized power, while power influences decision-making and the relationship among stakeholders involved in this process, sometimes can have a dynamic behavior, that is, fluctuating between centralized and decentralized power, and efforts must be focused so that power remains balanced among participants. In some cases, the Government initiates and coordinates policy networks and maintains great power over the nature and functioning of Collaborative governance, prevailing its opinion in decision-making (Eckerberg, Bjärstig & Zachrisson, 2015; Criado and Guevara-Gómez, 2021). However, the Todos Somos Program demonstrates that, even in a scenario where some actors may have more power (like the Government), the structure and planning of Collaborative governance, along with the willingness to maintain open dialogue and listen to all parties, can lead to effective collaboration.

Although power was centralized in the government, there was a continuous disposition to listen to all parties and maintain dialogue. This suggests that, even in a situation of centralized power, there can be a collaborative approach if there is a willingness to listen and engage all stakeholders, not confirming Proposition 4 of this study: “Actors who have centralized power in other spheres or decisions (such as in government) may not behave collaboratively in collective decision-making”.

In the initial literature analysis on collaborative governance, no elements of administrative burden were detected. However, in the context of the Todos Somos Program, interviewees reported facing barriers and redundancies in obtaining information, which necessitated a revision of the project structures. This situation illustrates how the government, or its public bodies, plays a critical role in structuring collaborations in the public sector. Administrative burden tends to emerge in contexts with multiple problems and can be more effective when the objectives are well-defined, supported by political backing, have adequate resources, and possess the autonomy to develop solutions based on specialized expertise, as suggested by Meier et al. (2019).

6. Conclusions

The analyzed case study emphasized the significance of trust among stakeholders in conflict management and collaborative decision-making. It highlighted the need for inclusive decision-making processes involving listening to all actors, including traditionally excluded ones, such as informal and organized recyclers. This contribution to society underscores the importance of trust in facilitating effective conflict resolution and decision-making. However, administrative burdens in governance can pose challenges that impact the effectiveness of social projects.

The study provides evidence supporting existing theories about the role of trust in collaborative governance (Ansell & Gash, 2008; Emerson, Nabatchi & Balogh, 2012), contributing to the understanding of how power dynamics affect collaborative governance (Eckerberg, Bjärstig & Zachrisson, 2015; Criado & Guevara-Gómez, 2021). Thus, it contributes to the existing literature on administrative burden and its impact on governance processes (Wanna, 2008; Meier et al., 2019). However, future research could examine projects in which pre-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

existing trust among stakeholders has been identified, to determine whether this factor can mitigate conflicts that may arise during the decision-making process.

It is important to note a limitation in our study, as we were unable to contact some self-employed informal recyclers (beneficiaries of the program) during the interviews. These recyclers were not involved in the Waste Pickers Forum. This group represents an unorganized working class, many of whom do not have access even to a telephone or a permanent address. However, despite this obstacle, it was possible to identify the factors that influenced decision-making through interviews with the Program's contributors, including the recycling practices of the cooperatives (leaders of the Screening Unit and members of the Waste Pickers Forum) and other stakeholders.

This study provides practical insights for public managers on promoting effective strategies to address complex problems. It shows the importance of clear and well-defined governance strategies that enhance social sustainability and its interconnected dimensions. Additionally, the findings can be useful for the government and public sector organizations in organizing collaborative efforts, with the goal of reducing administrative obstacles and improving the efficiency of public projects.

Acknowledgement

This work was conducted with the support of Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES). Financing Code 001.

References

Almeida, V., Getschko, D., & Afonso, C. (2015). The origin and evolution of multistakeholder models. *IEEE Internet Computing, 19*(1), 74–79. https://doi.org/10.1109/MIC.2015.15

Ansell, C., & Gash, A. (2008). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory, 18*(4), 543–571. https://doi.org/10.1093/jopart/mum032

Bardin, L. (2009). *Análise de conteúdo*. Edições 70.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(2), 544–559. https://doi.org/10.46743/2160-3715/2008.1573

Beck, D., & Ferasso, M. (2023). Bridging 'stakeholder value creation' and 'urban sustainability': The need for better integrating the environmental dimension. *Sustainable Cities and Society, 89*, 104316. https://doi.org/10.1016/j.scs.2022.104316

Bianchi, C., Nasi, G., & Rivenbark, W. C. (2021). Implementing collaborative governance: Models, experiences, and challenges. *Public Management Review, 23*(11), 1581–1589. https://doi.org/10.1080/14719037.2020.1795231

Borrini-Feyerabend, G., Dudley, N., Jaeger, T., Lassen, B., Pathak Broome, N., Phillips, A., & Sandwith, T. (2013). *Governance of protected areas: From understanding to action*. IUCN. https://portals.iucn.org/library/sites/library/files/documents/PAG-020.pdf

Bradley, S., Mahmoud, I. H., & Arlati, A. (2022). Integrated collaborative governance approaches towards urban transformation: Experiences from the Clever Cities project. *Sustainability, 14*(23), 15566. https://doi.org/10.3390/su142315566

Broccardo, L., Culasso, F., & Mauro, S. G. (2019). Smart city governance: Exploring the institutional work of multiple actors towards collaboration. *International Journal of Public Sector Management, 32*(4), 367–387. https://doi.org/10.1108/IJPSM-05-2018-0126

Buchan, P. M., Orchel, K. O., Lannin, A., Brett, E., Willis, M., Holtby, R., & Walker, R. (2024). *Opportunities for improved social sustainability in marine governance*. University of Exeter and Marine Management Organisation.

Burden, B. C., Canon, D. T., Mayer, K. R., & Moynihan, D. P. (2012). The effect of administrative burden on bureaucratic perception of policies: Evidence from election administration. *Public Administration Review, 72*(5), 741–751. https://doi.org/10.1111/j.1540-6210.2012.02600.x

Casti, J. L. (1986). On system complexity: Identification, measurement, and management. In J. L. Casti & A. Karlqvist (Eds.), *Complexity, language, and life: Mathematical approaches* (pp. 146–173). Springer. https://doi.org/10.1007/978-3-642-70941-1_6

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Cepeda, G., & Martin, D. (2005). A review of case studies publishing in *Management Decision* 2003–2004: Guides and criteria for achieving quality in qualitative research. *Management Decision, 43*(6), 851–876. https://doi.org/10.1108/00251740510603600

Choi, T., & Robertson, P. J. (2014a). Caucuses in collaborative governance: Modeling the effects of structure, power, and problem complexity. *International Public Management Journal, 17*(2), 224–254. https://doi.org/10.1080/10967494.2014.905398

Choi, T., & Robertson, P. J. (2014b). Deliberation and decision in collaborative governance: A simulation of approaches to mitigate power imbalance. *Journal of Public Administration Research and Theory, 24*(2), 495–518. https://doi.org/10.1093/jopart/mut003

Criado, J. I., & Guevara-Gómez, A. (2021). Public sector, open innovation, and collaborative governance in lockdown times: A research of Spanish cases during the COVID-19 crisis. *Transforming Government: People, Process and Policy, 15*(4), 612–626. https://doi.org/10.1108/TG-08-2020-0242

Davidson, M. (2010). Social sustainability and the city. *Geography Compass, 4*(7), 872–880. https://doi.org/10.1111/j.1749-8198.2010.00339.x

Eckerberg, K., Bjärstig, T., & Zachrisson, A. (2015). Incentives for collaborative governance: Top-down and bottom-up initiatives in the Swedish mountain region. *Mountain Research and Development, 35*(3), 289–298. https://doi.org/10.1659/MRD-JOURNAL-D-14-00068.1

Edmunds, D., & Wollenberg, E. (2001). A strategic approach to multistakeholder negotiations. *Development and Change, 32*(2), 231–253. https://doi.org/10.1111/1467-7660.00202

Emerson, K., Nabatchi, T., & Balogh, S. (2012). An integrative framework for collaborative governance. *Journal of Public Administration Research and Theory, 22*(1), 1–29. https://doi.org/10.1093/jopart/mur011

Ferrarezi, E., & Oliveira, C. G. (2012). Reflexões sobre a emergência da participação social na agenda das políticas públicas: Desafios à forma de organização burocrática do Estado. In *V Congresso CONSAD de Gestão Pública* (pp. 8–11). CONSAD.

Fischer, M., & Sciarini, P. (2016). Drivers of collaboration in political decision making: A cross-sector perspective. *Journal of Politics, 78*(1), 63–74. https://doi.org/10.1086/683061

Flick, U. (2009). *Desenho da pesquisa qualitativa*. Artmed.

Follador, D., Roy, M., & Bélanger, A. (2021). Collaborative governance in urban planning: Patterns of interaction in Curitiba and Montreal. *Journal of Planning and Development, 147*(1), 1–13. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000642

Fontanella, B. J. B., Ricas, J., & Turato, E. R. (2008). Amostragem por saturação em pesquisas qualitativas em saúde: Contribuições teóricas. *Cadernos de Saúde Pública, 24*(1), 17–27. https://doi.org/10.1590/S0102-311X2008000100003

Gontijo, A. C., & Maia, C. S. C. (2004). Tomada de decisão, do modelo racional ao comportamental: Uma síntese teórica. *Caderno de Pesquisa em Administração, 11*(4), 13–30. http://150.162.8.240/PNAP_2013_2/Modulo_4/Organizacao_processos_tomada_decisao/material_didatico/textos/Tomada%20de%20decisao.pdf

Gutberlet, J., Besen, G. R., & Morais, L. P. (2020). Participatory solid waste governance and the role of social and solidarity economy: Experiences from São Paulo, Brazil. *Detritus, 13*, 167–180. https://doi.org/10.31025/2611-4135/2020.14024

Hovardas, T. (2021). Social sustainability as social learning: Insights from multi-stakeholder environmental governance. *Sustainability, 13*(14), 1–20. https://doi.org/10.3390/su13147744

Kossmann, C. M. (2015). *Collaborative governance in the Nusa Penida Marine Protected Area, Indonesia* (Master's thesis). Wageningen University and Research Centre. https://edepot.wur.nl/350630

Kossmann, C. M., Behagel, J. H., & Bailey, M. (2016). Action and inertia in collaborative governance. *Marine Policy, 72*, 21–30. https://doi.org/10.1016/j.marpol.2016.06.007

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Liu, F., & Maitlis, S. (2010). Nonparticipant observation. In A. J. Mills, G. Durepos, & E. Wiebe (Eds.), *Encyclopedia of case study research* (Vol. 2, pp. 609–611). SAGE.

Maani, K. (2016). *Multi-stakeholder decision making for complex problems: A systems thinking approach with cases*. World Scientific. https://doi.org/10.1142/9294

Martins, G. A. (2008). Estudo de caso: Uma reflexão sobre a aplicabilidade em pesquisa no Brasil. *Revista de Contabilidade e Organizações, 2*(2), 8–18. https://doi.org/10.11606/rco.v2i2.34702

Meier, K. J., O'Toole, L. J., & Nicholson-Crotty, S. (2019). Bureaucracy and the failure of politics: Challenges to democratic governance. *Administration and Society, 51*(10), 1576–1605. https://doi.org/10.1177/0095399719874759

Mosley, J. E., & Wong, J. (2021). Decision-making in collaborative governance networks: Pathways to input and throughput legitimacy. *Journal of Public Administration Research and Theory, 31*(2), 328–345. https://doi.org/10.1093/jopart/muaa033

Naffaa, S. (2017). *Collaborative modelling in Deltares*. Deltares. https://publicwiki.deltares.nl/display/CM/Collaborative+Modelling+in+Deltares

Newig, J., Challies, E., Jager, N. W., Kochskämper, E., & Adzersen, A. (2017). The environmental performance of participatory and collaborative governance: A framework of causal mechanisms. *Policy Studies Journal, 46*(2), 1–29. https://doi.org/10.1111/psj.12209

Panday, P. (2018). Making innovations work: Local government-NGO partnership and collaborative governance in rural Bangladesh. *Development in Practice, 28*(1), 125–137. https://doi.org/10.1080/09614524.2018.1401588

Pashaei Kamali, F., Meuwissen, M. P. M., & Oude Lansink, A. G. J. M. (2018). Towards social sustainability: Screening potential social and governance issues for biojet fuel supply chains in Brazil. *Renewable and Sustainable Energy Reviews, 92*, 50–61. https://doi.org/10.1016/j.rser.2018.04.078

Picavet, M. E. B., van der Heijden, J., & van der Heijden, R. (2023). How can transnational municipal networks foster local collaborative regimes for environmental management? *Environmental Management, 71*(3), 505–522. https://doi.org/10.1007/s00267-022-01685-w

Purdy, J. M. (2012). A framework for assessing power in collaborative governance processes. *Public Administration Review, 72*(3), 409–417. https://doi.org/10.1111/j.1540-6210.2011.02525.x

Thomson, A. M., & Perry, J. L. (2006). Collaboration processes: Inside the black box. *Public Administration Review, 66*(1), 20–32. https://doi.org/10.1111/j.1540-6210.2006.00663.x

Tonelli, D. F., Brito, M. J., & Zambalde, A. L. (2018). Antecedents, process and equity outcomes: A study about collaborative governance. *Cogent Business and Management, 5*(1), 1–17. https://doi.org/10.1080/23311975.2018.1469381

Trimble, M., Olivier, T., Anjos, L. A., Tadeu, N. D., Giordano, G., Mac Donnell, L., ... & Pahl-Wostl, C. (2022). How do basin committees deal with water crises? Reflections for adaptive water governance from South America. *Water International, 47*(1), 1–20. https://doi.org/10.1080/02508060.2021.2000895

Ulibarri, N. (2015). Tracing process to performance of collaborative governance: A comparative case study of federal hydropower licensing. *Policy Studies Journal, 43*(2), 283–308. https://doi.org/10.1111/psj.12096

Ulibarri, N., & Scott, T. A. (2017). Linking network structure to collaborative governance. *Journal of Public Administration Research and Theory, 27*(1), 163–181. https://doi.org/10.1093/jopart/muw041

Ulibarri, N., Emerson, K., Imperial, M. T., Jager, N. W., Newig, J., & Weber, E. (2020). How does collaborative governance evolve? Insights from a medium-n case comparison. *Policy and Society, 39*(4), 617–637. https://doi.org/10.1080/14494035.2020.1785726

Wang, H., & Ran, B. (2023). Network governance and collaborative governance: A thematic analysis on their similarities, differences, and entanglements. *Public Management Review, 25*(6), 1187–1211. https://doi.org/10.1080/14719037.2022.2048687

Wanna, J. (2008). Collaborative government: Meanings, dimensions, drivers and outcomes. In J. O'Flynn & J. Wanna

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

(Eds.), *Collaborative governance: A new era of public policy in Australia* (pp. 3–12). ANU Press.

Yin, R. K. (2015). *Estudo de caso: Planejamento e métodos*. Bookman.

Yin, R. K. (2016). *Pesquisa qualitativa do início ao fim*. Penso.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Evaluation of Public Services Through the Lens of Digital Ethics

Narek Andreasyan[a*], *Daniele* Buson[b], *José* Mancera[c], *Edy* Portmann[d], *Luis* Terán[e]

[a] Institute of Human-Centered Interaction Science and Technology, University of Fribourg, Switzerland, narek.andreasyan@unifr.ch, ORCID: 0000-0002-2526-6476

[b] Institute of Communication and Marketing, Lucerne University of Applied Sciences and Arts, Switzerland, daniele.buson@stud.hslu.ch

[c] Institute of Communication and Marketing, Lucerne University of Applied Sciences and Arts, Switzerland, jose.mancera@hslu.ch, ORCID: 0000-0003-3837-6524

[d] Institute of Human-Centered Interaction Science and Technology, University of Fribourg, Switzerland, edy.portmann@unifr.ch, ORCID: 0000-0001-6448-1139

[e] Institute of Communication and Marketing, Lucerne University of Applied Sciences and Arts, Switzerland, luis.teran@hslu.ch, ORCID: 0000-0002-0503-511X

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 5 June 2025

Abstract. The rapidly growing popularity of digital services requires robust frameworks to identify and address associated ethical concerns. This paper presents a structured framework for assessing ethical concerns of digital services, offering a scalable and adaptable tool to assess concerns, including data misuse, cybersecurity, transparency, inequality, and sustainability. The framework employs a customized Delphi method to gather diverse expert insights, translating them into quantifiable metrics through a mathematical model. These metrics inform structured surveys, generating actionable outputs, including visual summaries, static recommendations, and AI-driven insights. To illustrate the framework's application, we detail its implementation in the context of electronic voting (e-voting). By addressing key ethical challenges, mainly privacy, transparency, and inclusivity, this use case demonstrates the framework's utility in analyzing complex digital services. The study highlights the importance of balancing technological innovation with ethical accountability, providing a practical approach to ensuring transparency and trust in public digital services.

Keywords. digital ethics, humanistic, AI ethics, ethical concerns, LLM
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1033

1. Introduction

As digital services become integral to modern society, addressing their ethical implications has become increasingly critical. For example the Facebook–Cambridge Analytica scandal in 2018 highlighted major ethical concerns regarding privacy and consent in digital services. Personal data from millions of Facebook users was collected without their explicit permission and used for political advertising, sparking global debates about data misuse and democratic integrity (The Guardian, 2018). Similarly, Google faced criticism when it was discovered that their Street View cars collected data from unsecured Wi-Fi networks during their image capture process. This raised serious privacy concerns, as users were unaware that their data was being intercepted and stored (The Guardian, 2010; Wired, 2012). Another significant case is Clearview AI, which built a powerful facial recognition tool by scraping billions of images from social media platforms without user consent. This practice ignited concerns over mass surveillance, potential misuse by law enforcement, and the lack of transparency in how facial recognition data is gathered and applied (Hart, 2024; The Guardian, 2022). These cases collectively emphasize the urgent need for ethical oversight, informed consent, and accountability in digital services.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This requires a comprehensive approach that spans the entire digital service lifecycle, encompassing design, development, and deployment, as outlined by (Cath et al., 2018). Building on these foundations, this paper presents a framework for assessing ethical concerns in digital services. The framework enables organizations to identify risks, implement actionable improvements, and expand on previous research in the field (Andreasyan et al., 2024; Teran et al., 2021; Wallimann-Helmer et al., 2021). The proposed framework utilizes a customized Delphi method (see subsection 3.2 and also previous work (Andreasyan et al., 2024)), fostering iterative discussions among experts to capture diverse perspectives rather than consensus. Unlike the traditional Delphi method, our version does not aim to achieve consensus among participants but rather to foster diverse perspectives that allow participants to reconsider their conclusions after hearing others' viewpoints. These expert insights inform structured surveys that allow service providers, such as Swiss Post employees, to evaluate their services against ethical criteria derived from expert input and scientific literature. A web-based application processes the survey responses to generate practical outputs, including visual summaries, tailored recommendations, and insights from a domain-specific large language model (LLM) (future development). These tools assist decision-makers in prioritizing and addressing ethical challenges. The framework serves two main purposes: evaluating ethical considerations for proposed digital services and diagnosing ethical issues in existing ones.

By focusing on critical ethical factors such as privacy, transparency, trust, and inclusivity, the framework promotes ethical accountability and fosters public trust in digital governance. These general ethical concerns (see subsection 4.2) align with the discussions in (Nabbosa and Kaar, 2020; Schoentgen and Wilkinson, 2021), which explore ethical issues in the digital era and societal digitalization. Figure 1 shows the results, namely consensus versus dissensus of the 75 responses of two customized Delphi methods after two rounds.

The results of these discussions are then integrated into a survey tool, where service providers, such as Swiss Post employees, can evaluate their own services based on ethical concerns raised by the experts and literature. A web-based application aggregates the survey responses and generates an output in the form of graphical summaries, recommendations with cited sources, and access to an LLM trained in the relevant domain to offer further insights into potential issues. Figure 2 illustrates the process flow of our framework. It provides an overview diagram highlighting key steps, including literature review, ethics assessment framework development, iterative evaluation, and finally generate ethical insights.

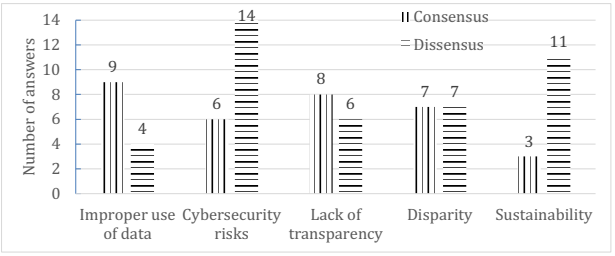


Fig. 1 – Survey results for two rounded customized Delphi method.

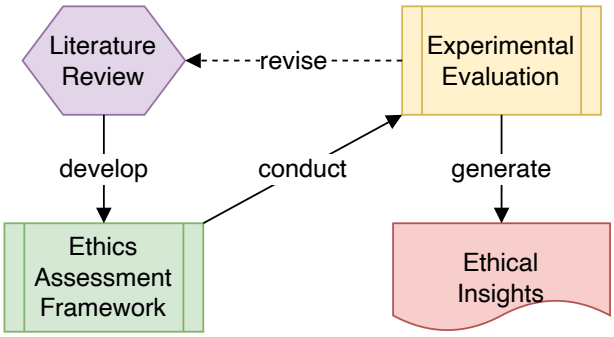


Fig. 2 – Process flow for identifying and analyzing ethical concerns in public digital services.

1.1. Public Services

In digital governance, public services stand at the forefront of societal well-being, requiring efficient delivery and a strong ethical foundation. As governments and organizations adopt new technologies to administer services—ranging from healthcare to education—balancing innovation with robust ethical standards becomes paramount, which is stated in international standard (Olszewska et al., 2022), that it is crucial to address ethical concerns during and from the beginning of the digital platform's development. As highlighted

by (Warner, 2023), public services play a crucial role in upholding societal values, necessitating transparent, inclusive, and accountable practices to maintain public trust.

We first examine the broader landscape of public services and emphasize the importance of aligning technological innovation with ethical principles to foster trust. We then delve into a specific application, the e-voting use case, which illustrates how our ethical evaluation framework can be adapted to safeguard critical democratic processes in the digital era. Future work will be dedicated to analyzing and implementing other public services (e.g., health and logistics, among others).

1.2. Evaluation Framework for Ethical Digital Services

We outline our ongoing efforts to develop a robust framework for evaluating the ethical concerns associated with digital services. This initiative builds upon our previous work, as outlined in (Andreasyan et al., 2024), which presented the theoretical foundation for addressing digital ethics challenges in public services, explicitly using the case of electronic voting. The current framework, conducted in collaboration with our implementation partner, Swiss Post, reflects our shared commitment to enhancing the transparency and trustworthiness of public digital services. Central to this mission is integrating expert insights and empirical data into a structured analytical process that supports creating and maintaining ethically sound digital solutions.

Our methodology begins with a diverse panel of experts participating in a modified Delphi method. Unlike traditional consensus-driven approaches, our adaptation of the Delphi method actively embraces a wide array of perspectives to ensure that differing viewpoints are captured and considered. This iterative process ensures that ethical standards are rigorously debated and refined. Following these expert panels, service providers complete structured surveys based on the ethical standards identified during the Delphi process. Responses are then processed through a Web-based application that consolidates the data into actionable insights, visual summaries, and tailored recommendations.

The systematic nature of our framework is designed to strengthen public trust in digital services, particularly within sensitive domains such as healthcare, education, and governance. The importance of ethical considerations in these areas is well-documented in the literature, with notable examples including the ethical use of digital trace data in education (Hakimi et al., 2021), the challenges of applying digital twins for personalized healthcare services (Huang et al., 2022), and the broader implications of digital innovation in public administration (Pakhnenko, Kuan, et al., 2023). Ethical lapses in these domains can significantly erode public confidence, making addressing these concerns from the design phase to deployment critical.

Through a cycle of expert-driven inquiry, data-gathering, and targeted recommendations, our framework aims to establish a scalable and adaptable model for ethical oversight that can be broadly applied to a diverse range of public digital services. By embedding ethical considerations into every stage of the process, we strive to create digital solutions that are functional, efficient, and aligned with the principles of fairness, transparency, and accountability.

1.3. Use Case: E-Voting

The first use case of our framework is in the context of e-voting systems by Swiss Post, a domain where ethical considerations are crucial. Electronic voting systems' integrity, transparency, and security are essential for protecting democratic processes and ensuring public confidence in electoral outcomes. By applying our framework to e-voting, we can identify and mitigate potential ethical risks such as data privacy breaches, voter manipulation, or transparency deficiencies.

In collaboration with the Swiss Post, we are currently developing this framework with their e-voting experts to evaluate and enhance the ethical aspects of their digital voting services. The process involves an iterative feedback cycle and refinement to adapt the framework precisely to the complexities of e-voting. This use case not only serves to demonstrate the framework's effectiveness but also sets a precedent for other digital services, such as e-health and logistics.

Through the e-voting pilot, we aim to establish a model for ethical digital governance that can be replicated and scaled across various public services. By focusing on critical issues such as privacy, security, and trust, the

framework supports creating e-voting systems that voters can trust. Moreover, this initiative aligns with global efforts to strengthen the resilience of democratic institutions against the challenges posed by digitization and cyber threats.

In conclusion, the development and application of our ethical evaluation framework represent a significant advancement in the governance of digital services. By proactively addressing ethical concerns, we can safeguard public trust and ensure that digital innovations in public services, like e-voting, are beneficial and secure.

Ultimately, this work addresses the following research questions: What ethical concerns and general ethical factors are important in the e-voting use case? How can a theoretical framework and user-friendly prototype address those ethical concerns and general factors?

2. Related Works

As digital services shape modern life, ethical design has become crucial. This section outlines advancements in evaluating digital ethics and reviews frameworks that offer structured approaches to addressing ethical challenges. These tools provide practical insights into embedding ethical principles in digital service design.

Our tool, the Swiss Digital Ethics Compass (SDEC), differs from others by focusing on twelve ethical concerns rather than general ethical factors. This approach builds on literature emphasizing ethics in technology design and governance.

Two prominent frameworks informed our work. The TEDS framework (Joisten et al., 2022) focuses on "technoethical" concerns, especially around data privacy and breaches. The AI Digital Tool Product Lifecycle Governance Framework (Ortega et al., 2023) emphasizes embedding ethics and compliance by design through human-centered principles and risk management.

Other valuable contribution includes the Digital Ethics Canvas (Hardebolle et al., 2023), which evaluates ethical risks through six key principles (e.g., beneficence, fairness, sustainability) (see Figure 3). It was positively received in evaluations with novices (N=26) and experts (N=16). The Ethics Canvas (Lukianets et al., 2021), inspired by the Business Model Canvas (Osterwalder and Pigneur, 2010), guides users in identifying stakeholders and ethical concerns across three stages. The Data Ethics Canvas[1] helps organizations navigate ethical data use, while the Ethics Canvas[2] promotes responsible innovation across various project types.

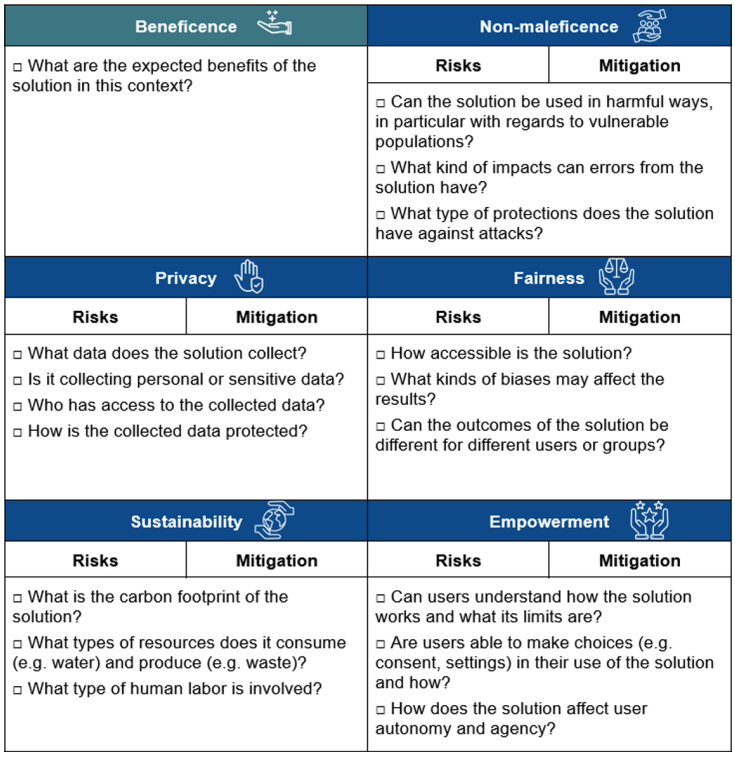


Fig. 3 – Digital ethics canvas (Hardebolle et al., 2023).

The ALTAI framework (on AI, 2020) offers a self-assessment for AI systems based on seven key requirements like oversight, safety, and transparency. In contrast, the AI4Belgium tool[3] focuses on an organization's readiness for AI deployment, covering infrastructure and strategic alignment.

[1] Data Ethics Canvas by the Open Data Institute (ODI): https://github.com/theodi/data-ethics-canvas
[2] The Online Ethics Canvas: https://www.ethicscanvas.org
[3] Online platform for assessing the trustworthiness of AI implementation: https://altai.ai4belgium.be/

In the Figure 4 is presented the AI System Ethics Self-Assessment Tool (Dubai, 2023) from Digital Dubai, which evaluates digital systems based on fairness, accountability, transparency, and explainability. It produces an ethics score based on system impact and mitigation measures.

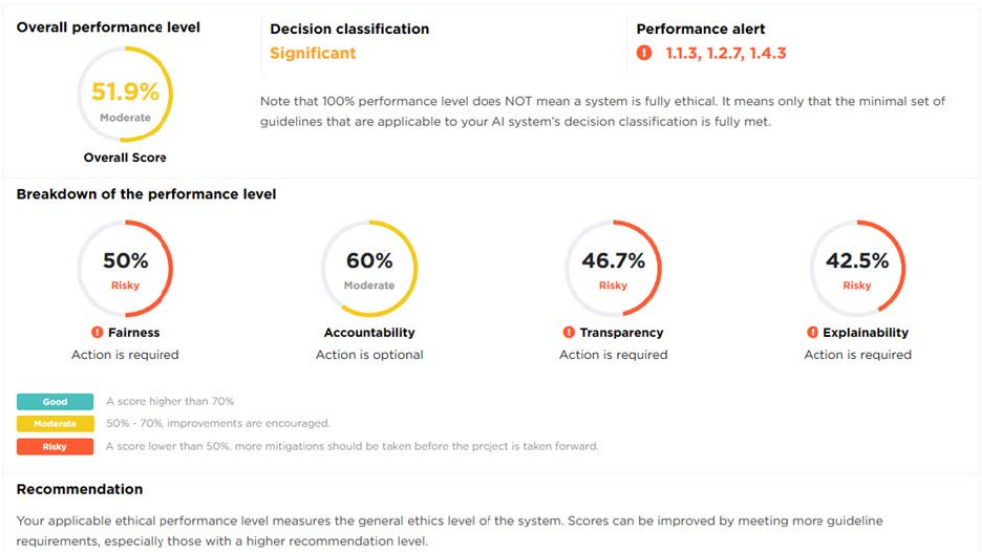


Fig. 4 – AI System Ethics Self-Assessment Tool (Dubai, 2023).

Our approach stands out by analyzing twelve ethical concerns found in our previous work (Andreasyan et al., 2024; Teran et al., 2021; Wallimann-Helmer et al., 2021):

- **Autonomy:** lack of decision-making ability due to external influence.
- **Discrimination:** unjustified differentiation for irrelevant reasons.
- **Domination:** actual or potential control over others.
- **Exclusion:** unfair denial of access to benefits.
- **Exploitation:** unfair advantage taken of individuals or groups.
- **Inequality:** unjustified unequal treatment or outcomes.
- **Justice:** biased or unfair distribution.
- **Privacy:** exposure without adequate protection.
- **Responsibility:** failure to acknowledge or prepare for negative impacts.
- **Trust:** weakened relationships among stakeholders.
- **Dignity:** disregard for human respect and rights.
- **Truth:** misrepresentation of identity or actions.

This approach enables deeper, context-specific evaluation of AI impacts, enhancing accountability and inclusivity. By addressing specific concerns often overlooked in traditional models, our framework promotes responsible and ethically grounded public digital systems.

3. Framework

This section outlines a comprehensive three-step process for evaluating ethical concerns in digital services. By integrating expert consultations, structured surveys, and advanced analytical tools, this framework ensures a robust assessment of critical issues such as privacy, transparency, and security. Leveraging proper methodologies such as the Delphi method and interactive web technologies facilitates informed decision-making while promoting explainability and transparency. The subsequent sections detail each step, supported by visual and technical insights, enhancing the ethical evaluation process. An overview of the process is provided in Figure 5.

3.1. System Architecture

Figure 6 illustrates the system architecture organized into two primary components: the user and technical layers.

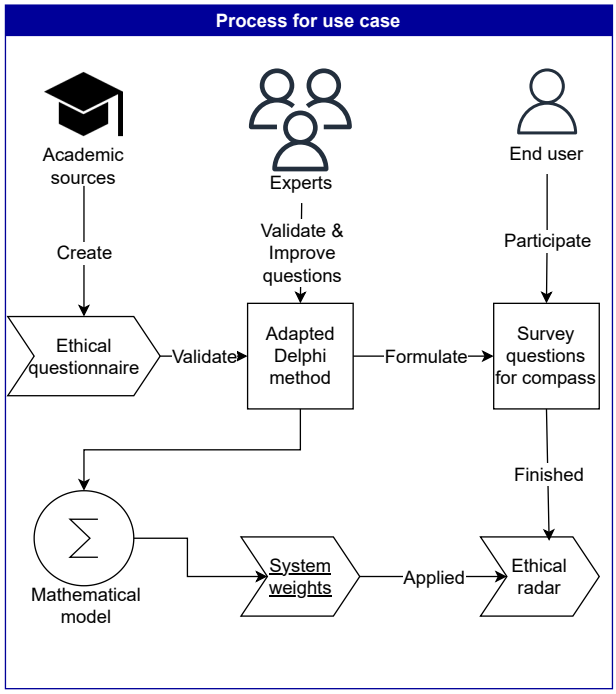


Fig. 5 – Overview of the framework's process for identifying and addressing ethical concerns in public digital services.

User Layer. In the user layer, a request and response system enables users, particularly internal Swiss Post employees, to complete surveys or seek clarification on ethical topics. The system then processes these inquiries and generates responses that assess ethical concerns and provide static recommendations. Additionally, users can interact with generative artificial intelligence (GenAI) to get extra information about the use case and digital ethics.

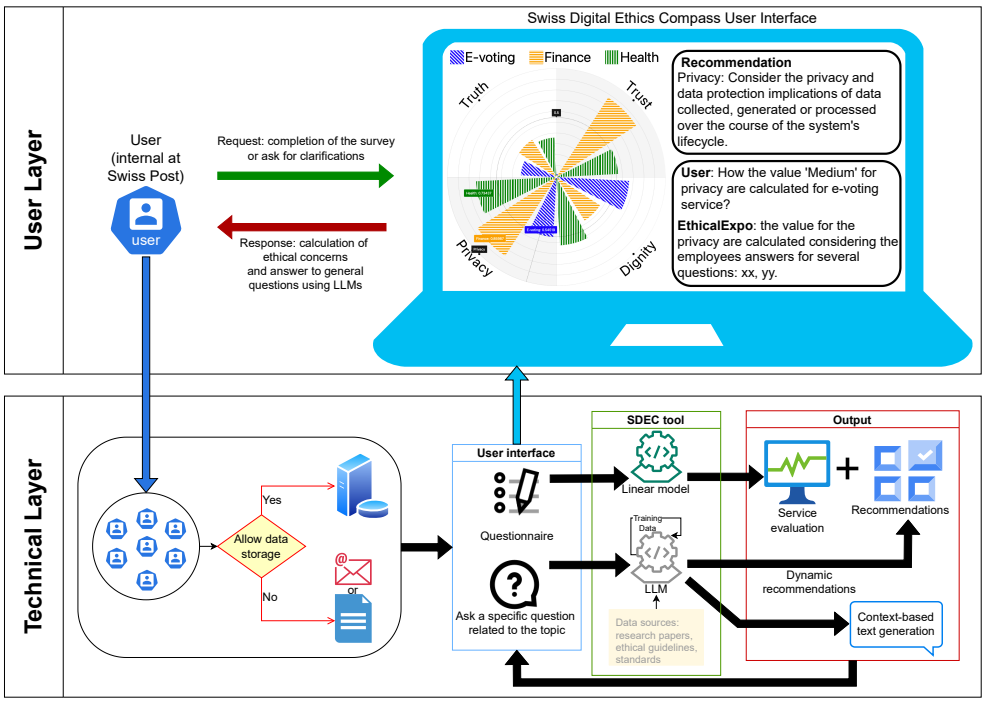


Fig. 6 – User and technical layers. Mock-up for the graphical interface of the smart radar, including static and dynamic recommendations.

Technical Layer. The technical layer begins with the user interface, where users can ask questions about ethical and compliance topics. The system employs a questionnaire format to capture the context of each query, prompting users to provide details relevant to their concerns. This information flows into an output module, which generates answers based on contextual text production, service evaluation, and dynamic recommendations. The data sources feeding into the GenAI modules include research papers, ethical guidelines, and standards, which were extracted from digital libraries such as ACM, IEEE, PhilPapers, and SprinerLink between 2010 and 2023 (Andreasyan et al., 2024; Teran et al., 2021). On top of LLM, retrieval-augmented generation (RAG) was built on academic literature identified within the development of this project. It interprets user questions and assists in ethical evaluations, while linear models are employed to refine response accuracy further. A recommendation component enhances this layer by giving users insights about privacy implications based on collected data. The framework is designed to support explainability and transparency, offering Swiss Post's internal users clear and contextualized responses to ethical questions related to data privacy and ethical standards. For instance, if a user would like to know more details on how the privacy rating of "medium" is determined for an e-voting service, the system provides a structured response. It includes referencing employee answers to relevant questions and offering transparency on how privacy values are computed.

Tab. 1 – Licensing and adaptability of various LLMs (* - with extra conditions) (MindsDB, 2024; UbiOps, 2024).

LLM	License	Commercial?	Adaptable?
Mistral	Apache-2.0	Yes	Yes
GPT-4	Closed Source	No	No
GPT-3	Closed Source	No	No
GPT-2	MIT	Yes	Yes
LLaMa 2	Custom LLaMa 2	Yes	Yes*
BART	Apache-2.0	Yes	Yes
BERT	Apache-2.0	Yes	Yes
Falcon	Apache-2.0	Yes	Yes
Falcon-180B	Custom Falcon	Yes	Yes*

LLM Framework Selection. Selecting an LLM framework was crucial for this project. Transparency and control were key drivers, leading to the adoption of an open-source LLM. This choice ensures visibility into the model's processes, allowing us to understand content generation and address ethical concerns. Such transparency aligns with our ethical AI practices and supports collaboration with the wider AI community. Data security and privacy were also vital. To avoid transmitting sensitive data to third-party providers, we chose a locally deployed solution. This minimizes the risk of data breaches and supports compliance with data protection regulations. Open-source LLMs offer technical flexibility, enabling customization to meet our ethical standards, such as allowing users to verify AI-generated content and supporting human oversight. Additionally, this approach avoids reliance on third-party infrastructure, mitigating risks related to data sovereignty and provider-imposed changes. In summary, our choice of an open-source LLM was based on transparency, privacy, flexibility, and control (Kukreja et al., 2024; Manchanda et al., 2024). This allows us to build a secure, customizable, and ethically aligned system. For the SDEC implementation, we choose the Mistral LLM framework[4].

Tab. 2 – Types and parameter sizes of various LLMs (MindsDB, 2024; UbiOps, 2024).

LLM	Type	# of parameters
Mistral	Decoder-only	7.24B, 46.7B
GPT	Decoder-only	124M, 350M, 760M, 1.3B, 2.7B, 6.7B
LLaMa	Decoder-only	6.74B, 70B
BART	Encoder-decoder	139M, 406M
BERT	Encoder-only	110M, 336M
Falcon	Decoder-only	7B, 40B

Mistral Technical Specifications. Mistral is a decoder-only, Apache-2.0 licensed model, making it commercially usable and highly adaptable. With parameter sizes of 7.24B and 46.7B, it balances performance and efficiency, competing with models like Falcon and LLaMa 2 while avoiding licensing constraints. Unlike closed-source models like GPT-3/4, Mistral enables customization and transparency, as detailed in Table 1. Ethically, Mistral's open license supports independent audits, bias detection, and safety improvements, in contrast to proprietary models. It avoids the restrictive terms found in models like LLaMa 2 and Falcon-180B, enabling ethical development and reducing risks of commercial lock-in. Mistral allows responsible fine-tuning to address bias and fairness. Its parameter efficiency supports sustainable AI development and makes it suitable for deployment in resource-limited environments Table 2. In summary, Mistral's open-source nature, adapt-

[4]Mistral LLM: https://mistral.ai/news/mistral-nemo

ability, and strong technical and ethical features position it as a superior alternative to closed or restricted models (Poszler et al., 2024).

3.2. Workshops with Experts

The experts have been chosen in the following way to provide diverse opinions. P2 and P5 was directly related to the e-voting team, but the rest were from different departments (see list of expert profiles in Table 3). We begin with expert consultations , structured around a customized version of the Delphi method, as illustrated in Figure 7. The primary objective is to engage specialists in fields relevant to the digital service under analysis (e.g., e-voting) and foster an exchange of diverse perspectives. Particular attention was paid to ensure the quality and reliability of the consultations and to avoid potential pitfalls associated with expert interviews, as highlighted in (Döringer, 2021).

Tab. 3 – Background of experts in the survey.

ID	Profession
P1	Communication Specialist E-Government
P2	Team E-Voting Product Manager
P3	Accessibility and Corporate Social Responsibility Specialist
P4	Chief Information Security Officer
P5	Information Security Officer Trusted Interaction Services, E-Voting
P6	Professor on Soft Computing

To accommodate the requirements of digital environments and mitigate time constraints, we adapted the Delphi method to be conducted partially online. This adaptation provides significant flexibility, allowing participants to contribute asynchronously from various geographic locations while maintaining the method's iterative and collaborative nature. The Delphi method offers several distinct advantages, especially when research is scarce, ethically, or logistically complex or where conflicting evidence exists. As noted in (Nasa et al., 2021) and their work on its application within the healthcare sector, the Delphi method has become a critical tool for developing best practice guidelines through collective intelligence over the past decades. While in (Nasa et al., 2021), the authors emphasize consensus-building, our adaptation shifts the focus to capture a broad range of expert opinions. After each round, participants are encouraged to revisit and refine their views, addressing limitations identified in the literature (Nasa et al., 2021) and ensuring a robust collection of insights.

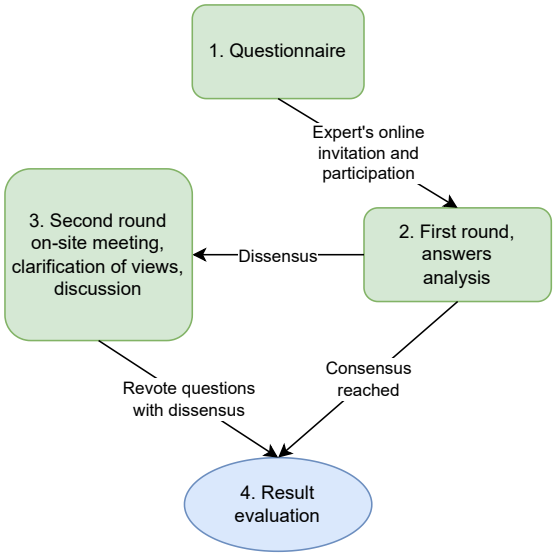


Fig. 7 – Workflow of our customized Delphi method.

For instance, in analyzing ethical concerns for e-voting services, experts were invited to deliberate on critical issues such as data privacy, voter anonymity, and fraud risks. These discussions were further enriched with insights from academic literature, including the emphasis on transparency, as discussed in (Enguehard, 2014). Together, these expert contributions and literature-based considerations form the foundation for the subsequent stages of the framework.

3.3. Survey Creation and Implementation

Once the expert discussions are complete, the concerns raised are distilled into a comprehensive survey aimed at service providers. This survey evaluates how the digital service is implemented from an ethical perspective. The questions cover multiple ethical factors related to the service, including the following:

- How is data privacy managed in the service?

- What measures are in place to ensure transparency?
- How does the service protect against malicious misuse?

The questions are grounded in expert opinions and existing literature to ensure a well-rounded assessment. End users, such as Swiss Post employees, interact with the survey through a web application designed specifically for this purpose. This app provides real-time feedback as the user answers each question.

3.4. Analysis and Recommendations

After completing the survey, users receive an analysis of their service's ethical concerns. The analysis includes:

- **Visualised Data**: A chart that summarises the levels of concern across different ethical domains (e.g., privacy, transparency, security).
- **Static Recommendations**: A list of suggestions for mitigating the identified risks, accompanied by citations from the relevant literature.
- **AI-driven Insights**: Users can use a service-trained LLM to explore further ethical implications and ask questions about specific issues.

Figure 8 provides an overview of these components in the evaluation process. The technical backbone of this framework involves leveraging pre-assessment surveys and interactive web technologies to deliver a seamless user experience.

An illustrative example from the forty-question framework demonstrates the computation of values for the smart radar is presented in Figure 6. To illustrate, consider the following question with predefined response options: *"Which authentication method is utilized in the service?"* The available choices are:

1. One-Time Password (OTP), level 2 domination, level 3 privacy
2. Multi-Factor Authentication (MFA), level 4 domination, level 5 privacy
3. Blockchain Authentication, level 3 domination, level 3 privacy
4. Biometric Authentication, level 8 domination, level 7 privacy
5. None

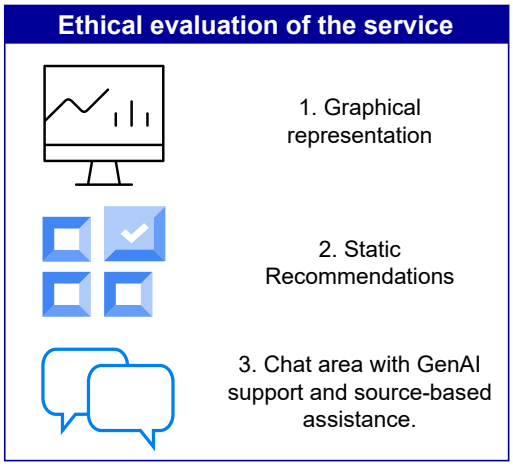


Fig. 8 – Overview of the ethical evaluation process, including graphical representation, recommendations, and AI-supported insights.

Each authentication mechanism influences ethical concerns, such as privacy, trust, and domination, as substantiated by scholarly literature (Druliac et al., 2024; Lauer, 2004; Trechsel et al., 2016). This question is accompanied by predefined static recommendations designed to enhance ethical compliance. Users receive tailored recommendations if the cumulative calculation across all questions exceeds a defined threshold (currently set at 0.6 out of 1). For example:

1. **Enhancing Privacy Protections:** To mitigate privacy risks, ensure that any personal data collected through MFA processes, such as phone numbers or email addresses, undergoes encryption and secure storage. This measure bolsters voter confidentiality and strengthens trust in the system (Lauer, 2004).
2. **Implementing Secure Authentication Mechanisms:** Combine multi-factor authentication (MFA) with a lightweight token-based OTP system to enhance security. Additionally, incorporate privacy-preserving techniques, such as hashing user identifiers, to reduce privacy threats (Druliac et al., 2024).
3. **Ensuring Secure Data Storage:** All personal data gathered during authentication must be encrypted and securely stored, ensuring confidentiality and integrity (Trechsel et al., 2016).

When users provide answers to questions, their selected responses determine concern levels associated with specific ethical factors. Based on expert opinions and literature, a concern score (1 to 10) is assigned to each answer for relevant ethical concerns. In this context, domination and privacy are two concerns commonly evaluated for such questions.

The scores are aggregated following a systematic procedure. The concern score contributes to a cumulative sum for each question for the respective ethical concern. The overall evaluation is calculated by summing the concern scores for each question and dividing by the total possible score. Assuming there are 20 questions, each with a maximum score of 10, the total maximum score for each concern is 200. If the cumulative score for privacy is 120 and for domination is 80, the evaluation is computed as follows:

$$\text{Evaluation (Privacy)} = \frac{120}{200} \times 100 = 60\% \tag{1}$$

$$\text{Evaluation (Domination)} = \frac{80}{200} \times 100 = 40\% \tag{2}$$

Based on the resulting percentage, the framework assigns fuzzy linguistic variables (e.g., *very high, high, neutral, low, very low*), which allow for more flexible and human-like reasoning by representing qualitative assessments rather than rigid numerical inputs. Figure 9 shows an example of the interface and the evaluation of ethical concern "exclusion" equal to "high risk." This is particularly useful in complex systems where expert judgments vary or when dealing with vague concepts such as ethics, trust, or risk.

By leveraging fuzzy logic, linguistic variables enhance interpretability and adaptability, leading to more realistic and context-aware evaluations (Zadeh, 1965, 2008). Furthermore, in Figure 9, a colored gradient is presented from *very low* to *very high* using a fuzzy index between (0:1). It indicates the overall ethnicity of the public digital services (see additionally Figure 6).

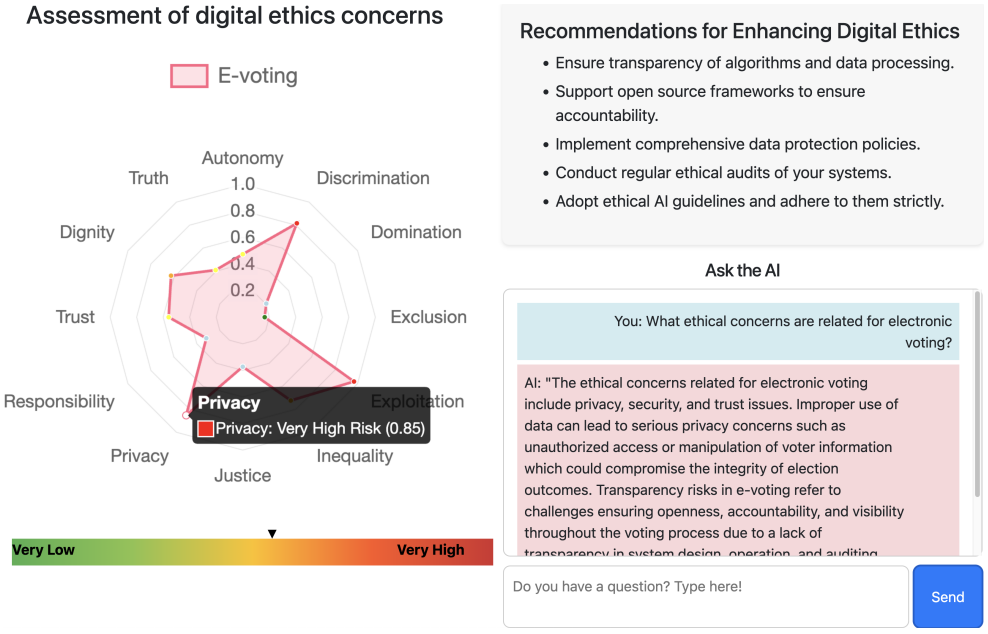


Fig. 9 – Swiss Digital Ethics Compass Interface.

Special Case Considerations: Not all questions adhere to the additive scoring model described in subsection 4.3. Certain questions are designed to assess the issue's magnitude rather than directly contribute to cumulative scores. For instance, consider the question: *"Specify the total number of eligible voters:"*

1. Less than 1k
2. 1k - 10k

3. 10k - 100k
4. 100k - 1M
5. More than 1M
6. None

This question evaluates the scale of the population affected and is used as a multiplier for related questions. By incorporating this proportionality, an issue's ethicality is scaled to reflect its broader societal impact.

The final scores for the smart radar are computed using the mathematical formula detailed in subsection 4.3 (see Equation 3). This comprehensive approach ensures that qualitative and quantitative ethicality dimensions are captured accurately. The threshold, which is set at the moment 0.6 out of 1, then the user gets the following recommendation:

1. Enhancing Privacy Protections: To mitigate privacy risks, ensure that any personal data collected through MFA processes, such as phone numbers or email addresses, undergoes encryption and is securely stored. This measure reinforces voter confidentiality and strengthens trust in the system's privacy safeguards (Lauer, 2004).
2. Implementing Secure Authentication Mechanisms: Employ multi-factor authentication (MFA) with a lightweight token-based OTP system to fortify security. Additionally, integrate privacy-preserving techniques, such as hashing user identifiers (e.g., phone numbers), to minimize exposure to privacy threats (Druliac et al., 2024).
3. Ensuring Secure Data Storage: All personal data gathered during the authentication process should be encrypted and stored securely, fostering trust by guaranteeing the confidentiality and integrity of voter information (Trechsel et al., 2016).

Once the user answers the question, he/she provides the system with a fact. Based on this fact, the level of concern is extracted. In this case, we use a table that maps each answer to the relative concern level from 1 to 10 based on experts' opinions, literature research, and logic. The values for smart radar are calculated utilizing a mathematical formula (described in subsection 4.3, Equation 3).

All final questions and static recommendations for the Compass can be found in the GitHub repository: [5].

4. Mathematical Model Development and Application of the Delphi Method

This framework employs a structured methodology combining mathematical modeling and the Delphi method to evaluate and address ethical concerns in digital services, specifically on e-voting systems. By integrating expert input, literature reviews, and iterative refinement, we quantify ethical challenges across five general ethical factors: improper use of data, cybersecurity risks, lack of transparency, disparity of treatment, and sustainability. The resulting framework provides actionable insights for stakeholders to improve service integrity (see subsection 4.2).

4.1. Methodological Overview

Our approach involves the following key steps (additionally, see Figure 5):

1. **Literature Review**: A comprehensive review of academic and industry sources was conducted to identify and understand ethical concerns in digital services. It included broad research on ethics in digital contexts and a focused analysis of e-voting systems. Robinson et al. explored ethical issues in e-voting security analysis, emphasizing vulnerabilities in system architectures (Robinson and Halderman, 2011). The authors outlined fundamental principles and requirements for a secure e-voting system, providing a framework for ethical considerations in digital voting (Gritzalis, 2002).
2. **Expert Discussions Using the Delphi Method**: Partnering with Swiss Post, we engaged six experts with diverse backgrounds. Leveraging the Delphi method (Linstone, Turoff, et al., 1975), a structured approach to achieving consensus among experts, we facilitated rounds of discussion to identify and evaluate critical ethical issues. The method, known for its iterative process of refining expert opinions (Dalkey and Helmer, 1963), enabled the experts to rate concerns on a scale from 1 (no concern) to 9 (maximum concern). It provided a robust, quantitative foundation for the model.

[5] Additional materials for the project: https://github.com/SwissDigitalEthicsCompass

3. **Weighted Evaluation System**: Based on expert input, we developed a mathematical model that calculates concern levels using weighted averages. These weights reflect the severity and importance of ethical risks and were normalized between 0 and 1 for consistency.
4. **Identification of Risk Scenarios**: A subsequent literature review focused on the e-voting domain to identify potential risk scenarios. For example, in (Lauer, 2004), the authors discussed the inherent risks of e-voting, highlighting the potential for breaches in security and voter trust. Insights from this review informed the development of targeted survey questions, ensuring the survey addressed critical vulnerabilities and ethical considerations in e-voting systems.
5. **User Survey Development**: A survey was created with 40 questions designed to evaluate the ethical and practical implications of e-voting services. In developing the survey, we tried to adhere to literature-proven methodologies for survey design and evaluation (Fowler Jr and Cosenza, 2009), ensuring a rigorous approach. The survey aims to collect data from end users and service developers, providing a foundation for refining the evaluation and addressing critical concerns in e-voting systems.
6. **Scoring and Concern Levels**: Survey responses are analyzed against a predefined table, assigning concern levels to each answer. These levels are aggregated to provide an overall evaluation of the service.
7. **Results Presentation**: Results are displayed on a dedicated website, offering static recommendations based on survey outcomes and a dynamic interface powered by a language model trained on scientific literature. The findings are also visualized using radar charts to highlight key concerns.

4.2. General Ethical Factors

The general factors are defined as five macro areas that serve as the foundation of our investigation (Andreasyan et al., 2024). This categorization was chosen to facilitate understanding and to group ethical concerns into specific categories, enabling a more focused and contextualized study. These factors are sufficiently broad to encapsulate all the ethical issues associated with e-voting systems. However, as noted in the conclusion in section 6, this framework is part of an iterative process and is subject to ongoing refinement. Future iterations, informed by expert input, may expand the number of factors to better address specific use case requirements.

Improper Use of Data. This factor evaluates risks related to data autonomy, privacy, and potential misuse of personal information. Expert ratings were used to develop a scale measuring the severity of data misuse concerns.

Cybersecurity Risks. Cybersecurity was assessed based on its role in ensuring privacy, trust, and fraud prevention. Weighted scores highlight the importance of robust authentication mechanisms and organizational accountability.

Lack of Transparency. Transparent communication and system comprehensibility were identified as critical factors for fostering trust and preventing exploitation. Numerical assessments informed recommendations for enhancing public trust in e-voting systems.

Disparity of Treatment. This factor addresses ethical concerns from unequal treatment, such as the digital divide and systemic exclusion. The model integrates expert evaluations to promote fairness and inclusivity.

Sustainability. Experts assessed environmental and economic considerations, including material reuse and cost efficiency. Sustainability scores were incorporated to balance ethical and practical priorities in e-voting systems.

4.3. Scoring and Explanation

The framework's scoring system for the end-user survey uses a formula designed to aggregate the concern levels derived from user responses. This method ensures that the results are normalized and accurately represent ethical risks. The calculation is defined as follows.

$$S = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} M_i}. \tag{3}$$

where S is the normalized concern score. C_i represents the concern level for the ith question, derived from the user's response. M_i is the maximum possible concern level for the ith question. n is the total number of questions answered by the user.

Explanation. The numerator ($\sum_{i=1}^{n} C_i$) sums up the concern levels indicated by the user's responses across all survey questions. These levels are derived from predefined scales (e.g., 1 to 9) that measure the severity of ethical risks. The denominator ($\sum_{i=1}^{n} M_i$) represents the sum of the maximum possible concern levels for the same set of questions. The formula normalizes the score by dividing the actual concern levels by the maximum potential concern levels, ensuring it falls within a range of 0 to 1. A higher score indicates more significant ethical concerns across the evaluated dimensions. This normalized score provides a concise and comparable measure of ethical risks, enabling stakeholders to prioritize areas requiring intervention or improvement.

5. Results

We employed a customized Delphi method to explore ethical concerns in public digital services, focusing on an e-voting use case and engaging expert opinions through iterative discussions. This approach was designed to capture a broad range of insights rather than reaching a consensus, prioritizing diverse perspectives that could shape a nuanced ethical analysis. Experts evaluated ethical general factors such as improper use of data, cybersecurity risks, lack of transparency, disparity, and sustainability with ratings assigned to each ethical concern based on their perceived significance within the context of Swiss Post's e-voting service (see subsection 4.2). This method allowed experts to highlight key aspects, such as privacy, fairness, and transparency, regarding their impact on public trust and data security.

Further, after implementing the Delphi method, the findings were integrated into a structured survey, specifically assessing digital services on ethical concerns. Experts rated various concerns, from minimal to high significance, identifying risks like inequality, discrimination, and environmental sustainability related to e-voting, such as unequal access to digital infrastructure and the environmental footprint of on-site voting. These ratings contributed weighted factors that were essential in building a final model, a straightforward linear framework assigning weights to each question, enabling the classification of ethical risks. The resulting model, a functional tool for ethical analysis, offers quantifiable measures of ethical compliance, allowing Swiss Post to prioritize critical ethical factors within digital voting services. By systematically processing expert insights into weighted survey responses, we developed a robust framework highlighting ethical concerns, providing a scalable and adaptable assessment tool for evaluating ethical risks across other sectors and digital applications.

6. Conclusion

Our framework is currently in the research phase, with initial testing focused on Swiss Post employees as our target users. We are continuously refining the expert discussion process to ensure it yields actionable insights, and we plan to enhance the survey tool to allow for more robust data analysis. In the future, we aim to expand the framework to a broader audience, allowing for assessing ethical concerns in various digital services. **Iterative Refinement and Broader Applications**. While already effective for e-voting use cases, the current framework is designed for iterative improvement. Future iterations will include the following.

- **Expand Expert Participation**: Increasing the number and diversity of experts to reduce bias and enhance the model's robustness.
- **Refine Weights and Survey Questions**: Conduct additional Delphi rounds and review survey weighting mechanisms for greater precision.
- **Broaden Contextual Applicability**: Adapt the framework to other digital services, leveraging insights from diverse sectors.

This iterative methodology ensures the framework's continuous evolution, enabling it to address emerging ethical challenges in digital services with precision and adaptability in different sectors. The prototype in Figure 9 is under development. It is expected to complete its implementation considering ethical concerns related to digital platforms and GenAI. Afterward, user-centric evaluation with employees has to be conducted to evaluate ethical problems and interface usability. In conclusion, our framework provides a scalable and

adaptable solution to evaluate ethical concerns in digital services. Combining expert discussions, surveys, and automated analysis enables service providers to identify and mitigate risks proactively. Over the coming months, we aim to transition from research to full implementation, targeting a service release within the next few years. Furthermore, we will compare and evaluate different LLM frameworks and versions in our compass for different use cases. In addition, it is plannednned to implement linguistic summaries basedfuzzy logic using static recommendationstions and smart radar valueimproveprove explainability and interpretability by converting numerical patterns into natural language insights (Kacprzyk and Yager, 2001; Wrede et al., 2022). The implementation will focus on the development of an adaptive summarization model that generates context-aware linguistic interpretations.

Acknowledgment

Special appreciation goes to Christina Meyer and Sophia Ding from Swiss Post for their important role in advancing this work. We are also thankful to the reviewers, whose critical insights greatly enhanced the clarity and quality of the final manuscript. This project was funded by Innosuisse – Swiss Innovation Agency (project number 102.887 IP-ICT).

References

Andreasyan, N., Buson, D., Rüst, J., Portmann, E., & Terán, L. (2024). Theoretical framework of digital ethics concerns for public services: Electronic voting use case. *2024 Tenth International Conference on eDemocracy & eGovernment (ICEDEG)*, 1–9.

Cath, C., Wachter, S., Mittelstadt, B., Taddeo, M., & Floridi, L. (2018). Artificial intelligence and the 'good society': The us, eu, and uk approach. *Science and engineering ethics*, *24*. DOI: https://doi.org/10.1007/s11948-017-9901-7.

Dalkey, N., & Helmer, O. (1963). An experimental application of the delphi method to the use of experts. *Management Science*, *9*(3), 458–467.

Döringer, S. (2021). 'the problem-centred expert interview'. combining qualitative interviewing approaches for investigating implicit expert knowledge. *International journal of social research methodology*, *24*(3), 265–278.

Druliac, H., Bardsley, M., Riches, C., Dunn, C., Harrison, L., Roy, B., & Hao, F. (2024). On the feasibility of e2e verifiable online voting–a case study from durga puja trial. *Journal of Information Security and Applications*, *81*, 103719.

Dubai, S. (2023). Ai system ethics self-assessment tool [Last accessed: 2025-01-17]. https://www.digitaldubai.ae/self-assessment

Enguehard, C. (2014). Ethics and electronic voting. *ETHICOMP 2014-Liberty and Security in an Age of ICTs*.

Fowler Jr, F. J., & Cosenza, C. (2009). Design and evaluation of survey questions. *The SAGE handbook of applied social research methods*, *2*, 375–412.

Gritzalis, D. A. (2002). Principles and requirements for a secure e-voting system. *Computers & Security*, *21*(6), 539–556.

Hakimi, L., Eynon, R., & Murphy, V. A. (2021). The ethics of using digital trace data in education: A thematic review of the research landscape. *Review of Educational Research*, *91*(5), 671–717.

Hardebolle, C., Macko, V., Ramachandran, V., Holzer, A., & Jermann, P. (2023). Digital ethics canvas: A guide for ethical risk assessment and mitigation in the digital domain. *European Society for Engineering Education (SEFI)*. DOI: https://doi.org/10.21427/9wa5-zy95.

Hart, R. (2024). *Clearview ai fined over 30 million usd for facial recognition database* [Accessed: 2025-04-10]. Forbes. https://www.forbes.com/sites/roberthart/2024/09/03/clearview-ai-controversial-facial-recognition-firm-fined-33-million-for-illegal-database

Huang, P.-h., Kim, K.-h., & Schermer, M. (2022). Ethical issues of digital twins for personalized health care service: Preliminary mapping study. *Journal of Medical Internet Research*, *24*(1), e33081.

Joisten, K., Thiemer, N., Renner, T., Janssen, A., & Scheffler, A. (2022). Focusing on the ethical challenges of data breaches and applications. *2022 IEEE International Conference on Assured Autonomy (ICAA)*, 74–82. DOI: https://doi.org/10.1109/ICAA52185.2022.00018.

Kacprzyk, J., & Yager, R. R. (2001). Linguistic summaries of data using fuzzy logic. *International Journal of General System*, *30*(2), 133–154.

Kukreja, S., Kumar, T., Purohit, A., Dasgupta, A., & Guha, D. (2024). A literature survey on open source large language models. *Proceedings of the 2024 7th International Conference on Computers in Management and Business*, 133–143. DOI: https://doi.org/10.1145/3647782.3647803.

Lauer, T. W. (2004). The risk of e-voting. *Electronic Journal of E-government*, *2*(3), pp169–178.

Linstone, H. A., Turoff, M., et al. (1975). *The delphi method*. Addison-Wesley Reading, MA.

Lukianets, N., Nekrutenko, V., & Pavaloiu, A. (2021). Openethicsai/canvas: The open ethics canvas v1.0.1 [Accessed: 2025-01-16]. DOI: https://doi.org/10.5281/zenodo.5211845.

Manchanda, J., Boettcher, L., Westphalen, M., & Jasser, J. (2024). The open source advantage in large language models (llms). *arXiv preprint arXiv:2412.12004*. https://arxiv.org/abs/2412.12004

MindsDB. (2024). Which llm to choose: 12 key aspects to consider when building ai solutions [Accessed: 2025-01-23]. https://mindsdb.com/blog/which-llm-to-choose-12-key-aspects-to-consider-when-building-ai-solutions

Nabbosa, V., & Kaar, C. (2020). Societal and ethical issues of digitalization. *Proceedings of the 2020 international conference on Big Data in Management*, 118–124.

Nasa, P., Jain, R., & Juneja, D. (2021). Delphi methodology in healthcare research: How to decide its appropriateness. *World journal of methodology*, *11*(4), 116.

Olszewska, J. I., Systems, Committee, S. E. S., et al. (2022). Ieee/iso/iec international standard–systems and software engineering–life cycle management–part 7000: Standard model process for addressing ethical concerns during system design. *ISO/IEC/IEEE 24748-7000 First edition 2022-11*, 1–86. DOI: https://doi.org/10.1109/IEEESTD.2022.9967807.

on AI, E. C. H.-L. E. G. (2020). The assessment list for trustworthy artificial intelligence (altai) [Last accessed: 2025-01-17]. https://digital-strategy.ec.europa.eu/en/library/assessment-list-trustworthy-artificial-intelligence-altai-self-assessment

Ortega, E., Tran, M., & Bandeen, G. (2023). Ai digital tool product lifecycle governance framework through ethics and compliance by design†. *2023 IEEE Conference on Artificial Intelligence (CAI)*, 353–356. DOI: https://doi.org/10.1109/CAI54212.2023.00155.

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: A handbook for visionaries, game changers, and challengers.

Pakhnenko, O., Kuan, Z., et al. (2023). Ethics of digital innovation in public administration. *Business Ethics and Leadership*, *7*(1), 113–121.

Poszler, F., Portmann, E., & Lütge, C. (2024). Formalizing ethical principles within ai systems: Experts' opinions on why (not) and how to do it. *AI and Ethics*, 1–29.

Robinson, D. G., & Halderman, J. A. (2011). Ethical issues in e-voting security analysis. *International Conference on Financial Cryptography and Data Security*, 119–130.

Schoentgen, A., & Wilkinson, L. (2021). Ethical issues in digital technologies [conference session]. *23rd Biennial Conference of the International Telecommunications Society (ITS), Gothenburg, Sweden. https://www.econstor. eu/bitstream/10419/238052/1/Schoentgen-Wilkinson. pdf*.

Teran, L., Pincay, J., Wallimann-Helmer, I., & Portmann, E. (2021). A literature review on digital ethics from a humanistic and sustainable perspective. *14th International Conference on Theory and Practice of Electronic Governance*, 57–64. DOI: https://doi.org/10.1145/3494193.3494295.

The Guardian. (2010). *Google admits collecting wi-fi data through street view cars* [Accessed: 2025-04-10]. The Guardian. https://www.theguardian.com/technology/2010/may/15/google-admits-storing-private-data

The Guardian. (2018). *Revealed: 50 million facebook profiles harvested for cambridge analytica in major data breach* [Accessed: 2025-04-10]. The Guardian. https://www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election

The Guardian. (2022). *Clearview ai fined in uk over facial recognition data collection* [Accessed: 2025-04-10]. The Guardian. https://www.theguardian.com/technology/2022/may/25/techscape-clearview-ai-facial-recognition-fine

Trechsel, A. H., Kucherenko, V. V., & da Silva, F. F. (2016). *Potential and challenges of e-voting in the european union* (tech. rep. No. 2016/11) (Last accessed: 2025-01-17). European Union Democracy Observatory (EUDO). https://hdl.handle.net/1814/44926

UbiOps. (2024). Which llm to choose for your use case [Accessed: 2025-01-23]. https://ubiops.com/which-llm-to-choose-for-your-use-case

Wallimann-Helmer, I., Terán, L., Portmann, E., Schübel, H., & Pincay, J. (2021). An integrated framework for ethical and sustainable digitalization [ISSN: 2573-1998]. *2021 Eighth International Conference on eDemocracy & eGovernment (ICEDEG)*, 156–162. DOI: https://doi.org/10.1109/ICEDEG52154.2021.9530972.

Warner, L. M. (2023). Ethics in public service. In *Global encyclopedia of public administration, public policy, and governance* (pp. 4394–4398). Springer.

Wired. (2012). *Google engineer told colleagues street view wi-fi data collection was not a mistake* [Accessed: 2025-04-10]. Wired. https://www.wired.com/2012/05/google-wifi-fcc-investigation/

Wrede, C., Winands, M., & Wilbik, A. Linguistic summaries as explanation mechanism for classification problems [The 34th Benelux Conference on Artificial Intelligence and the 31th Belgian Dutch Conference on Machine Learning, BNAIC 2022 ; Conference date: 07-11-2022 Through 09-11-2022]. English. In: In *The 34th benelux conference on artificial intelligence and the 31th belgian dutch conference on machine learning*. The 34th Benelux Conference on Artificial Intelligence and the 31th Belgian Dutch Conference on Machine Learning, BNAIC 2022 ; Conference date: 07-11-2022 Through 09-11-2022. 2022, November.

Zadeh, L. A. (1965). Fuzzy sets. *Information and control*, *8*(3), 338–353.

Zadeh, L. A. (2008). Is there a need for fuzzy logic? *Information Sciences*, *178*(13), 2751–2779. DOI: https://doi.org/https://doi.org/10.1016/j.ins.2008.02.012.

Track 19: Sustainable Public and Open Data Ecosystems for inclusive and innovative Digital Government

Track Description

Public and open data ecosystems promise the transformation of government data-driven actions, the fostering of public sector innovations, and the collaborative smartification of cities, society , and life, triggering value-adding sustainable development goals-compliant smart living and society 5.0. New research is needed to help public managers and politicians with (1) implementing emerging technologies and technological innovations, (2) improving the achievement of sustainable development goals for increasing transparency, participation, and cooperation, and (3) meeting the stakeholders' expectations, needs, regulations, and demands.

Track Chairs

A. Nikiforova, University of Tartu, Estonia
A. Simonofski, Université de Namur ASBL, Belgium
A. Zuiderwijk, Delft University of Technology, The Netherlands
M. P. R. Bolívar, University of Granada, Spain

Contents

Assessing the capability of open government data for process mining: a study on a Brazilian open data portal 1211
G. Vasconcelos, J. Viterbo, and F. Bernardini

Data circulation between statistics agencies and journalists 1226
R. Kadouaki

The Impact of Data Orchestration on Data Value Generation in the Judicial Data Ecosystem 1239
F. F. Salerno, A. C. G. Maçada, and J. O. Mastella

Unpacking Digital Public Infrastructures: Foundational Capabilities for Public-Interest Digital Value Creation 1252
L. T. Bauer, K. Degen, S. Schönborn, and B. Niehaves

Assessing the capability of open government data for process mining: a study on a Brazilian open data portal

*Gyslla*Vasconcelos[a*], *Jose*Viterbo[a], *Flavia*Bernardini[a]

[a]Institute of Computing, Universidade Federal Fluminense, Niterói, Rio de Janeiro, Brazil, gysllav@id.uff.br, {viterbo, fcbernardini}@ic.uff.br, 0000-0001-7886-5109, 0000-0002-0339-6624, 0000-0001-8801-827X.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. The growth in Open Government Data (OGD) availability over the last decade offers significant potential for promoting transparency and improving operational efficiency in government. OGD can support the identification of inefficiencies and the extraction of process models through Process Mining (PM) applied to public service tasks. Various OGD portals, maintained by federal and subnational governments, provide access to diverse public datasets that can be explored for these purposes. Applying PM to OGD, however, requires addressing key aspects such as the tabular nature of data, variability in quality and standardization, and the frequent lack of process context. This study proposes a method to classify and evaluate OGD datasets based on their relevance and potential for process discovery. The method was applied to data from the Brazilian Federal OGD portal (dados.gov.br) to investigate whether OGD can be effectively used in PM tasks to identify processes and bottlenecks. The research involved steps of data collection, selection, and evaluation. Datasets were classified based on their potential utility and suitability for transformation into event logs. The results showed that 24% of the sampled datasets were considered relevant for PM, with 23% in dated tabular format and 1% already in event log structure. Moreover, 52% of the datasets addressed public policies, suggesting the potential of PM to reveal inefficiencies in processes that affect citizens. These findings demonstrate that, with structured evaluation criteria, PM can be effectively applied to public data. This research contributes by presenting an empirical and replicable method to support the evaluation and preparation of OGD for PM applications in digital government. The results reinforce the importance of adopting clear assessment protocols to broaden the use of OGD in understanding and improving public processes.

Keywords. Digital Government, Process Mining, Open Government Data, Public Service Optimization.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1041

1. Introduction

In the context of digital government, Open Government Data (OGD) is a transparency policy that enables broad dissemination of information on public services such as hiring, document issuance, and certifications (Jetzek et al., 2019). This dissemination seeks to enhance transparency and support external analyses that contribute to optimizing these services. Despite its potential, studies applying Process Mining (PM) to OGD remain limited and are considered rare (Rawiro et al., 2023), revealing a gap in the literature and the need for methodologies that leverage OGD to discover and improve public service processes. PM plays a key role in public administration by enabling process discovery and operational analysis based on real activity data. Its openness and adaptability present valuable opportunities to expand its application in the public sector.

Another challenge involves citizen engagement in data analysis (Barcellos et al., 2024). Improved methods are essential to facilitate access and interpretation of OGD, enabling more meaningful participation and con-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

tributing to better public service processes (Lanoue, 2020). Accessible metadata can democratize analysis and promote broader involvement, helping to harness OGD's potential to identify and address service bottlenecks. In this context, bottlenecks refer to delays, rework, or inefficiencies in public service operations revealed through the process execution flow.

Recent research has explored the application of PM in various public contexts, such as improving processing times in birth registration in Indonesia (Febrianti, 2024), and in Brazil, analyzing judicial data to enhance the efficiency of the justice system (Unger et al., 2021). It has also been used to identify gaps, bottlenecks, and redundancies in regulatory processes proposed by the Federal Executive Branch (da Costa et al., 2020). However, the application of PM on OGD faces significant challenges due to availability, data quality and suitability for such analyses, like the lack of specific context that accompanies the data.

This study aims to assess these challenges by proposing a method for evaluating OGD datasets, available on OGD portals, in order to identify which datasets can be effectively used in PM tools, particularly to discover processes and address bottlenecks in public service operations. Our main Research Question (RQ) in this work is to verify whether OGD can be used to identify processes and their bottlenecks, which we divided into two Research Questions (RQs): (RQ1) "How to evaluate the application of OGD in PM tools to discover processes and bottlenecks in the public service?", and (RQ2) "What criteria are needed to select and prepare OGD for process mining?".

Our method was applied on the Brazilian Federal Government's open data platform. We observed a significant and varied data source indicating that our method offers an approach tailored to the complexities of government data (da Costa et al., 2020; Macedo & da Silva Lemos, 2024). In this context, the research was structured into three main phases: data collection, selection, and evaluation. During the collection phase, the open data portal to be used was mapped and defined, followed by the determination of the sample, collecting datasets, organization, and classification based on relevance. In the selection phase, a preliminary selection of datasets was carried out, where ranking criteria were established, calculated, and normalized for standardized comparison, leading to the selection of the highest-ranked datasets for testing in PM tools. In the final phase, the tests were executed, and the final evaluation was conducted.

Our work contributes by proposing a categorization for the data available on Brazilian government open data portals and to the practices of PM on OGD datasets, providing steps for the evaluation and preparation of datasets that facilitate the identification of processes and operational bottlenecks. From this work, researchers and professionals can evaluate and prepare OGD for PM analyses, to identify the inherent processes within the data and detect bottlenecks, thereby enhancing the understanding of the data and the efficiency of governmental processes. This paper has been structured as follows: a background of PM to process discovery and bottlenecks identification has been presented in Section 2. Literature review in Section 3. Our Method in Section 4. In Section 5 the analysis of dados.gov.br. Finally, the conclusions and future work in Section 6. Supplementary sections such as acknowledgments and appendix follow the main content.

2. Process mining to process discovery and bottlenecks identification on OGD

PM is considered the missing link between process science and data science, bringing process perspective and behavioral insights to machine learning and data mining (der Aalst, 2016). It can be applied across domains to identify processes and bottlenecks, supporting improvement efforts. By 2025, 80% of companies are expected to use PM in at least 10% of their operations (Kerremans et al., 2023), and by 2026, 25% of global companies should adopt PM tools (Kerremans et al., 2024). Google Trends data shows increased interest in "process mining" since 2019, especially in Brazil (Google LLC, 2024).

Event data, which provide details on when, where, and under what context specific activities occur, are crucial for PM. Despite the varied sources and forms of these data—from event logs to tabular datasets—aligning them with a process perspective remains a challenge (de Murillas et al., 2019; der Aalst, 2016). This is especially true for OGD, which often lacks detailed process context. The term "data without context" refers to the absence of crucial information about data origin, collection methods, and purpose, making analysis more complex. This is a specific challenge in PM on OGD, as there is usually no access to data originators for clarifications that could enrich interpretation.

From a digital government perspective, as PM continues to advance, its application in the public sector be-

comes increasingly strategic. Since the 1950s, digital government efforts have aimed to enhance transparency, efficiency, and citizen engagement. Parks (1957) emphasized that open government and access to information should be the norm in public administration worldwide. These initiatives sought greater accountability, driven by the goal of democratizing knowledge and increasing transparency (Barcellos et al., 2022; Corrêa et al., 2017). Supported by Freedom of Information (FOI) laws, OGD portals serve as key platforms to promote transparency, improve service quality, and enable citizen participation in democratic processes (de Oliveira et al., 2024).

To enable citizen participation through OGD, data must be accessible and interpretable (Barcellos et al., 2022). Challenges such as complexity, lack of standardization, availability, and format (Rajabi et al., 2023; Vasconcelos et al., 2020) hinder the effective use of OGD. Rajabi et al. (2023) note that most OGD portals do not adhere to Linked Data standards (Berners-Lee, 2006), while Vasconcelos et al. (2020) highlight inconsistencies that make preprocessing essential. Furthermore, public data is often statistical, such as census or demographic tables (Rajabi et al., 2023). Although standardized data improves understanding and decision-making (Heumann et al., 2024), PM requires more specific characteristics to be feasible: sequential event data with case identifiers, timestamps, and activity labels (Burke et al., 2024; der Aalst, 2016; Elkoumy et al., 2023).

These structural elements (caseid, timestamp, and activity) are mandatory for datasets to be used in PM. In this work, to test the datasets identified through our method, we selected ProM, Disco, and Celonis, three widely used tools in academia and industry (de Vasconcelos et al., 2024a). ProM, an open-source tool, is known for its flexibility and rich plugin ecosystem (der Aalst, 2016); Disco, developed by Fluxicon, stands out for its intuitive interface; Celonis leads the market with support for automated data entry and complex analytics (Kerremans et al., 2024). Despite the opportunities OGD offers for process discovery, applying PM techniques remains challenging, particularly due to data inconsistency and absence of context. The next section explores how these limitations are addressed in the literature.

3. Literature Review

Recent publications indicate a growing interest in digital government topics, including OGD. This trend was verified by a search in the Scopus database using queries related to broader themes connected to this study: digital government or open data (egov), digital government in computing (egov-comp), and process mining (pm)[1]. According to the retrieved data, publications in the egov category reached 5,851 in 2024, an increase of 7% compared to 2023, reinforcing the relevance of initiatives exploring the reuse of public data to improve government processes. Among the motivations found in the literature, we highlight the need for transparency (Corrêa et al., 2017), democratization of knowledge (Barcellos et al., 2022), reuse of public data (Rawiro et al., 2023), and the availability and interpretability of information (Barcellos et al., 2022).

To answer research questions RQ1 and RQ2, on identifying processes, bottlenecks, and assessing the quality of public data available on OGD portals, a literature review was conducted to identify exploratory studies and methodologies supporting the understanding, treatment, and standardization of OGD for PM. The search string used was: (“exploratory” OR “analysis” OR “categorization” OR “investigation” OR “application” OR “methodology” OR “process mining tools” OR “open data”) AND (“process mining” AND “government”).

Following structured steps inspired by Rapid Review principles (Cartaxo et al., 2020), studies were selected through mapping, filtering, and data extraction. Searches were performed in Scopus (Elsevier B.V., 2025), for its peer-reviewed content, and Google Scholar (Google LLC, 2025), due to its broad coverage. In Scopus, 45 articles were retrieved. In Google Scholar, with filters (2020–2024, peer-reviewed, excluding citations), 401 results were found. After reviewing titles, abstracts, and keywords, 47 articles mentioning “process mining” and “government data” were selected and fully read to ensure relevance. These studies supported the identification of research gaps and definition of this study’s scope.

The review revealed significant gaps in applying PM to OGD. One major challenge is the lack of methods for processing and selecting OGD for PM tools, especially when contextual information is missing (de Vasconcelos

[1]The data was retrieved from Scopus using the following queries to *egov*, *egov-comp* and *pm*, respectively: (i) TITLE-ABS-KEY((digital AND government) OR (open AND government AND data)); (ii) same as (i) but filtered by subject area “COMP”; (iii) TITLE-ABS-KEY(process AND mining). These strings represent broader research themes connected to this work and were not limited exclusively to OGD. The intention is to illustrate general trends relevant to the study.

et al., 2024a; Rawiro et al., 2023). Although some publications apply PM in public sectors, such as health, administrative workflows, resource optimization, compliance, and citizen services (Chen et al., 2023, 2024; da Costa et al., 2020; de Murillas et al., 2019; Dilmegani, 2024; Drakoulogkonas & Apostolou, 2021; Erdem & Demirörs, 2017; Ito et al., 2020; Rawiro et al., 2023; Unger et al., 2021; Zerbato et al., 2021), there is still a lack of methodologies for categorizing and evaluating data attributes required for PM (de Murillas et al., 2019; Zerbato et al., 2021).

Although PM requires event data, few studies address the transformation of OGD into event logs, an essential step for process discovery (de Murillas et al., 2019). The use of AI techniques to process event logs in the public sector also remains underexplored (Seeliger et al., 2019), and no study was found that comprehensively defines selection criteria or maps key data attributes for PM. Most public data originates from varied sources (databases, ERP systems, transaction logs, spreadsheets, or CSV files der Aalst, 2016) and is typically tabular, requiring transformation into event logs, a complex yet crucial process. Despite these challenges, PM techniques have shown value in the public sector. In Brazil, PM was used to analyze judicial data, improving justice system efficiency (Unger et al., 2021); to identify bottlenecks in regulatory processes within the Federal Executive Branch (da Costa et al., 2020); and to reduce processing times in birth registration (Febrianti, 2024). Still, limitations in infrastructure, trained personnel, and data quality remain critical barriers.

Therefore, some gaps were identified in literature review, like: (i) methods for processing and selecting OGD for PM tools, spatially handling data without context knowledge, (ii) methods for categorizing and evaluating data attributes for process analysis, (iii) studies focused on transforming data into event logs from governmental data, and (iv) the use of artificial intelligence techniques to process existing event logs, adapted to the objectives or needs of governmental organizations. However, in this work we focus is on these gaps (i) and (ii). Given this gaps identified, this study aims to address these challenges by proposing a method for evaluating OGD datasets to process discovery and bottleneck identification, contributing to the broader application of PM techniques in digital government.

Complementary to this, a previous study conducted a comparative analysis of the PM tools most commonly used in academia and the market (de Vasconcelos et al., 2024a). This study, based on a qualitative and quantitative evaluation of tool functionalities and various criteria, served as the foundation for selecting the tools applied here. Building on these findings, an empirically based study was conducted, starting with the choice of the OGD portal, followed by data collection, selection, and evaluation.

Although PM techniques have gained attention in various domains, their application to OGD remains limited, as discussed in Section 2. As identified in the literature review (Section 3), few studies address how to select and assess OGD for use in PM tools, particularly when the data lacks context or is inconsistently structured. These gaps motivated the formulation of this study's Research Questions, as presented in the introduction. The following section presents the methodological approach developed to address them, focusing on the collection, classification, and evaluation of OGD datasets, with particular emphasis on their suitability for process discovery and bottleneck identification.

4. Our Method

For the development of the research, Brazilian OGD was chosen as the source of the case study. The research was organized in steps to collect OGD from the Brazilian open data portal, to evaluate the datasets available on OGD portals: may these datasets can be used to identify processes and bottlenecks? This is our main Research Question (RQ). OGD-PM Evaluation Method (Open Government Data Process Mining Evaluation Method) was divided in steps into collection, selection and evaluation (Figure 1), with the aim of proposing a method for processing OGD datasets, as well as categorizing and selecting the datasets according to the attributes required for PM, covering gaps (i) and (ii). A visual overview of all these stages (Steps 1 to 3) is available online[2].

The choice of Brazilian data stems from the size and diversity of the country, which has a vast population, varied regional interests and numerous public institutions. Despite its potential, many Brazilian cities face limitations that hinder investment in information technology, as well as challenges in the knowledge and application of new technologies for the management and standardized availability of public data (Barcellos et al.,

[2]Visual summary of the OGD-PM Evaluation Method steps, provided in a mind map "Evaluating datasets of open government data for identifying processes".

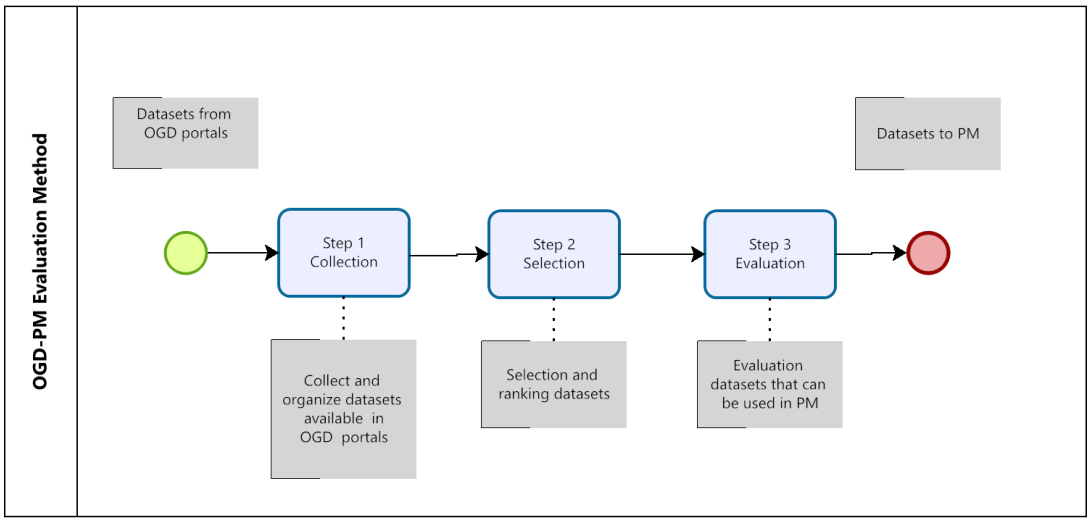


Fig. 1 – OGD-PM Evaluation Method (Open Government Data Process Mining Evaluation Method): Steps of evaluating datasets of open government data for identifying processes and bottlenecks.

2022). This scenario of large scale and diversity makes Brazil an ideal environment for investigating solutions that can improve the transparency and efficiency to population and government institutions. This diversity, combined with the frequent lack of structure in public datasets, makes Brazilian OGD a suitable field for empirical investigation. These characteristics justify its selection for the application of the proposed method, as presented in the Section 5.

4.1. Defining the portal and the sample

To clarify the development of our OGD-PM Evaluation Method (Figure 1), it is important to note that the approach was built empirically, based on exploratory testing and refinement. Initial tests were conducted using publicly available datasets already structured for process mining, allowing the authors to explore initial evaluation parameters and classification strategies. Subsequently, some OGD from ANEEL (the Brazilian Electricity Regulatory Agency) was analyzed[3], selected based on domain familiarity but without knowledge of the internal processes involved. These preliminary experiments are documented in *de Vasconcelos, 2024*. This enabled the identification of challenges typical of OGD, such as data without process context. The method was gradually refined throughout the experimentation conducted on datasets from the Brazilian open data portal.

Therefore, we need to analyze the extent to which the data made available on open data portals can be used in PM tools, to achieve the objective which is possible to apply discovery techniques of PM to OGD, to identify possible bottlenecks and propose improvements. To begin the study, the main Brazilian data repository portals were mapped for potential research. To do this, a search was carried out for articles in the Scopus database (Elsevier B.V., 2025) and the Google Scholar database (Google LLC, 2025) to find publications listing the main portals, in the same manner as the literature review (Section 3). At this point, the aim is to select a portal as the starting point for the Brazilian case study, based on the following search string: “brazilian” AND “open data portals” AND “government”.

The search returned a total of 508 papers, considering the results from 2018 to 2024. The abstracts were analyzed and those that mentioned “Brazilian open data portals” was selected. The research identified that there are independent Brazilian open data portals, but it was identified that dados.gov.br[4] and the Transparency Portal[5] are the main open data portals of the Brazilian Federal Government (Brazil, 2024a, 2024b; Macedo & da Silva Lemos, 2024), published by the Federal Government, various State and Municipal bodies. The Transparency Portal focuses on financial and budgetary data, providing transparency in the use of public resources.

[3] The RALIE dataset (Report on Monitoring the Expansion of Electricity Generation Supply - *Relatório de Acompanhamento da Expansão da Oferta de Geração de Energia Elétrica*) is composed of four open datasets available for download on the ANEEL open data portal here, with an interactive dashboard available here. All materials are in Portuguese.

[4] Open Data Portal (content in Portuguese): https://dados.gov.br/home

[5] Transparency Portal (content in Portuguese): https://portaldatransparencia.gov.br/

The dados.gov.br portal brings together a variety of datasets with diverse content, promoting the reuse of data for different purposes. Given the range of information and the aim of the research, dados.gov.br was chosen as the data source for this study.

Based on this, the information available on the Brazilian Federal Government's Open Data Portal - dados.gov.br (Brazil, 2024a) was analyzed, which provided 12,789 datasets verified on 14 March 2024. For statistical analysis of the data, a systematic representative sample of the population was carried out, with size calculated based in equation Eq.1, where n represents the selected sample size, N the population size referring to the dataset available on the portal, Z the standardized z-score value corresponding to a 95% confidence level (which in this case was 1.96), p the standard deviation of 50% to ensure the sample is sufficiently large, and e the margin of error set at 0.05, determining the maximum permissible error. Based on these parameters, the calculated sample size was 373 datasets to be collected from the portal.

$$n = \frac{N \cdot Z^2 \cdot p \cdot (1-p)}{Z^2 \cdot p \cdot (1-p) + e^2 \cdot (N-1)} \tag{1}$$

4.2. Cataloging the data obtained

The collection stage primarily involves defining the OGD portal, the sample, and the organization of the datasets, involving steps of mapping the OGD portals, defining the chosen portal, defining the sample, collecting the datasets, organizing the datasets and classifying them according to relevance, prioritizing event logs and tables with temporal data, ensuring a structured collection in line with the study's objectives. The data was organized with metadata information obtained from the OGD portal such as the "originating agency", "links" and "file names". As an important part of the proposed method, another metadata defined was the "categorization", established on the type of data collected.

Therefore, the datasets has been organized and categorized for the analysis and selection of data that are relevant to the objectives of this research. This information were created from the data collected to standardize information and not from a pattern defined on the portal. The description as shown in Table 1, according to the datasets available on the dados.gov.br open data portal: assimilating the title (i), the body responsible for the data (ii), the download link (iii), the name of the file (iv) and its categorization (v) in order to identify if the file refers to an event log (1), if there is a complete date that can be used as a Timestamp (2), if it consists a list of data or an information table (3), documents (4), if there is no file at all (5) or just a link to another portal (6). The full list of categorizing datasets can be found in online repository (de Vasconcelos et al., 2024c) of datasets and more information.

Tab. 1 – Description of the categorized datasets obtained from the Brazilian Federal Government's Open Data Portal - dados.gov.br[4]

Column	Name	Description	Domain of collected data
(i)	Dataset	Title of the dataset	Text
(ii)	Organization	Originating organization	Text
(iii)	Link	Link to the data on dados.gov.br	Text
(iv)	File	Name of the file	Text
(v)	Categorization	Categorization of the obtained dataset	(1) Event logs
			(2) Data table with date
			(3) Data table (list)
			(4) Documents
			(5) Nonexistent file
			(6) Nonexistent file - external link

Based on the categories defined in item (v), Table 1, in order to verify whether the datasets could be used in PM tools, the data obtained from the dados.gov.br portal was analyzed and classified as "Relevant" or "Not Relevant" for this research. Among these, only categories (1) and (2) were considered "Relevant" for this research, as they met the necessary conditions for process mining. The remaining categories were classified as "Not Relevant" due to lack of required structure or accessibility. The complete table with all the datasets and their relevance classification is available at the online repository[6] (de Vasconcelos et al., 2024b).

[6] Link for the complete table with the results of the analysis the data obtained from the dados.gov.br portal, classifying them as "Relevant" and "Not Relevant" for the research: open_data_sample.xlsx

Although categories (3), (4) and (6) could be more deeply analyzed and methods for transforming and adapting the data studied, we didn't go into this merit in the study, opting for more objective resources for the preliminary development of the research, choosing categories (1) and (2) as relevant. These decisions are grounded in the core requirements for PM, which include the presence of identifiable case identifiers, timestamps, and activities. Only datasets categorized as (1) Event logs and (2) Data tables with date were found to potentially satisfy these conditions, justifying their classification as "Relevant".

4.3. Definition of ranking criteria

In order to make a ranking of the selected datasets to classify them according to their score, criteria to assessment metadata from datasets were created according to the information (In), importance (I), difficulty (D) and ease (E) of manipulation. These criteria were developed empirically, based on the practical challenges faced during the development of the research, based on tests carried out with various datasets. In this way, the information contained in each dataset was qualified according to these criteria. The focus was to create criteria that reflect specific demands of process mining applications, and their structure was refined iteratively as the analysis progressed. Table 2 shows all the evaluation criteria and their domains used to carry out the study. In items 6, 7 and 8, the integer domain from 1 to 5 corresponds to 1 minimum and 5 maximum values. The criteria were refined iteratively as the study progressed and were specifically designed to support the identification of datasets most suitable for PM. Further information on this research can be found in an online repository (de Vasconcelos et al., 2024b).

Tab. 2 – Evaluation and qualification criteria for the selected datasets

Item #	In/I/D/E	Criteria	Domain
1	In	Number of records	Integer
2	In	Number of columns	Integer
3	In	Number of columns with dates	Integer
4	I	Part of the 17 Goals	Yes or No (1 or 0)
5	I	Public Policies prioritized by the PPA	Yes or No (1 or 0)
6	D	Difficulty based on the number of records	Integer from 1 to 5
7	D	Difficulty based on the number of columns	Integer from 1 to 5
8	D	Difficulty in identifying processes	Integer from 1 to 5
9	D	Records with perceptible issues	Yes or No (1 or 0)
10	D	Need to transform the data (columns to rows)	Yes or No (1 or 0)
11	E	Event log	Yes or No (1 or 0)
12	E	Data standardization	Yes or No (1 or 0)

The information criteria (In), which deal with the number of records (rows/instances), number of columns (features) and columns with dates (items 1, 2 and 3), received their nominal values identified in each dataset. Importance (I) was assessed on the basis of its significance for public policies (items 4 and 5), difficulty (D) on the basis of the complexity of manipulating the data (items 6 to 10) and ease (E) on the simplicity of using the data in mining tools (items 11 and 12). The importance of the data, as it is a subjective criterion, was measured based on belonging or not (Yes or No) to the 17 UN Sustainable Development Goals (ONU, 2015) and the public administration's priority public policies in the Multi-Year Plan (PPA) (Brasil et al., 2023). The numbered list of priorities can be found in the online repository (de Vasconcelos et al., 2024b).

The difficulty related to the number of records and columns (items 6 and 7) was calculated using the raw values previously stored as informational criteria (items 1 and 2). These values were sorted in ascending order, and a frequency distribution analysis was performed. Based on this, the values were grouped into five classes using a class interval method, which divides the full range of values into equal-width intervals (Montgomery & Runger, 2018). This approach facilitates transforming continuous variables into discrete difficulty levels. The difficulty rating for items 6, 7 and 8 ranged from 1 (least difficulty) to 5 (greatest difficulty). For the number of records, the classes were defined as follows: Class 1 for 1 to 300 records, Class 2 for 301 to 2,000, Class 3 for 2,001 to 4,000, Class 4 for 4,001 to 100,000, and Class 5 for more than 100,000 records. For the number of columns, Class 1 included datasets with 6 to 13 columns, Class 2 with 14 to 20, Class 3 with 21 to 27, Class 4 with 28 to 34, and Class 5 with 35 to 38 columns.

The criteria that identify the presence of noticeable problems in the records (item 9), the need to transform data from columns to rows (item 10), whether the file is an event log (item 11) and the existence of standard-

ization in the data (item 12) were evaluated individually, each receiving a "Yes" or "No" answer as appropriate. In order to properly rank the datasets, the results were normalized to standardize the results, the calculations used for normalization are described in Appendix A.

5. Analysis of dados.gov.br

The Brazilian OGD Portal – dados.gov.br(Brazil, 2024a), launched in 2012, is the central platform for accessing public data published by Brazilian government agencies. Each organization is responsible for its own data. The portal currently hosts around 14k datasets across diverse areas such as supply, administration, agriculture, fishing, communications, and national defense. Due to its volume, heterogeneity, and lack of standardization, dados.gov.br was chosen as the case study for this research, representing a realistic scenario to test the applicability of PM techniques to OGD in complex and large-scale environments. Based on the sampling method described in the methodology, 373 datasets were collected by selecting every 20th item from the portal's unordered list. All collected datasets are available in an online repository (de Vasconcelos et al., 2024c).

Based on the categories defined in Table 1, the datasets from dados.gov.br were analyzed and classified by their relevance to PM tools. The analysis presented practical challenges: each file had to be manually examined to identify potential processes, which was particularly time-consuming when dealing with large datasets with many instances and features (columns and records). Long files made it harder to detect distinct activities, requiring an iterative approach to narrow the focus. Additionally, the lack of standardization across datasets demanded constant transformations, increasing the workload in this phase.

As a result, most of the data was found unsuitable for PM tools, often due to corrupted files, empty links, or redirections to other portals. Some datasets consisted only of documents (e.g., PDF, DOC) or simple lists without timestamps. Although redirected portals may offer usable data, analyzing external sources was beyond the scope of this study. The proposed method focuses on evaluating data directly from the main OGD platform. Consequently, 24% of the sample (89 datasets) was deemed relevant, 23% in dated table format and 1% as event logs. The remainder was excluded. Details of this methodology are in Section 4.2, and the full relevance classification is available in de Vasconcelos et al., 2024b.

5.1. Preliminary selection of datasets

In the previous step, 89 datasets were identified as relevant to this research. However, analyzing all of them in depth would require considerable time and effort. Since this study represents an exploratory effort to demonstrate the feasibility and applicability of the proposed evaluation method, we opted to apply the method to a representative subset of this data. To select this subset, we used the Pareto principle (Koch, 1999), which suggests that a small portion of data can often yield most of the valuable insights[7]. We then selected 24 datasets for this analysis (just over 20% of the data considered relevant) as follows: all the "Event Logs" identified in the sample (4 datasets) and 20 categorized as "Data table with date". The selected datasets are listed in Table 3. The titles have been translated but the originals are in Portuguese.

Of the sets categorized as "Data table with date", the topic, update date (from 2020 to 2024) and origin of the data were taken into account, so that a maximum of three data sets from the same government agency were selected to ensure data variability. We then selected data from 16 different government organizations, such as: ANAC, ANATEL, ANEEL, ANVISA, BCB, CGU, FURG, IBAMA, IFBA, IFCE, INPI, MGI, PBH, TSE, UFG and UFRB.

Therefore, the 24 selected datasets were organized, analyzed individually according to each criterion defined in this section and the information obtained was recorded, as shown in Table 4. Table 2 shows all the evaluation criteria and their domains used to carry out the study. As part of the difficulty criterion (D), item 8, "Difficulty in identifying processes", the data from each dataset was analyzed in order to identify which process should be analyzed first. In addition, the key attributes were identified (mapping of "caseid", "timestamps" and "activities") which served as the starting point for each dataset. The time spent on this analysis was recorded. Finally, the average time for the initial analysis and mapping was 77 minutes, used to calculate the total analysis time.

[7] The Pareto Principle (Koch, 1999), also known as the 80/20 rule, states that 80% of relevant information can be obtained from 20% of the available data

Tab. 3 – Datasets selected for preliminary analysis

ID	Dataset	Agency	Update	Cat.
002	R&D Projects in Electric Energy	ANEEL	02/01/2024	2
003	SIGA - ANEEL Generation Information System	ANEEL	02/01/2024	2
040	Last Day Contracts	MGI	02/10/2024	2
061	Aeronautical Safety Recommendations	ANAC	02/11/2024	2
096	CNEP - National Registry of Punished Companies	CGU	02/10/2024	2
128	COVID-19 Spreadsheet 07-27-2020	PBH	07/28/2020	2
133	Industrial Design Registration Requests (2018)	INPI	01/14/2021	2
137	Computer Program Registration Requests (2020)	INPI	02/16/2021	2
138	Public Commitments Agenda of the Director of Patents, Computer Programs, and Integrated Circuit Topographies at INPI (2017)	INPI	02/17/2021	2
166	Aircraft - Registered Drones	ANAC	09/09/2021	2
186	Money in Circulation - Detailed Daily Information	BCB	02/13/2024	2
195	Offered Courses	IFBA	05/17/2022	2
205	Spectrum and Orbit - Satellites	ANATEL	06/10/2022	2
206	Competition - Infrastructure Sharing Contracts	ANATEL	10/23/2020	2
247	Periodicals	UFRB	10/19/2022	1
251	Results - 2016 - Expected and Actual Correspondences - 1st Round	TSE	10/25/2022	1
253	Extension Actions	IFCE	10/26/2022	2
258	Registered Diplomas	UFG	11/08/2022	2
270	Post-Market Hemovigilance	ANVISA	01/12/2023	2
284	Results - 2008	TSE	03/04/2023	1
307	Fala.BR - Access to Information Module	CGU	06/14/2023	2
316	Sinaflor - POA Amazon Legal	Ibama	07/08/2023	2
356	FURG - Registration of Fiscal Officers for Public Tenders	FURG	10/02/2023	1
357	ANEEL Consumer Satisfaction Index (IASC)	ANEEL	11/22/2023	2

Tab. 4 – Result of comparative analysis of datasets based on Informative Data (In), Importance (I), Difficulty (D), and Ease of Use (E). Table 2 shows details relating number 1 until 12 evaluation criteria.

#	Informative Data (In)			Importance (I)		Difficulty (D)					Ease of use (E)	
Dataset	1	2	3	4	5	6	7	8	9	10	11	12
002	3718	17	3	Yes	Yes	3	2	5	Yes	No	No	Yes
003	25909	23	4	Yes	Yes	4	3	1	Yes	Yes	No	Yes
002	3718	17	3	Yes	Yes	3	2	5	Yes	No	No	Yes
003	25909	23	4	Yes	Yes	4	3	1	Yes	Yes	No	Yes
040	1	34	4	No	No	1	4	5	Yes	Yes	No	No
061	3090	14	4	No	Yes	3	2	1	Yes	Yes	No	Yes
096	906	21	4	Yes	No	2	3	1	Yes	Yes	No	Yes
128	130	29	3	Yes	Yes	1	4	2	Yes	Yes	No	No
133	80161	21	6	Yes	No	4	3	1	Yes	No	No	No
137	3122	17	4	Yes	No	3	2	1	No	No	No	Yes
138	213	12	1	No	No	1	1	5	Yes	Yes	No	No
166	135287	10	1	No	No	5	1	5	Yes	Yes	No	No
186	198195	6	1	No	No	5	1	5	No	Yes	No	Yes
195	50525	23	2	Yes	Yes	4	3	5	Yes	Yes	No	Yes
205	723	26	3	No	No	2	3	1	No	No	No	Yes
206	8207	11	3	Yes	Yes	4	1	5	Yes	Yes	No	No
247	12	13	1	Yes	Yes	1	1	5	Yes	Yes	Yes	No
251	1780	13	2	No	No	2	1	5	Yes	No	Yes	Yes
253	2104	11	2	Yes	Yes	3	1	3	No	Yes	No	Yes
258	79	15	5	Yes	Yes	1	2	1	No	Yes	No	Yes
270	189403	16	2	Yes	Yes	5	2	2	No	Yes	No	Yes
284	646942	38	2	No	No	5	5	3	No	No	Yes	Yes
307	1756	18	3	No	No	2	2	3	No	Yes	No	Yes
316	57573	50	5	Yes	Yes	4	5	5	Yes	No	No	Yes
356	2517	6	2	No	Yes	3	1	2	Yes	No	Yes	Yes
357	1185	159	1	No	No	2	5	5	Yes	Yes	No	Yes

Although no specific weight was applied to the criteria, it is recognized that an event log or certain information, such as “caseid”, “timestamps” and “activities” identified, are crucial to the study of the data. In addition, the data was selected from an initial sample of 373 datasets and subjected to various filtering steps in order to ensure a choice of the most up-to-date and relevant data possible. The normalization was calculated as shown in Appendix A.

5.2. Ranking of datasets

With the computed values, it was possible to identify that 52% of the selected datasets were classified as important for society because they are part of public policies, 55% present a degree of difficulty for manipulation in the mining tools and 44% show no apparent difficulty for use in the PM tools. Based on the criteria presented, the final classification of the data sets was reached. It was possible to identify that the 80th percentile is less than 6 (six), i.e. 80% of the data achieved a score of less than 6 (six) and 50% of the cases achieved a score of less than 5 (five). The normalized values and complete ranking data can be found in online repository (de Vasconcelos et al., 2024b). The result of ranking by normalized criteria (Appendix A) of selected datasets are described in Table 5.

Tab. 5 – Result of ranking by normalized criteria of selected datasets based on Informative Data (In), Importance (I), Difficulty (D), and Ease of Use (E). Table 2 shows details relating number 3 until 12 evaluation criteria.

#	Inf. (In)	Importance (I)		Difficulty (D)					Ease of use (E)		Classification	
Dataset	3	4	5	6	7	8	9	10	11	12	Score	Rank
258	1.00	1.00	1.00	1.00	0.75	1.00	1.00	0.00	0.00	1.00	7.75	1st
137	0.80	1.00	0.00	0.50	0.75	1.00	1.00	1.00	0.00	1.00	7.05	2nd
356	0.40	0.00	1.00	0.50	1.00	0.75	0.00	1.00	1.00	1.00	6.65	3rd
253	0.40	1.00	1.00	0.50	1.00	0.50	1.00	0.00	0.00	1.00	6.40	4th
270	0.40	1.00	1.00	0.00	0.75	0.75	1.00	0.00	0.00	1.00	5.90	5th
002	0.60	1.00	1.00	0.50	0.75	0.00	0.00	1.00	0.00	1.00	5.85	6th
205	0.60	0.00	0.00	0.75	0.50	1.00	1.00	1.00	0.00	1.00	5.85	7th
003	0.80	1.00	1.00	0.25	0.50	1.00	0.00	0.00	0.00	1.00	5.55	8th
316	1.00	1.00	1.00	0.25	0.00	0.00	0.00	1.00	0.00	1.00	5.25	9th
247	0.20	1.00	1.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	5.20	10th
061	0.80	0.00	1.00	0.50	0.75	1.00	0.00	0.00	0.00	1.00	5.05	11th
096	0.80	1.00	0.00	0.75	0.50	1.00	0.00	0.00	0.00	1.00	5.05	12th
284	0.40	0.00	0.00	0.00	0.00	0.50	1.00	1.00	1.00	1.00	4.90	13th
133	1.00	1.00	0.00	0.25	0.50	1.00	0.00	1.00	0.00	0.00	4.75	14th
128	0.60	1.00	1.00	1.00	0.25	0.75	0.00	0.00	0.00	0.00	4.60	15th
307	0.60	0.00	0.00	0.75	0.75	0.50	1.00	0.00	0.00	1.00	4.60	16th
195	0.40	1.00	1.00	0.25	0.50	0.00	0.00	0.00	0.00	1.00	4.15	17th
251	0.40	0.00	0.00	0.75	1.00	0.00	0.00	0.00	1.00	1.00	4.15	18th
206	0.60	1.00	1.00	0.25	1.00	0.00	0.00	0.00	0.00	0.00	3.85	19th
186	0.20	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00	1.00	3.20	20th
138	0.20	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	2.20	21st
040	0.80	0.00	0.00	1.00	0.25	0.00	0.00	0.00	0.00	0.00	2.05	22nd
357	0.20	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	1.00	1.95	23rd
166	0.20	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.20	24th

With this in mind, the three best-scoring datasets were selected for testing in the tools, namely: (i) 258 - Registered Diplomas, (ii) 137 - Computer Program Registration Requests (2020) and 356 - FURG - Registration of civil servants for Public Tenders, two from universities (UFG and FURG) and one from the INPI. 258 requires columns to be transformed into rows, the others don’t, and only 356 is an event log. The other event logs did not score well due to various problems found in the data. Although they are event logs, some did not have complete information, making it difficult to define a process to be analyzed (characterized only as a poorly identified event log with a lack of documentation). Another problem was the excess of instances (records), making these the main reasons for the low score of such datasets.

5.3. Evaluating the datasets and preliminary tests

Given the nature of OGD, which often lacks explicit processes, a preliminary evaluation was conducted to identify datasets with attributes (features) essential for process discovery and bottleneck identification. Al-

though the evaluation began early in the research, further analysis was needed before applying datasets to PM tools—such as verifying the presence of minimum required attributes and assessing whether the processes discovered made sense for each dataset. As this study focuses on evaluating datasets for process discovery, these initial tests helped confirm the potential use of the selected datasets.

To guide this assessment, datasets were examined based on their structural adequacy for PM, and availability of key attributes such as event identifiers, timestamps, and activity descriptions. These attributes play a fundamental role in enabling the reconstruction of process flows and the identification of inefficiencies. As a result of this evaluation, a subset of datasets was selected for preliminary testing using the PM tools Disco, ProM and Celonis, chosen to carry out the tests. In order to choose the most suitable PM tools for comparing the results proposed in this study, a previous study was used to evaluate the PM tools used in academia and the market (de Vasconcelos et al., 2024a). This study evaluated the tools using qualitative and quantitative criteria and ranked them, among other criteria, based on user adherence, relevance to the market and academia and objectivity in generating results. Another study that also served as a reference carried out an analysis, based on a structured methodology that allows the analyst to compare any number of PM tools using any number of comparative analysis criteria (Drakoulogkonas & Apostolou, 2021).

As for the content of the first dataset selected for testing, dataset 258, the results indicate that the data is clean, i.e. there are no records of bottlenecks or process deviations, only data that has been successfully completed. In addition, a comparative analysis between the tools shows that there is no significant difference in the tests, with the variation in average time between activities showing little difference between the discovery algorithms of each tool. In terms of use, it was found that loading data into the tools was considerably faster in the Disco and ProM tools. Dataset 137 was more complex, requiring re-analysis of the mapping; however, the process graph was successfully generated, and the information was clear. It was found that the process occurs relatively quickly, but with some deviations that increase the completion of cases. As for the comparative analysis of the content, the results showed a significant difference when calculating the average duration of the cases. As for the usage analysis, the data loading time varied greatly and required advanced analysis in the ProM tool. Figure 2 shows the process discovered and its bottlenecks in the three tools tested.

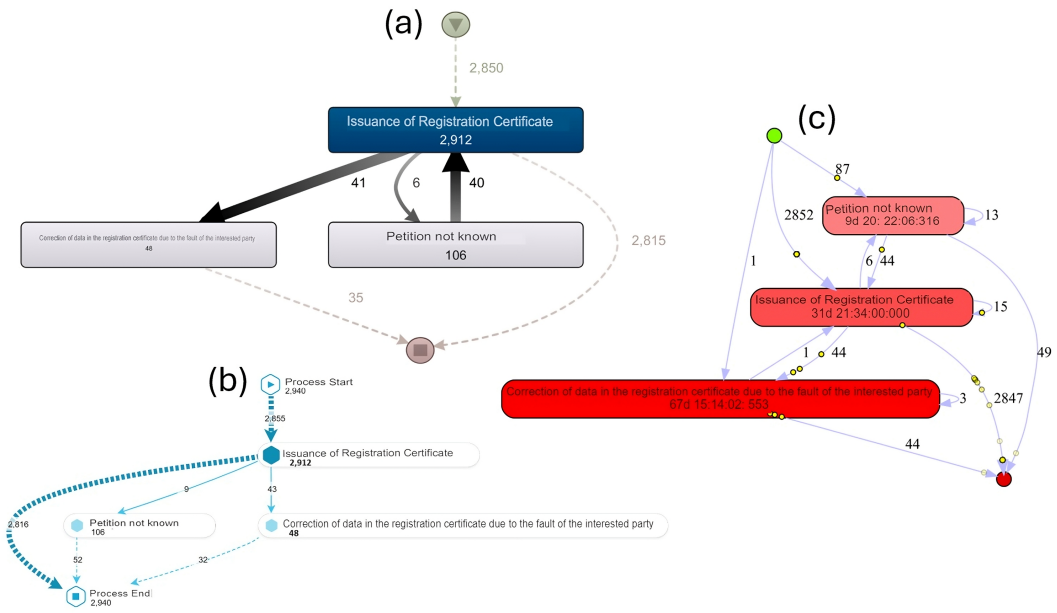


Fig. 2 – Process map discovered with dataset 137 - Computer Program Registration Requests (2020) in (a) in Disco, (b) Celonis and (c) ProM. These process maps highlight the issuance of registration certificates as the main activity, with variations in visualization and process details across tools. ProM emphasizes execution times, revealing a bottleneck in data correction (67 days), while Disco and Celonis focus on process flows and frequencies.

In the last experiment, dataset 356, the level of complexity increased considerably, marked by difficulties in understanding the data, lack of standardization, and re-analysis of the mapping. Analyzing the content, the data was only similar when an advanced analysis was carried out on the tools, and even then, with differences in the main activities and the longest average time. As for the use of the tools, ProM was the one that responded best to the complexity of this dataset. From these experiments, it was possible to see the difficulty in preparing this data, made available on open data portals, for testing in the PM tools. This is evident from the lack of reference documentation (hindering understanding) and the increased complexity given the amount of data found in the datasets (quantities of records and columns to be analyzed). Although challenging, the difficulty in pre-processing the data can be measured by ranking the datasets. In addition, despite the difficulties mentioned, it was possible to analyze the data, establish processes, identify bottlenecks, points of attention in the datasets and recommendations.

6. Conclusions and Future Work

This study addressed the challenges in evaluating OGD for PM applications, focusing on the collection, selection, and assessment of datasets. The findings highlight the difficulties in handling datasets without predefined context, a common characteristic of OGD, which requires structured evaluation criteria to determine their relevance and suitability for process discovery. It was possible to identify datasets with the necessary attributes for PM, demonstrating that, despite inconsistencies in data representation and quality, these datasets can be adapted for meaningful analysis. The study reinforces the importance of well-defined methodologies for assessing data structure, selecting relevant datasets, and verifying their adequacy for PM, ensuring that public data can be effectively used to understand and improve government processes.

This work contributes to the literature by addressing two gaps identified in the field: the lack of (i) methods for processing and selecting OGD for PM tools, especially when dealing with data without context knowledge, and also (ii) of methods for categorizing and evaluating data attributes to process analysis. The OGD-PM Evaluation Method responds to these gaps by offering a transparent and replicable procedure for assessing OGD datasets. While many existing studies apply PM to predefined event logs or within specific domains, this work offers a generalizable approach that can be adapted to varied OGD, including those without structured metadata or contextual information. This flexibility makes the method particularly valuable for advancing future research on OGD, supporting broader adoption of PM in digital government contexts.

The findings of this study provide a direct response to the proposed research questions. Regarding RQ1, the results demonstrate that OGD can be evaluated and applied in PM tools to discover processes and identify bottlenecks in public services. Despite the challenges of data inconsistencies and the lack of contextual metadata, the approach used in dataset selection and evaluation made it possible to identify relevant datasets and successfully apply them to PM analyses. In response to RQ2, the study established key criteria for selecting and preparing OGD, emphasizing the need for evaluation based on data suitability for PM. The research reveals that even in the absence of a predefined context, it is possible to extract meaningful insights from OGD when applying PM. These contributions reinforce the importance of methodologies for OGD analysis, ensuring its effective use in understanding and optimizing government processes.

Our work contributes to PM practices on OGD, providing steps for the evaluation and preparation of datasets that facilitate the identification of processes and operational bottlenecks. From this work, researchers and professionals can evaluate and prepare OGD for PM analyses, to identify the inherent processes within the data and detect bottlenecks, thereby enhancing the understanding of the data and the efficiency of governmental processes. The limitations of this research are primarily associated with the generalization of the results due to the diversity of the OGD and the categorization method applied, which may not capture all the nuances of the varied datasets. Moreover, the results may vary according to the quality and specific structure of the available data. Future research could extend the application of the proposed method to the full set of relevant datasets, allowing for broader validation and refinement of the evaluation framework. Additional studies may also explore datasets currently classified as not relevant, to assess the boundaries of their applicability to PM and further test the evaluation criteria. Expanding the method to include datasets accessed via external links and developing automated tools to support large-scale assessment and selection are also promising directions. These extensions may support more analyses, promoting a deeper understanding of how PM can be applied to improve governmental processes.

Acknowledgement

The authors would like to thank the Graduate Program in Computer Science at Fluminense Federal University (PGC/UFF) for the institutional support provided throughout this research, which were essential for the development and dissemination of this work.

Funding or Grant

This work was partially supported by the Brazilian National Council for Scientific and Technological Development (CNPq) under the Public Call No. 23/2018 – Academic Doctorate for Innovation Program (*Doutorado Acadêmico para Inovação* – DAI), grant number 161128/2019-0.

Data/Software Access Statement

All datasets used in this study are publicly available and were obtained from the Brazilian Federal Government's Open Data Portal (dados.gov.br). The full list of datasets analyzed, along with metadata, classification details, and the evaluation criteria used in the study, is available in the following repositories: (i) https://doi.org/10.6084/m9.figshare.25514884.v5 and (ii) https://doi.org/10.17632/x8sgcykthn.1.

Contributor Statement

Author 1 contributed to Conceptualization, Methodology, Data Curation, Investigation, Formal Analysis, Visualization, and Writing – Original Draft. Author 2 and Author 3 contributed to Conceptualization, Supervision, and Writing – Review & Editing.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Barcellos, R., Bernardini, F., & Viterbo, J. (2022). Towards defining data interpretability in open data portals: Challenges and research opportunities. *Information Systems*, *106*. DOI: https://doi.org/10.1016/j.is.2021.101961.

Barcellos, R., Bernardini, F., Zuiderwijk, A., & Viterbo, J. (2024). Exploring interpretability in open government data with chatgpt. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 186–195. DOI: https://doi.org/10.1145/3657054.3657079.

Berners-Lee, T. (2006, July). Linked data - design issues. https://www.w3.org/DesignIssues/LinkedData

Brasil, do Planejamento e Orçamento, M., & de Planejamento, S. N. (2023). Plano plurianual 2024-2027: Mensagem presidencial/ministério do planejamento e orçamento, secretaria nacional de planejamento. https://www.gov.br/planejamento/pt-br/assuntos/plano-plurianual/paginas/lei-do-ppa-2024-2027%20https://www.gov.br/planejamento/pt-br/assuntos/plano-plurianual/arquivos/projeto-de-lei-ppa-2024-2027/projeto-de-lei-ppa2024-2027.pdf

Brazil. (2024a). Brazilian federal government's open data portal - portal brasileiro de dados abertos. https://dados.gov.br/home

Brazil. (2024b). What it is and how it works. federal government transparency portal. https://portaldatransparencia.gov.br/sobre/o-que-e-e-como-funciona

Burke, A. T., Leemans, S. J., Wynn, M. T., van der Aalst, W. M., & ter Hofstede, A. H. (2024). A chance for models to show their quality: Stochastic process model-log dimensions. *Information Systems*, *124*, 102382. DOI: https://doi.org/10.1016/J.IS.2024.102382.

Cartaxo, B., Pinto, G., & Soares, S. (2020). Rapid reviews in software engineering. In M. Felderer & G. H. Travassos (Eds.), *Contemporary empirical methods in software engineering* (pp. 357–384). Springer International Publishing. DOI: https://doi.org/10.1007/978-3-030-32489-6_13.

Chen, K., Abtahi, F., Carrero, J.-J., Fernandez-Llatas, C., & Seoane, F. (2023). Process mining and data mining applications in the domain of chronic diseases: A systematic review. *Artificial Intelligence in Medicine*, *144*, 102645. DOI: https://doi.org/https://doi.org/10.1016/j.artmed.2023.102645.

Chen, K., Abtahi, F., Carrero, J.-J., Fernandez-Llatas, C., Xu, H., & Seoane, F. (2024). Proposing a novel methodology for process mining in clinical epidemiology: Insights and validation from a case study on chronic kidney disease progression. *SSRN*.

Corrêa, A. S., de Paula, E. C., Corrêa, P. L. P., & da Silva, F. S. C. (2017). Transparency and open government data: A wide national assessment of data openness in brazilian local governments. *Transforming Government: People, Process and Policy*, *11*, 58–78. DOI: https://doi.org/10.1108/TG-12-2015-0052/FULL/PDF.

da Costa, H. P., de Assis, J. M. V., & de Vasconcelos, C. C. (2020, January). Case study: Government process mining in the brazilian executive branch. https://www.tf-pm.org/resources/casestudy/government-process-mining-in-the-brazilian-executive-branch

de Murillas, E. G. L., Reijers, H. A., & van der Aalst, W. M. (2019). Connecting databases with process mining: A meta model and toolset. *Software and Systems Modeling*, *18*, 1209–1247. DOI: https://doi.org/10.1007/S10270-018-0664-7/FIGURES/34.

de Oliveira, D., de Oliveira, D. G., & Filho, O. O. (2024). Dados abertos da previdência social: Um estudo avaliativo. *Revista Meta: Avaliação*, *0*. DOI: https://doi.org/10.22347/2175-2753v0i0.4797.

de Vasconcelos, G. S. (2024, October). *Process mining in open government data* [PhD thesis]. Fluminense Federal University, Computer Science Institute. https://sucupira-legado.capes.gov.br/sucupira/public/consultas/coleta/trabalhoConclusao/viewTrabalhoConclusao.jsf?popup=true&id_trabalho=15574584

de Vasconcelos, G. S., Bernardini, F., & Viterbo, J. (2024a). A comparison between the most used process mining tools in the market and in academia: Identifying the main features based on a qualitative analysis. In A. Rocha, H. Adeli, G. Dzemyda, F. Moreira, & V. Colla (Eds.), *Information systems and technologies* (pp. 218–228). Springer Nature Switzerland. DOI: https://doi.org/10.1007/978-3-031-45645-9_21.

de Vasconcelos, G. S., Bernardini, F., & Viterbo, J. (2024b). Criteria for evaluating and qualifying public datasets obtained from the brazilian federal government's open data portal - dados.gov. DOI: https://doi.org/10.17632/X8SGCYKTHN.1.

de Vasconcelos, G. S., Bernardini, F., & Viterbo, J. (2024c, March). Datasets obtained from the brazilian federal government's open data portal - dados.gov. DOI: https://doi.org/10.6084/m9.figshare.25514884.v5.

der Aalst, W. V. (2016). *Process mining: Data science in action*. Springer. DOI: https://doi.org/10.1007/978-3-662-49851-4.

Dilmegani, C. (2024). Top 44 process mining use cases applications in 2024. *AIMultiple Research*. https://research.aimultiple.com/process-mining-use-cases/

Drakoulogkonas, P., & Apostolou, D. (2021). On the selection of process mining tools. *Electronics (Switzerland)*, *10*, 1–24. DOI: https://doi.org/10.3390/electronics10040451.

Elkoumy, G., Pankova, A., & Dumas, M. (2023). Differentially private release of event logs for process mining. *Information Systems*, *115*. DOI: https://doi.org/10.1016/j.is.2022.102161.

Elsevier B.V. (2025). Scopus preview - scopus - welcome to scopus. https://www.scopus.com/home.uri

Erdem, S., & Demirörs, O. (2017). An exploratory study on usage of process mining in agile software development. *Communications in Computer and Information Science*, *770*, 187–196. DOI: https://doi.org/10.1007/978-3-319-67383-7_14.

Febrianti, N. A. (2024). Analisis proses pengajuan akta kelahiran dispendukcapil surabaya menggunakan process mining untuk mempercepat waktu proses. *ITS*. https://repository.its.ac.id/105592/

Google LLC. (2024). Google trends: Search term "process mining", from 2004 to 2024, in brazil. https://trends.google.com/trends/explore?date=all&geo=BR&q=process%20mining&hl=pt-BR

Google LLC. (2025). About google scholar. https://scholar.google.com.br/intl/pt-BR/scholar/about.html

Heumann, M., Kraschewski, T., Werth, O., & Breitner, M. H. (2024). Reassessing taxonomy-based data clustering: Unveiling insights and guidelines for application. *SSRN*. DOI: https://doi.org/10.2139/SSRN.4716206.

Ito, S., Vymětal, D., & Šperka, R. (2020). Process mining approach to formal business process modelling and verification: A case study. *Journal of Modelling in Management*, *16*. DOI: https://doi.org/10.1108/JM2-03-2020-0077.

Jetzek, T., Avital, M., & Bjørn-Andersen, N. (2019). The sustainable value of open government data. *Journal of the Association for Information Systems*, *20*, 6. DOI: https://doi.org/10.17705/1jais.00549.

Kerremans, M., Iijima, K., Sachelarescu, A. R., Duffy, N., & Sugden, D. (2023, March). Magic quadrant for process mining tools. https://www.gartner.com/en/documents/4192799

Kerremans, M., Sugden, D., & Duffy, N. (2024, April). Magic quadrant for process mining platforms. https://www.gartner.com/doc/reprints?id=1-2HGMM7VN&ct=240502&st=sb

Koch, R. (1999). *The 80/20 principle: The secret of achieving more with less* (3a). Crown Business.
Lanoue, J. (2020). Disparate environmental monitoring as a barrier to the availability and accessibility of open access data on the tidal thames. *Publications*, *8*(1), 6.
Macedo, D. F., & da Silva Lemos, D. L. (2024). Open government data: Maturity diagnosis model for quality data published on the web. *Em Questão*, *30*, 1–14. DOI: https://doi.org/10.1590/1808-5245.30.132617.
Montgomery, D. C., & Runger, G. C. (2018). *Applied statistics and probability for engineers* (7th). Wiley.
ONU. (2015). Objetivos de desenvolvimento sustentável. https://brasil.un.org/pt-br/sdgs
Parks, W. (1957). The open government principle: Applying the right to know under the constitution. *The George Washington Law Review*, *26*, 1–22. https://heinonline.org/HOL/LandingPage?handle=hein.journals/gwlr26&div=10&id=&page=
Rajabi, E., Midha, R., & de Souza, J. F. (2023). Constructing a knowledge graph for open government data: The case of nova scotia disease datasets. *Journal of Biomedical Semantics*, *14*, 1–10. DOI: https://doi.org/10.1186/S13326-023-00284-W/FIGURES/5.
Rawiro, D., Gaol, F. L., Supangkat, S., & Ranti, B. (2023). Process mining applications in government sector: A systematic literature review. *IEOM*, 1–14. DOI: https://doi.org/10.46254/eu05.20220617.
Seeliger, A., Guinea, A. S., Nolle, T., & Mühlhäuser, M. (2019). Processexplorer: Intelligent process mining guidance. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *11675 LNCS*, 1]. DOI: https://doi.org/10.1007/978-3-030-26619-6_15.
Unger, A. J., Neto, J. F. D. S., Fantinato, M., Peres, S. M., Trecenti, J., & Hirota, R. (2021). Process mining-enabled jurimetrics: Analysis of a brazilian court's judicial performance in the business law processing. *Proceedings of the 18th International Conference on Artificial Intelligence and Law, ICAIL 2021*, 240–244. DOI: https://doi.org/10.1145/3462757.3466137.
Vasconcelos, L., Barcellos, R., Viterbo, J., Bernardini, F., Salgado, L., & Trevisan, D. (2020). Investigating communicability issues in the open data manipulation flow. *AMCIS 2020 Proceedings*. https://aisel.aisnet.org/amcis2020/sig_hci/sig_hci/18
Zerbato, F., Soffer, P., & Weber, B. (2021). Initial insights into exploratory process mining practices. *Lecture Notes in Business Information Processing*, *427 LNBIP*, 145–161. DOI: https://doi.org/10.1007/978-3-030-85440-9_9.

Appendix A

Calculations for normalization

As each criterion for the selected datasets (Table 2) had its own way of scoring due to its characteristics, in order to make it easier to compare them and standardize them, it was decided to normalize the scores on a scale of 0 to 1. The overall score, which enabled the final classification of the data sets, ranged from 0 to 10, where 0 (zero) corresponds to a minimum value and 10 to a maximum value. For the criteria that assess difficulty, the score was 0 (zero) for the greatest difficulty, and 1 for minimum difficulty. Criteria 1 and 2 were used to generate 6 and 7 respectively, as seen in the previous section, so normalization was applied from criteria 3 to 12. Calculations for normalization were based on the following conversions, described in the table 6 and details can be found at de Vasconcelos et al. (2024b).

Tab. 6 – Normalization rules for criteria 3 to 12 items in Table 2 used to calculate final dataset scores.

Item #	Description and Normalization Rule
3	Number of columns with dates: normalized from 1 to 5 using $NumCol = \frac{Val_o}{VMax_o}$, where Val_o is the original value to be normalized and $VMax_o = 5$.
4	Data aligned with the 17 UN Sustainable Development Goals: 1 if yes, 0 otherwise.
5	Data aligned with priority public policies (Multi-Year Plan): 1 if yes, 0 otherwise.
6–8	Difficulty due to number of records, columns, and process identification: normalized as $Diff = 1 - \frac{Val_o - VMin_o}{VMax_o - VMin_o}$.
9	Data with no noticeable problems: 1 if clean, 0 if problems are found.
10	No transformation needed from column to row: 1 if not needed, 0 otherwise.
11	File is an event log: 1 if yes, 0 otherwise.
12	Standardized data structure: 1 if yes, 0 otherwise.

Data circulation between statistics agencies and journalists.

Ricardo Kadouaki [a*]

[a] Escola de Administração de Empresas de São Paulo, Fundação Getulio Vargas, ricardo.kadouaki@fgv.edu.br, https://orcid.org/0009-0009-9648-4946

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. This study investigates how data circulate between statistics agencies and journalists, with particular attention to the role of dissemination strategies—especially press releases—in shaping news production. While much of the literature addresses data production and use, the dynamics of data circulation remain understudied. Drawing on a case study of the statistical agency of the state of São Paulo (SEADE) in Brazil, the paper analyzes all news articles published in 2024 that referenced SEADE data. Articles were categorized according to the level of influence of press releases: full reproductions (verbatim replication), value-added reproductions (with complementary analysis or context), or organically produced (independent of any press release). These were examined through the lenses of framing theory and journalistic role performance approach. Results show that 70% of the news articles were influenced by press releases, with a significant presence of the Loyal-Facilitator dimension, particularly in government-issued releases. National outlets were more likely to produce organic content, while local media—despite showing higher demand for statistical information—relied more heavily on press releases to produce their coverage. Thematic focus also varied: national journalists prioritized economic indicators, while local outlets focused more on labor statistics. The study also found that articles based on SEADE press releases more frequently incorporated added value, while those based on government releases were more likely to be reproduced verbatim. These patterns may indicate structural constraints, particularly in local newsrooms, and varying levels of data literacy among journalists. By mapping how official statistics circulate in the media ecosystem, the research highlights the importance of hybrid, user-centered dissemination strategies that combine traditional tools like press releases with open government data practices. Such approaches can broaden the reach and enhance the relevance of official statistics in journalism and public discourse. By demonstrating how a better understanding of data circulation helps statistical agencies tailor their dissemination practices, this study contributes to the Open Government Data literature and highlights how user-centered strategies can foster more meaningful and critical engagement with official data.

Keywords. Data circulation, official statistics, journalism, data dissemination, Open Government Data, OGD, data literacy, journalistic role performance, framing.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1042

1. Introduction

The rapid evolution of data production technologies, particularly within Big Data, has transformed how governments generate and disseminate official statistics (Signorelli et al., 2023). Open Government Data (OGD) initiatives have enhanced transparency and broadened data access (Attard et al., 2015). However, despite the tendency to adopt OGD in pursuit of seamless data dissemination, structural and institutional barriers often hinder the frictionless data circulation (Piattoeva et al., 2018). While research has extensively covered data production

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and use, the process of data circulation—how data moves between stakeholders—remains underexplored (Porto de Albuquerque et al., 2021).

This study examines the circulation of data between statistical agencies and journalists. The research question asks: How does data circulation occur between official statistics agencies and journalists? To answer this, the study employs a case study methodology, analyzing interactions between the São Paulo State Statistics Agency (SEADE) and journalists in Brazil during 2024.

The research investigates journalists' engagement with official data, particularly the role of press releases in shaping news production. The analysis is informed by Framing theory (Entman, 1993) and the Dimensions of Journalistic Role Performance (Mellado, 2015), providing insights into how journalists frame and disseminate statistical information. The study examines news articles published in 2024 that utilized SEADE data, comparing local and national media in terms of reliance on press releases, reporting depth, data literacy, and thematic focus. It also applies the Dimensions of Journalistic Role Performance framework to assess whether journalists critically engage with government-produced data or simply reproduce it. Additionally, news articles are categorized into themes such as Economy, Labor, and Demography to understand how different types of statistics are prioritized.

By analyzing press releases, journalistic practices, and media characteristics, the study highlights challenges and opportunities in improving the dissemination and use of official statistics. This research contributes to the discussion of data circulation in the OGD context, emphasizing the importance of user-centered approaches in data dissemination to bridge the gap between producers and users.

The paper is structured as follows: Chapter 2 reviews key literature on data, data users, data circulation, and journalism's role in data dissemination. Chapter 3 details the research methodology, including the case study approach and methods for analyzing news articles and press releases. Chapter 4 presents the results, while Chapter 5 discusses their implications. Finally, Chapter 6 concludes with recommendations for improving data circulation and suggestions for future research.

2. Literature review

2.1 Data and official statistics

Data play a fundamental role in shaping social and economic systems, influencing everything from daily decision-making to large-scale policy development (Kitchin, 2014). However, as data are never neutral, their meaning and use depend on how they are collected, analyzed, and interpreted (Kitchin, 2014). The rise of "datafication"—the process by which various aspects of life are transformed into data (Mayer-Schonberger & Cukier, 2014)— has resulted in an unparalleled growth of digital records, produced as unintended outcomes of routine activities (Torres-Freire, 2021). This transformation has been driven by the rapid development of new technologies, increased computational power, and enhanced data storage capabilities, all of which have enabled the large-scale collection, processing, and dissemination of data. With the advent of this phenomenon, commonly referred to as Big Data (Signorelli et al., 2023), governments have increasingly adopted new methods for collecting, processing, and storing vast amounts of information, integrating these resources into policymaking (Kitchin, 2014) and into the production of official statistics (Signorelli et al., 2023).

Official statistics, produced and disseminated by government agencies, serve as essential tools for informing public policies and promoting transparency (Signorelli et al., 2023; United Nations Statistics Division, 2013). Covering areas such as economics, demography, labor markets, and environment (United Nations Statistics Division, 2013), these data provide a foundation for decision-making across multiple sectors (Attard et al., 2015; Misra, Ranjan, et al., 2021). As the demand for timely and accessible statistics grows, statistical agencies are under increasing pressure to modernize their approaches, ensuring that official statistics remain relevant in an ever-evolving data landscape (Citro, 2014). This transformation reflects a shift in how data users interact with official statistics. Audiences seek not only access to data but means for their interpretation and application. Ensuring the use of official statistics is just as important as making it available (Laaboudi et al., 2024).

In response, Open Government Data initiatives have sought to make government data—including official statistics—freely available in machine-readable formats (Attard et al., 2015; Gascó-Hernández et al., 2018). These policies aim to increase transparency, improve public policymaking, and encourage civic participation (Attard et al., 2015). To be effective, OGD frameworks emphasize the need for standardized data structures, improved search mechanisms, and enhanced interoperability, making it easier for users to find and work with official data (Attard et al., 2015; Lourenço, 2015). An example is the implementation of Linked Open Data (LOD) by Eurostat, the European statistics agency, which not only provides raw datasets but also integrates metadata and employs diverse communication strategies to expand the reach and usability of official statistics (Laaboudi et al., 2024). While open data initiatives have significantly expanded access, researchers argue that availability alone does not guarantee

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

effective use. Meaningful engagement with data requires well-structured dissemination strategies that account for the diverse needs of users (Attard et al., 2015; Craveiro et al., 2023; Gascó-Hernández et al., 2018; Lourenço, 2015).

However, the role of statistical agencies in the dissemination process remains a subject of debate. Should their responsibility extend beyond publishing high-quality datasets to actively guiding users in their interpretation? Eurostat raised this very question: "Is it the role of the official statistics community to guide key users [...] in their use [...], or does our responsibility stop with putting the LOD 'out there'?" (Laaboudi et al., 2024, p. 88). Scholars argue that understanding user demand is crucial to enhancing the impact of open data initiatives (Attard et al., 2015; Begany et al., 2021; Craveiro et al., 2023), as it provides insight into how data circulation fosters informed decision-making and drives social transformation (Porto de Albuquerque et al., 2021).

2.2 Data circulation

Most research on data focuses on its acquisition and use processes (Porto de Albuquerque et al., 2021). While this perspective highlights the role of data in informing policies and institutional actions, it overlooks the potential for broader transformations that emerge when data flows across different stakeholders and governance levels. Some studies suggest that structural changes in public policy and governance are more effectively realized through dynamic data circulation, where data moves between actors, fostering recognition, coordination, and the opening of new channels for communication (Porto de Albuquerque et al., 2021). In this context, data circulation refers to the movement of data across different actors, enabling interactions that reshape governance arrangements and influence decision-making processes (Porto de Albuquerque et al., 2021). The way data travels within and between institutions, communities, and other stakeholders determines its accessibility, usability, and impact. Official statistical agencies often rely on seamless data flows to effectively disseminate information (Misra, Ranjan, et al., 2021). However, the ideal of frictionless data circulation is rarely achieved in practice due to contextual barriers, institutional limitations, and other structural constraints (Piattoeva et al., 2018). Ultimately, the influence of data is determined not just by its content but also by how it is applied, who uses it, and the purpose it serves (Beer, 2016).

The data circulation approach proposes mapping the circulation of stories and narratives created by users from data (Porto de Albuquerque et al., 2021). This mapping involves identifying key actors, the channels through which data is disseminated, the motivations behind its use, and its tangible impact on public policies and social dynamics. By analyzing these factors, researchers and practitioners can identify ways to enhance data circulation, ensuring broader access and more meaningful engagement with the information being shared. Strengthening these interactions can lead to more inclusive decision-making processes and a more democratized use of data for social transformation (Porto de Albuquerque et al., 2021). Beyond improving accessibility, mapping data circulation also provides valuable insights into the broader data ecosystem. It helps identify bottlenecks that restrict data flow, allowing for targeted interventions to address these issues (Porto de Albuquerque et al., 2021). Furthermore, it supports efforts to tailor data dissemination to different levels of data literacy, ensuring that diverse users—from policymakers to local communities—can effectively interpret and apply the information (Porto de Albuquerque et al., 2021). Strengthening these relationships fosters deeper engagement among stakeholders and enhances the overall impact of data on governance and civic participation. By understanding these dynamics, researchers and institutions can refine strategies for improving data circulation, maximizing its reach, and ensuring that data serves as a tool for meaningful and equitable change (Cinnamon, 2020; Pappas et al., 2018; Porto de Albuquerque et al., 2021).

2.3 Dimensions of journalistic role performance

Journalism shapes power dynamics in modern societies by influencing public and private debates through the way news is framed and delivered (Cushion et al., 2017; Mellado, 2015). Understanding how journalists operate within these dynamics requires examining their relationship with power, their presence in news narratives, and the strategies they use to engage audiences. In Dimensions of Journalistic Role Performance, Mellado (2015) explores these dynamics by mapping the features of news content that connect journalism's normative ideals with how these roles manifest in practice. The author's analysis identifies key journalistic roles. The Intervention role highlights the journalist's voice and interpretation in news content. The Watchdog role emphasizes holding public and private institutions accountable, while the Loyal-Facilitator role aligns with elite power structures or comparison with other regions. The Service role focuses on addressing audience interests through practical and utilitarian reporting. Civic Journalism fosters public engagement by adopting a citizen-centric perspective, while Infotainment prioritizes entertainment and emotional appeal, treating audiences as spectators (Mellado, 2015).

2.4 Journalism and data

Data is a powerful tool for democratic inquiry, enhancing information flows and enriching public debate. However, because most people do not engage directly with raw datasets, journalists play a crucial role in discovering, translating, and interpreting data (Cushion et al., 2017; Rogers, 2013).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The fast-paced nature of modern news production places significant pressure on journalists to process and communicate complex statistical information with clarity and accuracy. Data journalism encompasses a wide range of practices, from traditional infographics to in-depth investigative reporting based on raw data analysis (Knight, 2015). Its rise has been seen as a means of democratizing information through innovative reporting techniques (Bradshaw, 2011; Cushion et al., 2017; Rogers, 2013). While often associated with investigative projects, Cushion (2017) expands the definition to include the routine use of secondary data in reporting, emphasizing that data analysis and interpretation are increasingly part of journalists' daily work.

Data literacy is fundamental to how journalists engage with and use data. This skill set goes beyond technical proficiency, encompassing the ability to critically analyze data, understand its context, and interpret the realities it represents (Carmi & Yates, 2020; Helsper, 2021; OECD, 2019; Scheerder et al., 2017; Senra, 1994; Tygel & Kirsch, 2016). Despite its growing importance, significant gaps in data literacy persist. Media organizations with strong public broadcasting systems or larger budgets tend to invest more in data journalism, providing greater statistical expertise and shaping how data is incorporated into reporting (Appelgren et al., 2019; Cushion et al., 2017). These structural conditions influence journalistic role performance, reflecting newsroom decisions shaped by internal and external pressures (Shoemaker & Vos, 2009). For example, a study on the Arab Region found that journalists lacking numerical proficiency and technical skills for data acquisition and analysis tended to adopt a passive approach to data, rather than the active engagement necessary for effective data journalism (Lewis & Nashmi, 2019).

2.5 Framing

Framing shapes how journalists construct news stories, influencing public perceptions of issues (Lee & Basnyat, 2013; Scheufele & Tewksbury, 2007). At its core, framing involves selecting and emphasizing specific aspects of reality within a text to promote a particular interpretation (Entman, 1993). As one of the dominant theories in media studies (Lee & Basnyat, 2013), framing acts as a cognitive filter that simplifies complex issues into digestible narratives. This process helps audiences make sense of intricate events while also shaping their emotional and intellectual responses (Scheufele & Lewenstein, 2005).

2.6 The statistics agency of the state of São Paulo

The State of São Paulo, with a large territorial area comparable to countries like the United Kingdom, is composed of 645 municipalities and has Brazil's most significant economy. The case studied is that of the State of São Paulo Statistics Agency (SEADE). It is a public institution linked to the Government of the State of São Paulo, responsible for producing and disseminating socioeconomic and demographic data that support public policies in the state. Data dissemination occurs through the publication of its outputs on its website (www.seade.gov.br), sending press releases to the media and sharing audiovisual content on social media. The published data are made available in various formats, including an open data repository, text-based analyses, and dashboards featuring dynamic infographics for data visualization.

3. Methodology

This study conducted a case study of the State of São Paulo Statistics Agency (SEADE) in Brazil, analyzing data circulation between the agency and journalists, a key user group of official statistics (Attard et al., 2015; Misra, Ranjan, et al., 2021). It examined all news articles published in the Brazilian press in 2024 that referenced SEADE's data, comparing organically produced news to articles based on press releases issued by SEADE or the State Government. The analysis took place in January 2025.

São Paulo's economic significance and diverse media landscape provided a strong basis for the study. Newspapers in the region range from local to national coverage, and media classification was based on each outlet's self-declared reach on their websites. The year 2024 was selected to ensure accessibility to news articles and press releases, maintaining reliability and completeness of sources. To identify relevant articles, the author consulted SEADE's "Imprensa" (Press) section (https://www.seade.gov.br/imprensa/page/2/), used SEADE's internal news monitoring service (clipping), and conducted Google News searches with the keyword "SEADE," filtering results for Portuguese-language content from Brazil in 2024. Only written articles available online were analyzed, excluding video, audio, and print-only publications.

Press releases containing statistical data and citing SEADE were retrieved from SEADE's official website (https://www.seade.gov.br/press-release/) and the State Government's communication portal (https://www.agenciasp.sp.gov.br/?s=seade). In some cases, press releases from both sources were identical. To link news articles with specific press releases, the study assessed whether they covered the same topics and statistics within a 20-day window of publication.

News articles were categorized based on the level of influence from press releases. "Full Reproduction" included

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

articles that replicated the press release content verbatim. “Value-added Reproduction” referred to articles that incorporated press release content but added contextual elements, such as additional data or analysis. “Organic” articles were produced independently, without any influence from press releases. Each article was fully reviewed, including its title and body. Based on Framing theory (Entman, 1993), articles were classified by main theme. Themes aligned with commonly analyzed statistical areas: “Economy”, including GDP, economic projections, and investments; “Labor”, covering employment rates, informal work, and salaries; “Demography”, addressing population size, life expectancy, and fertility rates; and “Other”, for topics outside these categories (United Nations Statistics Division, 2013).

The study further applied Mellado’s (2015) Dimensions of Journalistic Role Performance, classifying articles into “Intervention”, “Watchdog”, “Loyal-Facilitator”, “Service”, “Infotainment”, and “Civic” roles, with some articles fitting multiple dimensions. Additionally, word count was measured to assess the depth of reporting. Media outlets were classified as “Local” if they primarily served a limited regional audience and “National” if they reached broader country-wide readerships.

4. Results

The research identified that throughout 2024, 81 Brazilian media outlets published 237 news articles that utilized official statistical data citing SEADE, the statistics agency of the State of São Paulo. During this period, the press received 112 press releases containing statistical data produced by the agency, of which 71 (63%) were sent directly by SEADE, and 41 (37%) were issued by the Secretariat of Communication of the State Government of São Paulo.

The analysis revealed significant differences in the use of press releases as sources for news. Of the 38 news articles based on Government press releases, 26 (68%) were fully reproduced without changes. In contrast, of the 125 news articles based on SEADE press releases, 81 (65%) were reproduced with value added, incorporating additional elements such as interviews, context, or data from other sources.

The average word count of news articles from local media outlets (476.1 words) was similar to that of national media outlets (473.7 words), with a difference of only 2 words. At the local level, the average word count difference between news articles induced by press releases (533.9 words) and organic news articles (531.0 words) was marginal, at only about 3 words. However, at the national level, organic news articles were significantly longer (644.9 words) compared to those based on press releases (299.5 words), showing a substantial difference of approximately 345 words.

The demand for news articles was higher among local media outlets than among national outlets. Of the 166 analyzed news articles (excluding the 71 articles that were full reproductions of press releases), 125 (75%) were published by local media outlets, while 41 (25%) were published by national outlets. Among local media outlets, most articles used press releases with added value (79 of the 125 or 63%). On the other hand, among national media outlets, 25 (61%) of the 41 news articles were produced organically, without any influence from press releases. Table 1 presents a summary of these findings, highlighting the differences in press release usage, word count averages, and the distribution of news articles between local and national/state-level outlets.

Based on the Framing approach (Entman, 1993), the 237 news articles were classified into three main themes: Economy, with 81 articles (34%); Labor, with 73 articles (31%); and Demography, with 40 articles (17%). Additionally, there was an “Other” category, which included 43 articles (18%). All themes exhibited a higher occurrence of articles induced with added value, except for the “Other” category. The Labor theme presented a significantly higher proportion of value-added articles (55%) compared to the other themes, which averaged 32%.

Among the 54 national news articles, most (25 articles, or 46%) focused on the Economy theme. In contrast, among the 183 local news articles, the majority (63 articles, or 34%) were related to the Labor theme. Regarding article length, value-added articles averaged 494 words, with Demography, Economy, and Labor frames averaging 519, 443, and 496 words, respectively. A notable difference was observed in the average length of organic articles, which were significantly longer: 939 words for Demography, 498 words for Economy, and 301 words for Labor. Table 2 provides data about distribution of types of use of press releases, article lengths, and coverage according to the frames.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 - Summary of findings.

	TOTAL OF OCURRENCES				PERCENTUAL			
	Value-Added Reproduction	Organic	Full Reproduction	TOTAL	Value-Added Reproduction	Organic	Full Reproduction	TOTAL
TOTAL	95	71	71	237	40%	30%	30%	100%
Source of Press Releases								
SEADE				71				63%
Government				41				37%
Source of Press Releases used								
None	0	71	0	71	0%	100%	0%	100%
Both	2	0	1	3	67%	0%	33%	100%
SEADE	81	0	44	125	65%	0%	35%	100%
Government	12	0	26	38	32%	0%	68%	100%
Word average								
Local	533,9	531,0	353,8	476,1				
National	299,5	644,9	358,8	473,7				
Coverage								
Local	79	46		125	63%	37%		100%
National	16	25		41	39%	61%		100%

Tab. 2 - News articles according to frames.

	Demography	Economy	Others	Labor
Type of use of Press Release				
Value-Added Reproduction	15	31	9	40
Organic	12	24	23	12
Full Reproduction	13	26	11	21
TOTAL	40	81	43	73
Type of use of Press Release (%)				
Value-Added Reproduction	38%	38%	21%	55%
Organic	30%	30%	53%	16%
Full Reproduction	33%	32%	26%	29%
Word average				
Value-Added Reproduction	519	443	625	496
Organic	939	498	597	301
Full Reproduction	706	467	605	451
Coverage				
Local	16%	31%	19%	34%
National	19%	46%	17%	19%

The 166 news articles—excluding those classified as full reproduction—were classified according to the Dimensions of Journalistic Role Performance, with a single article potentially receiving more than one classification (Mellado, 2014). The Service dimension was predominant, encompassing nearly 100% of the analyzed articles. Within the Loyal-facilitator dimension, 70 out of the 95 value-added articles (74%) were categorized under this dimension. In comparison, among the 71 organic articles, 36 (51%) received the same classification.

In terms of thematic frames, the Economy and Labor themes showed high levels of Loyal-facilitator classification, with 84% and 90% of articles, respectively, categorized under this dimension. In contrast, the Demography and Other themes had significantly lower levels of Loyal-facilitator classification, at 25% and 19%, respectively. Regarding the Civic dimension, the Demography (32%) and Other (35%) themes had higher occurrences, while Labor showed very low values, and Economy had no occurrences classified under this dimension.

When analyzing the overlap between the Loyal-facilitator dimension and the origin of the press releases, the study found that 57 (70%) of the 81 articles influenced by SEADE press releases and all 12 (100%) articles influenced by Government press releases were classified under this dimension. In terms of the scope of the media outlet, of the 106 articles classified under the Loyal-facilitator dimension, 83 (78%) were published in local outlets, while 23 (22%) appeared in national outlets. Table 3 provides data about the Dimensions of Journalistic Role Performance dimensions across themes, press release origins, and media outlet scopes.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 3 - News according to dimensions of journalistic role performance.

		TOTAL OF OCURRENCES						PERCENTUAL					
	TOTAL	Interven-tion	Watch-dog	Loyal-facilitator	Service	Infotain-ment	Civic	Interven-tion	Watch-dog	Loyal-facilitator	Service	Infotain-ment	Civic
Frame													
Demography	28	0	1	7	27	5	9	0%	4%	25%	96%	18%	32%
Economy	55	0	0	46	54	1	0	0%	0%	84%	98%	2%	0%
Others	31	0	2	6	31	5	11	0%	6%	19%	100%	16%	35%
Labor	52	0	3	47	52	0	1	0%	6%	90%	100%	0%	2%
Coverage													
Local	125	0	3	83	124	9	14	0%	2%	66%	99%	7%	11%
National	41	0	3	23	40	2	7	0%	7%	56%	98%	5%	17%
Source of Press Releases													
Both	2	0	0	1	2	1	1	0%	0%	50%	100%	50%	50%
SEADE	81	0	3	57	81	3	9	0%	4%	70%	100%	4%	11%
Government	12	0	0	12	12	0	0	0%	0%	100%	100%	0%	0%
Ocurrences	166	0	6	106	164	11	21	0%	4%	64%	99%	7%	13%
Type of use of Press Release													
Value-Added Reproduction	95	0	3	70	95	4	10	0%	3%	74%	100%	4%	11%
Organic	71	0	3	36	69	7	11	0%	4%	51%	97%	10%	15%

5. Discussion

5.1 Media dependency on government inputs

Among the news articles published in 2024 that utilized government statistical data, 30% were produced organically, 30% directly reproduced press releases issued by the agency or the government, and 40% were influenced by press releases but incorporated value-added elements (Figure 1). These figures highlight two key aspects: the influence of press releases on news production and the varying ways in which data is utilized.

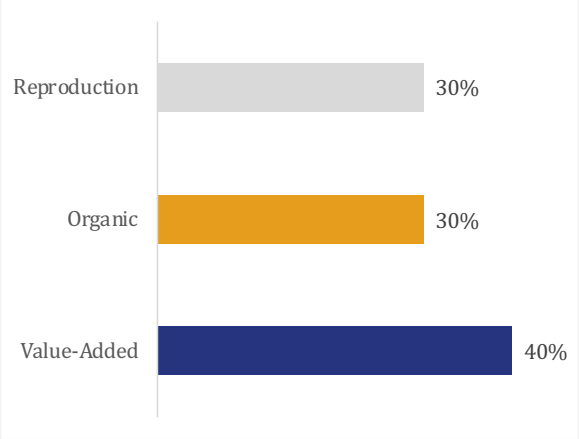


Fig. 1 - Press release use in statistical data-based news production.

Regarding the influence of press releases, 70% of the analyzed articles were impacted by these documents. This finding demonstrates that, despite advancements in the Big Data era within public statistics—such as new technologies for data collection and analysis (Citro, 2014; Signorelli et al., 2023)—there have been slow changes in the dissemination stage. The research suggests that data dissemination remains dependent on traditional practices, such as press office and public relations. Despite a tendency to rely on seamless data flows to disseminate information (Misra, Ranjan, et al., 2021), the frictionless circulation of data between statistical producers and journalists faces barriers, possibly related to resource limitations, time constraints, or editorial pressures (Cushion et al., 2017; Piattoeva et al., 2018).

On the other hand, the study indicates that frictionless data circulation is partially achieved. The analysis of data usage revealed that in 70% of the articles, journalists actively sought statistical data—30% independently and 40% by adding value to press release content. This value addition involved incorporating complementary information from other sources or directly from the statistical agency, adapting the data to better serve their audiences. These findings highlight the need to integrate both traditional and modern approaches to statistical data dissemination.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The literature emphasizes that Open Government Data producers must go beyond merely making data available (Attard et al., 2015; Craveiro et al., 2023; Gascó-Hernández et al., 2018; Lourenço, 2015). Studies suggest that statistical agencies, such as Eurostat, should not only provide data but also offer well-structured metadata to support data redistributors (Laaboudi et al., 2024). Well-designed metadata facilitates the integration of new data by redistributors, ultimately increasing the value of official statistics (Laaboudi et al., 2024).

However, in contexts such as the Brazilian, traditional dissemination methods—particularly press releases—continue to play a key role, especially in promoting the circulation of locally relevant statistics. In the studied case, journalists accessed official data through a hybrid model, combining traditional tools like press releases with modern approaches aligned with OGD principles (Attard et al., 2015; Gascó-Hernández et al., 2018; Lourenço, 2015; Misra, Ranjan, et al., 2021). This combination underscores the need for complementary strategies that enhance the accessibility and usability of official statistics for different audiences.

5.2 Capacity of local and national media

To understand local realities, the study analyzed the characteristics of news articles published by local media compared to those from national outlets, excluding articles that fully reproduced press releases. Among national outlets, organic articles were, on average, 345 words longer than those based on press releases, indicating a significant difference in terms of depth. Conversely, in the local context, the difference in length between organic articles and those influenced by press releases was minimal, with only a three-word variation. Previous studies have highlighted that well-structured media organizations with greater resources are better equipped to utilize data in their reporting (Appelgren et al., 2019; Cushion et al., 2017; Shoemaker & Vos, 2009). This disparity between the capacities of local and national media was also observed in the present study. Local outlets often face structural and financial limitations, while national outlets typically have greater resources, better-trained journalists, and access to advanced tools for investigation, enabling the production of more in-depth reporting with data (Lewis & Nashmi, 2019).

Despite these limitations, this study adds a new dimension to the discussion by identifying that the local demand for data is significantly greater than at the national level. In 2024, 75% of news articles utilizing São Paulo's state-level official statistics were published by local outlets, with most of these articles (63%) influenced by value-added press releases. In contrast, only 25% of such articles were published by national media, and among them, the majority (61%) utilized SEADE data obtained organically (Figure 2). Even with more limited resources, local media play a crucial role in covering the territory of São Paulo, surpassing national outlets in terms of the volume of published news. Although they may exhibit lower technical proficiency, local outlets demand more data, particularly those that address specific local realities across various themes. This underscores the importance of adopting different strategies to promote data access for local and national media.

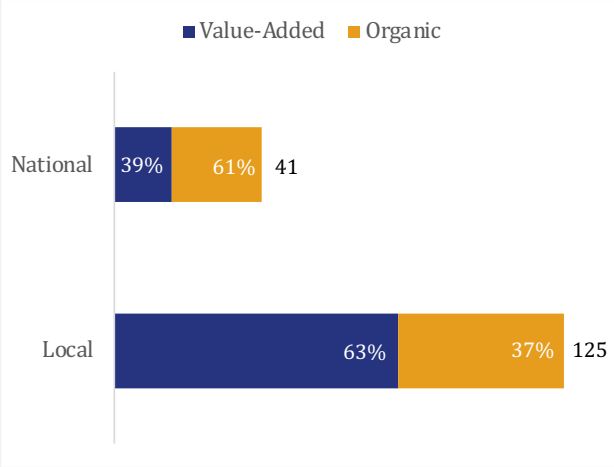


Fig. 2 - Media scope and press release use in statistical data-based news production.

5.3 Relationship between the press and the government

When producing news articles based on press releases, journalists added value to most of the releases originating from SEADE by including analyses and additional information. In contrast, most press releases issued by the State Government were reproduced verbatim, without significant modifications or additions. This practice of full reproduction can be attributed to structural limitations in newsrooms, such as lack of time, resources, or editorial capacity (Cushion et al., 2017). However, the data suggest that this tendency is more prevalent when press releases are directly linked to the government.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The more analytical use of press releases from the statistical agency may partially reflect the technical nature and credibility attributed to the agency, encouraging journalists to produce more customized articles. By complementing the data provided with additional information, journalists enhanced the value and relevance of these articles for their audiences. On the other hand, as data are not inherently neutral (Kitchin, 2014), press releases issued by the government containing statistical data may exhibit a bias toward highlighting positive results of government actions. The full reproduction of these releases might indicate a relationship of alignment between newsrooms and government power structures.

5.4 Journalists role performance

The analysis of the Dimensions of the Journalistic Role Performance, as proposed by Mellado (2015), enabled the exploration of the relationship between news articles and the roles performed by journalists. According to this approach, the study classified the news articles into different dimensions, allowing a single article to fit into more than one category (Mellado, 2015). To ensure greater analytical precision, the classification process excluded press releases that were fully reproduced.

The results showed that news influenced by value-added press releases had a higher incidence of the Loyal-Facilitator dimension, accounting for 64% of occurrences (Figure 3). This dimension was identified in 70% of news articles based on SEADE press releases and in 100% of those associated with press releases issued by the Government. In the case of news articles based on Government press releases, even when published with added value, they often exalted the region or supported power groups. On the other hand, news articles based on SEADE press releases also displayed these characteristics but to a lesser extent. Among the other dimensions, Service appeared in nearly all news articles (99%), reflecting the technical approach inherent in official statistics. The dimensions Civic, Infotainment, and Watchdog showed low incidence, with 13%, 7%, and 4%, respectively. Furthermore, no article was classified under the Intervention dimension.

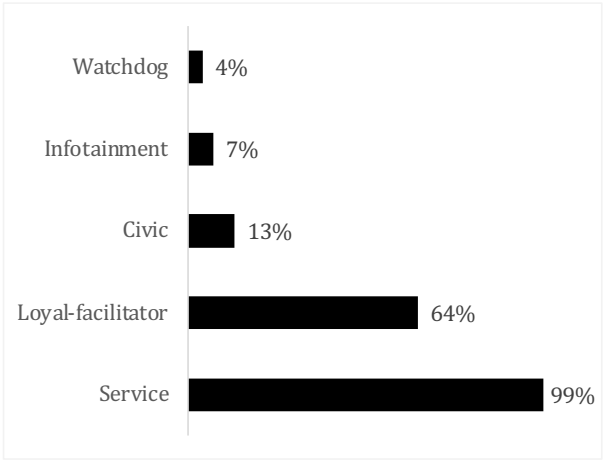


Fig. 3 - Role performance dimensions in statistical data-based news production.

The high number of news articles classified under the Loyal-Facilitator category, particularly those based on Government press releases, may suggest political alignment with power groups. Another explanation for the high prevalence of Loyal-Facilitator articles, alongside the low incidence of Civic, Infotainment, Watchdog, and Intervention dimensions, could be the low level of data literacy among journalists. These limitations may include difficulties navigating data repositories, using specialized software, mastering mathematical and statistical skills, and critically analyzing data (Carmi & Yates, 2020; Helsper, 2021; Misra, Jütting, et al., 2021; OECD, 2019; Porto de Albuquerque et al., 2023; Scheerder et al., 2017; Senra, 1994; Tygel & Kirsch, 2016). Although many journalists strive to complement press releases with information, they may face barriers to conducting more in-depth analyses, as the lack of technical skills may contribute to a more passive professional approach (Lewis & Nashmi, 2019). Journalists seeking statistical data independently may have chosen to conduct more accessible and easier-to-communicate analyses, such as comparisons between local and regional indicators, characteristic of the Loyal-Facilitator dimension. While practical, these choices can limit the complexity and depth of their analyses.

The dimensions of journalistic roles may reflect cultural aspects that vary by context (Mellado, 2015). In this sense, another possible explanation for the high incidence of the Loyal-Facilitator dimension is that Brazilian journalists may culturally lean toward comparing local indicators with other regions—a characteristic that, according to the author, defines the Loyal-Facilitator dimension. This hypothesis allows for a distinction between journalistic practices aimed at highlighting local progress and potential alignments with elites or power structures.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5.5 Frames

The relationship between public statistics agencies and journalists becomes clearer through the lens of framing theory. By framing statistical data in news coverage, journalists influence how the public interprets and engages with official statistics. The way they present, contextualize, and emphasize certain aspects of data can shape societal debates and public understanding of policy issues. To understand the themes analyzed through the perspective of framing (Entman, 1993), the news articles were classified into the frames of Economy, Demography, and Labor, as well as an "Other" dimension that was excluded from the analysis due to its broad scope of unrelated topics. Based on this classification, it was observed that journalists from national media outlets showed greater interest in Economy-related news (46%), while local media focused more on the Labor theme (34%). Demography had a lower incidence in both local and national media, accounting for 16% and 19% of articles, respectively.

The analysis of dimensions based on the total occurrences within each frame revealed significant differences. The frames of Labor and Economy showed the highest incidence of articles classified as Loyal-Facilitator, whereas Demography had a considerably lower occurrence. The observed percentages for Labor, Economy and Demography were 90%, 84%, and 25%, respectively. The average word count for articles using data obtained organically also differed significantly across the frames, with averages of 301, 498 words and 939 words, respectively.

Economic indicators, such as GDP and investments, and labor indicators, such as employment and wages, are directly related to government actions with immediate impacts on society. The relevance of São Paulo to Brazil's economy may explain the national media's heightened interest in economic indicators, as economic events in São Paulo often have nationwide repercussions. In contrast, local media's emphasis on Labor may reflect the perception that news about employment opportunities and wages has a more immediate impact on readers' daily lives, meeting the urgent needs of their communities.

News related to demographic indicators, such as life expectancy and population size, were less common, likely due to journalists perceiving them as having a more indirect impact on daily life, despite their societal and public policy relevance. These articles had the lowest incidence of the Loyal-Facilitator classification. In local media, demographic indicators were less frequently used for regional or state comparisons, which often characterize the Loyal-Facilitator frame. By contrast, the Economy and Labor frames frequently related local data to broader contexts. While demographic outcomes are also influenced by government actions, they often stem from long-term investments, such as in public health, and are less associated with specific power groups.

5.6 Data circulation

The study revealed a range of variables that help characterize journalists, one of the user groups of public statistics. Factors such as the scope of the media outlet, the type of relationship with power groups, the level of data literacy, the journalist's role, and the chosen frame theme influence how statistical data is used.

Once the impact of data depends not only on what it represents but also on how it is utilized and by whom (Beer, 2016), from the perspective of user characteristics and needs, as highlighted by Porto de Albuquerque (2021), the study identified significant differences in the circulation of statistical data. Considering specific characteristics of users allows data-producing institutions, such as statistics agencies, to properly segment user groups and meet their needs. In the studied case, it was observed that cohesive groups, such as journalists from national outlets with higher data literacy covering themes like Demography, have different demands compared to, for example, journalists from local outlets with lower data literacy, who often focus on topics related to the labor market. For each group, data producers can adopt tailored dissemination strategies that maximize the impact and accessibility of statistics.

As suggested by Porto de Albuquerque (2023), mapping data circulation helps identify bottlenecks and propose improvements. For example, given that local media tend to cover labor-related topics and often demonstrate low data literacy, the statistical agency could adopt targeted strategies, such as sending press releases with data on local labor markets. This approach facilitates access to relevant information and helps contextualize the data to meet local audiences' needs. Segmenting user groups and adapting dissemination strategies based on data circulation enables data to reach users more effectively

5.7 Limitations and opportunities

This study has limitations that should be considered. The exclusive focus on São Paulo and its state statistical agency means that the findings reflect a specific regional context and may not be directly applicable to other settings. The study did not include direct engagement with journalists or their audiences, which could have provided additional insights into their motivations, challenges, and perceptions regarding data usage. Future research on detailing journalists' data literacy could complement the analysis of data circulation, contributing to a

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

more comprehensive understanding of their role as data users. Similarly, examining how data circulate between newspapers and their audiences could offer valuable perspectives on the broader impact of statistical information in journalism. The paper did not assess specific aspects of reporting quality, such as accuracy, contextualization, and source diversity. Including these elements in future research could provide a deeper understanding of how statistical data are integrated into journalistic narratives and how they contribute to public discourse.

6. Conclusion

This study examined data circulation between official statistics agencies and journalists, focusing on the role of press releases and news production in shaping how journalists use official statistics. By analyzing journalistic coverage of the data of the statistical agency of the state of São Paulo in 2024, the research identified key factors influencing the dissemination and use of official statistics.

The findings indicate that press releases play a significant role in shaping journalistic narratives, with a substantial portion of news articles either reproducing or adding value to the data provided by the agency. While this suggests that official statistics reach the media though Open Government Data practices, it also underscores the reliance on traditional dissemination strategies. Despite advancements in OGD initiatives, press releases remain an essential tool for facilitating data circulation. The study highlights the need for a hybrid dissemination strategy that combines traditional approaches, such as press releases and direct media engagement, with open data practices. By integrating OGD practices alongside conventional press materials, statistical agencies can enhance the reach and usability of their data, ensuring broader and more effective engagement with journalists and other stakeholders.

The study also found notable differences between local and national media outlets. Local journalists relied more heavily on press releases, while national media demonstrated greater independence in sourcing and analyzing data. These disparities might reflect variations in newsroom resources and data literacy, emphasizing the need for tailored strategies to enhance data accessibility across different media environments. The analysis of journalistic role performance revealed a predominance of the Loyal-Facilitator and Service roles, suggesting that most reporting on official statistics focuses on providing information rather than engaging in critical oversight. While this approach helps disseminate statistical data effectively, it raises questions about the extent to which journalists critically engage with government-produced statistics.

From a broader perspective, this study contributes to the research on Open Government Data by demonstrating how official statistical data move through different stages of the media ecosystem. It reinforces the idea that making data available is not enough—in the Brazilian context, a of user-centered hybrid approach of proactive dissemination practices combined with OGD practices, like an open data repository portal are crucial for ensuring that official statistics serve their intended purpose within the journalists.

By understanding the nuances of data circulation, statistics agencies can refine their dissemination practices, fostering an environment where official statistics are not only accessible but also critically examined and used by the public. Future research could build on these findings by exploring the motivations and constraints faced by journalists when using statistical data, as well as examining how audiences engage with news articles that incorporate official statistics. Additionally, further investigation into the impact of data literacy initiatives for journalists could provide valuable insights into improving data-driven journalism.

Acknowledgements

Use of AI**:** During the preparation of this work, the author used ChatGPT 4o and DeepSeek as assistants to structure, translate and review the text. After using these tools, the author reviewed, edited, made the content his own and validated the outcome as needed, and takes full responsibility for the content of the publication.

Conflict Of Interest (COI)**:** The author currently is an employee of SEADE.

References

Appelgren, E., Lindén, C.-G., & van Dalen, A. (2019). Data Journalism Research: Studying a Maturing Field across Journalistic Cultures, Media Markets and Political Environments. *Digital Journalism*, *7*(9), 1191–1199. https://doi.org/10.1080/21670811.2019.1685899

Attard, J., Orlandi, F., Scerri, S., & Auer, S. (2015). A systematic review of open government data initiatives. *Government Information Quarterly*, *32*(4), 399–418. https://doi.org/10.1016/j.giq.2015.07.006

Beer, D. (2016). *Metric Power*. Palgrave Macmillan UK. https://doi.org/10.1057/978-1-137-55649-3

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Begany, G. M., Martin, E. G., & Yuan, X. (Jenny). (2021). Open government data portals: Predictors of site engagement among early users of Health Data NY. *Government Information Quarterly*, *38*(4), 101614. https://doi.org/10.1016/j.giq.2021.101614

Bradshaw, P. (2011). *The Online Journalism Handbook: Skills to survive and thrive in the digital age* (1st edition). Routledge.

Carmi, E., & Yates, S. J. (2020). What do digital inclusion and data literacy mean today? *Internet Policy Review*, *9*(2). https://policyreview.info/digital-inclusion

Cinnamon, J. (2020). Data inequalities and why they matter for development. *Information Technology for Development*, *26*(2), 214–233. https://doi.org/10.1080/02681102.2019.1650244

Citro, C. (2014). From multiple modes for surveys to multiple data sources for estimates. *Survey Methodology*, *40*, 137–161.

Craveiro, G., Albano, C. S., & Soletto, J. S. (2023). Demand for open government data: A study using data from the brazilian ministry of health, before and during the Covid-19 pandemic. *Cadernos Gestão Pública e Cidadania*, *28*, e88602. https://doi.org/10.12660/cgpc.v28.88602.84529

Cushion, S., Lewis, J., & Callaghan, R. (2017). Data Journalism, Impartiality And Statistical Claims. *Journalism Practice*, *11*(10), 1198–1215. https://doi.org/10.1080/17512786.2016.1256789

Entman, R. M. (1993). Framing: Toward Clarification of a Fractured Paradigm. *Journal of Communication*, *43*(4), 51–58. https://doi.org/10.1111/j.1460-2466.1993.tb01304.x

Gascó-Hernández, M., Martin, E. G., Reggi, L., Pyo, S., & Luna-Reyes, L. F. (2018). Promoting the use of open government data: Cases of training and engagement. *Government Information Quarterly*, *35*(2), 233–242. https://doi.org/10.1016/j.giq.2018.01.003

Helsper, E. (2021). *The Digital Disconnect: The Social Causes and Consequences of Digital Inequalities* (1ª edição). Sage Publications Ltd.

Kitchin, R. (2014). *The Data Revolution: Big Data, Open Data, Data Infrastructures and Their Consequences*. SAGE Publications Ltd. https://doi.org/10.4135/9781473909472

Knight, M. (2015). Data journalism in the UK: A preliminary analysis of form and content. *Journal of Media Practice*, *16*(1), 55–72. https://doi.org/10.1080/14682753.2015.1015801

Laaboudi, C., Karlberg, M., & Islam, M. (2024). Open data dissemination at Eurostat: State of the art. *Statistical Journal of the IAOS*, *40*(1), 81–90. https://doi.org/10.3233/SJI-230115

Lee, S. T., & Basnyat, I. (2013). From Press Release to News: Mapping the Framing of the 2009 H1N1 A Influenza Pandemic. *Health Communication*, *28*(2), 119–132. https://doi.org/10.1080/10410236.2012.658550

Lewis, N. P., & Nashmi, E. A. (2019). Data Journalism in the Arab Region: Role Conflict Exposed. *Digital Journalism*, *7*(9), 1200–1214. https://doi.org/10.1080/21670811.2019.1617041

Lourenço, R. P. (2015). An analysis of open government portals: A perspective of transparency for accountability. *Government Information Quarterly*, *32*(3), 323–332. https://doi.org/10.1016/j.giq.2015.05.006

Mayer-Schonberger, V., & Cukier, K. (2014). *Big Data: A Revolution That Will Transform How We Live, Work, and Think* (Reprint edição). Eamon Dolan/Houghton Mifflin Harcourt.

Mellado, C. (2015). Professional Roles in News Content: Six dimensions of journalistic role performance. *Journalism Studies*, *16*(4), 596–614. https://doi.org/10.1080/1461670X.2014.922276

Misra, A., Jütting, J., & Kuonen, D. (2021). *Advancing data literacy in the post-pandemic world—A primer to catalyse policy dialogue and action* (p. 24) [White paper]. The Partnership in Statistics for Development in the 21st Century (PARIS21). https://paris21.org/sites/default/files/inline-files/DataLiteracy_Primer_0.pdf

Misra, A., Ranjan, R., Rudow, C., & Swanson, E. (2021). *Data dissemination in the digital age: A review of data portals for official statistics in IDA-eligible countries* (p. 72) [White paper]. Partnership in Statistics for Development in the 21st Century (PARIS21), Open Data Watch (ODW). https://www.paris21.org/sites/default/files/2022-03/Data_dissemination_in_the_digital_age.pdf

OECD. (2019). *The Path to Becoming a Data-Driven Public Sector*. OECD. https://doi.org/10.1787/059814a7-en

Pappas, I. O., Mikalef, P., Giannakos, M. N., Krogstie, J., & Lekakos, G. (2018). Big data and business analytics ecosystems: Paving the way towards digital transformation and sustainable societies. *Information Systems and E-Business Management*, *16*(3), 479–491. https://doi.org/10.1007/s10257-018-0377-z

Piattoeva, N., Centeno, V. G., Suominen, O., & Rinne, R. (2018). Governance by data circulation? The production, availability, and use of national large-scale assessment. In *Politics of Quality in Education*. Routledge.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Porto de Albuquerque, J., Anderson, L., Calvillo, N., Cattino, M., Clarke, A., Cunha, M. A., Degrossi, L. C., Garde-Hansen, J., Klonner, C., Lima-Silva, F., Marchezini, V., Martins, M. H. da M., Pajarito Grajales, D., Pitidis, V., Rizwan, M., Tkacz, N., & Trajber, R. (2023). Dialogic data innovations for sustainability transformations and flood resilience: The case for waterproofing data. *Global Environmental Change*, *82*, 102730. https://doi.org/10.1016/j.gloenvcha.2023.102730

Porto de Albuquerque, J., Anderson, L., Calvillo, N., Coaffee, J., Cunha, M. A., Degrossi, L. C., Dolif, G., Horita, F., Klonner, C., Lima-Silva, F., Marchezini, V., Martins, M. H. da M., Pajarito-Grajales, D., Pitidis, V., Rudorff, C., Tkacz, N., Traijber, R., & Zipf, A. (2021). The role of data in transformations to sustainability: A critical research agenda. *Current Opinion in Environmental Sustainability*, *49*, 153–163. https://doi.org/10.1016/j.cosust.2021.06.009

Rogers, S. (2013). *Facts are Sacred* (Main edition). Faber & Faber.

Scheerder, A., van Deursen, A., & van Dijk, J. (2017). Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. *Telematics and Informatics*, *34*(8), 1607–1624. https://doi.org/10.1016/j.tele.2017.07.007

Scheufele, D. A., & Lewenstein, B. V. (2005). The Public and Nanotechnology: How Citizens Make Sense of Emerging Technologies. *Journal of Nanoparticle Research*, *7*(6), 659–667. https://doi.org/10.1007/s11051-005-7526-2

Scheufele, D. A., & Tewksbury, D. (2007). Framing, agenda setting, and priming: The evolution of three media effects models. *Journal of Communication*, *57*(1), 9–20. https://doi.org/10.1111/j.0021-9916.2007.00326.x

Senra, N. C. (1994). Por uma disseminação democrática de informações. *São Paulo em Perspectiva*, *8*(4), 40–45.

Shoemaker, P. J., & Vos, T. (2009). *Gatekeeping Theory*. Routledge. https://doi.org/10.4324/9780203931653

Signorelli, S., Fontana, M., Gabrielli, L., & Vespe, M. (2023). Challenges and Opportunities of Computational Social Science for Official Statistics. In *Handbook of Computational Social Science for Policy* (p. XXI, 490). Springer Cham. https://link.springer.com/book/10.1007/978-3-031-16624-2

Torres-Freire, C. (2021). Tecnologia, dados e novas possibilidades para a pesquisa social. In *Mosaico de olhares: Pesquisa e futuro* (p. 344). Sesc SP.

Tygel, A., & Kirsch, R. (2016). Contributions of Paulo Freire for a Critical Data Literacy: A Popular Education Approach. *The Journal of Community Informatics*, *12*. https://doi.org/10.15353/joci.v12i3.3279

United Nations Statistics Division. (2013, July 24). *Fundamental Principles of Official Statistics*. https://unstats.un.org/unsd/dnss/gp/fundprinciples.aspx

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The Impact of Data Orchestration on Data Value Generation in the Judicial Data Ecosystem.

Felipe Fonseca Salerno[a], Antonio Carlos Gastaud Maçada[b], Juliana Obino Mastella[c]*

[a] Programa de Pós-Graduação em Administração, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, 00193140@ufrgs.br, 0000-0003-1305-7957

[b] Programa de Pós-Graduação em Administração, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, acgmacada@ea.ufrgs.br, 0000-0002-8849-0117

[c] Tribunal de Justiça do Estado do Rio Grande do Sul, Porto Alegre, Brazil, jmastella@tjrs.jus.br, 0009-0009-7439-6988

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. This study investigates the role of data orchestration in enhancing data value generation within the judicial data ecosystem, grounded in Resource-Orchestration Theory (ROT). Data orchestration is defined as a multidimensional construct comprising data strategy, data governance, synergy, and technological infrastructure. These dimensions collectively facilitate the integration and coordination of data resources, processes, and stakeholders to maximize data value. Guided by the principles of ROT, which conceptualizes data as strategic resources to be structured, bundled, and leveraged, this study emphasizes the importance of orchestrating data resources to enhance their value within the judicial data ecosystem, where diverse actors and complex systems interact, ensuring data is effectively utilized as a strategic asset. A quantitative methodology was employed, with a survey conducted among experts from Brazilian courts and councils. Regression analysis was used to evaluate the relationship between data orchestration and data value, revealing a significant positive effect (0.687, $p < 0.001$), with data orchestration explaining 45.6% of the variance in data value. These findings demonstrate that coordinated efforts to align data-related resources and practices significantly enhance the value generated from data within the judicial ecosystem. By operationalizing ROT in this context, the study provides empirical evidence of how data orchestration contributes to improving the strategic potential of data in data ecosystems. The research advances theoretical understanding of ROT in the field of data ecosystems and offers practical insights for improving data management and governance in judicial settings. Although limited by sample size, the study opens pathways for future research to explore additional dimensions influencing data value generation and to validate these findings in other institutional contexts, acknowledging that generalizability is constrained by the specific characteristics of the Brazilian judicial data ecosystem.

Keywords. Data orchestration, data value, resource orchestration theory, data ecosystems.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.993

1. Introduction

Data orchestration is a broad concept that encompasses the integration of data strategy, data governance, synergy among stakeholders, and technological infrastructure (Schreieck *et al.*, 2022; Queiroz *et al.*, 2020). Data strategy involves planning how information is collected, analyzed, and shared to achieve organizational objectives (Gür *et al.*, 2021). Data governance establishes norms and responsibilities to ensure quality, security, and ethical use of information (Abraham *et al.*, 2019). Synergy fosters effective collaboration among various stakeholders (Cui & Han, 2022), while technological infrastructure supports interoperability and scalability of implemented digital solutions (Teece, 2020; Gupta *et al.*, 2020).

Through the lens of Resource-Orchestration Theory (ROT) (Zhang *et al.*, 2022), orchestration highlights the importance of strategically coordinating human, financial, technological, and informational resources to create value. ROT posits that organizations embedded in ecosystems can structure and bundle resources optimally,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

enabling them to respond to changes and generate value through efficiency and cost reduction, among other benefits. Within data environments, the strategic coordination of informational resources modernizes management practices and strengthens evidence-based decision-making (Queiroz *et al.*, 2020).

In the context of the Brazilian Judiciary, the efficient coordination of resources is particularly relevant. The Judiciary is organized into multiple instances and bodies—such as superior, federal, state, and district courts—reflecting the complexity of the judicial ecosystem established by the 1988 Federal Constitution (Brazil, 1988). While this institutional diversity is important for ensuring autonomy and independence among courts, it also creates challenges that require coordinated actions to meet growing demands for transparency and effectiveness. The National Council of Justice (CNJ) functions as the orchestrator of this ecosystem, promoting programs that integrate technology and innovation to modernize the Judiciary and improve access to justice (CNJ, 2023). For such initiatives to succeed, reliable and integrated data are indispensable, allowing the CNJ to align administrative practices, monitor court performance, and implement evidence-based public policies.

Building on this institutional arrangement, this paper conceptualizes the judicial data ecosystem as a domain-specific, orchestrated environment regulated by the CNJ (Oliveira & Lóscio, 2018; Gelhaar *et al.*, 2021). Within this framework, structured and centralized data management enables evidence-informed decision-making across judicial institutions. Data orchestration emerges as a strategic approach, with the potential to enhance analytical capabilities through big data applications (Mikalef *et al.*, 2023). The integrated analysis of large datasets generates insights that inform policy design, resource allocation, and operational efficiency. Moreover, the standardization and centralization of data contribute to greater transparency and help build public trust in judicial services, reinforcing the Judiciary's role in promoting citizenship (Salerno & Maçada, 2024a; Nikiforova *et al.*, 2024).

These dynamics are reflected in specific CNJ-led initiatives that exemplify the orchestration of data resources in practice. One such initiative is DataJud, which centralizes procedural data from all Brazilian courts (CNJ, 2022). By offering thematic dashboards, DataJud makes a wide range of information available to support institutional decision-making and the formulation of evidence-based public policies. This initiative is embedded within the broader Justice 4.0 Program, which promotes the adoption of technologies such as artificial intelligence and big data to enhance judicial efficiency and the quality of services provided by the courts (Barreto & da Costa, 2020; Vivian, 2020).

Despite its advantages, implementing data orchestration in the Judiciary faces significant challenges, including cultural resistance, limited technical training, and insufficient interoperability among systems of different courts (Castro, 2022; Vivian, 2020). Moreover, ensuring data security and privacy, especially regarding sensitive information, requires ongoing investments in technology and governance (Mikalef *et al.*, 2023).

These limitations highlight the complexity of advancing data orchestration and reinforce the need to better understand its actual contribution to data value generation within judicial ecosystems. Against this backdrop, the present study investigates the following question: *What is the impact of data orchestration on data value generation in the judicial data ecosystem*? To address this question, an exploratory quantitative methodology was adopted, employing a survey among experts from Brazilian courts and councils. The goal is to provide empirical evidence on the relationship between data orchestration and data value, contributing to the refinement of Resource-Orchestration Theory and to improved judicial data management.

2. Theoretical Framework

This section presents the theoretical framework underpinning the research, beginning with the foundations of Resource-Orchestration Theory, the core theory informing the phenomenon under study. Subsequently, the concept of data orchestration is developed as a construct comprising four interrelated dimensions: data strategy, data governance, synergy, and technological infrastructure, each detailed in subsequent sections.

2.1 Resource-Orchestration Theory

Resource-Orchestration Theory (ROT) is a theoretical approach widely used to analyze how organizations structure and manage resources to achieve strategic objectives in dynamic environments, such as ecosystems. Although originally developed in private sector contexts (Sirmon *et al.*, 2007; 2011), ROT has been increasingly applied in public administration, where resource alignment and coordination are also important (Gao *et al.*, 2022). ROT asserts that the value of a resource lies not only in its possession but also in an organization's ability to orchestrate it effectively through three key processes: structuring, bundling, and leveraging. These processes enable organizations to identify strategic resources, combine them efficiently, and use them to create value through mechanisms such as efficiency and cost reduction (Queiroz *et al.*, 2020).

Structuring involves identifying and mobilizing available resources to ensure their accessibility and alignment with

organizational objectives. Bundling entails combining resources in a complementary manner, creating synergies that enhance their utility. Finally, leveraging refers to the strategic use of resources to maximize their impact, capitalizing on opportunities and effectively responding to external threats. This approach is particularly relevant in data ecosystems, where multiple actors interact and share information to pursue common goals (Lin *et al.*, 2023; Zhang *et al.*, 2022; Sirmon, 2007).

Queiroz *et al.* (2020) argue that orchestration positively impacts ecosystems, with the phenomenon surpassing the sum of individual effects. In the data context, orchestration enables value generation that exceeds individual contributions. Autio (2022) highlights the utility of ROT in digital ecosystems, where coordinating intangible assets such as data enhances management practices. Additionally, Salerno and Maçada (2024a) emphasize that in ecosystems like the Brazilian Judiciary, data orchestration fosters the alignment of strategic initiatives and improves data quality.

By centralizing and integrating information through technologies such as DataJud, ROT principles can be applied to the judicial data ecosystem. ROT thus provides a theoretical foundation for analyzing how data, treated as strategic resources, can be structured and bundled to generate value (leveraging). After exploring these theoretical foundations, the next section elaborates on the concept of data ecosystems.

2.3 Data Ecosystems

Data ecosystems integrate organizations, technologies, processes, and stakeholders in a collaborative environment where data is collected, shared, and utilized as a strategic resource (Guggenberger *et al.*, 2020). This concept is especially pertinent in a context of intense flow of information. According to Oliveira and Lóscio (2018), a data ecosystem can be defined as a complex and interconnected network of organizations, technologies, and individuals utilizing data as a fundamental asset for their activities. This definition reveals the dynamic nature of ecosystems, where interactions among participants are pivotal for maximizing data value. Nikiforova *et al.* (2024) add that data ecosystems evolve over time, influenced by technological advancements, regulatory changes, and societal demands. Gelhaar *et al.* (2021) highlight that data ecosystems differ from other informational systems due to their capacity to foster collaboration among multiple actors, often from distinct sectors. These ecosystems are characterized by adaptability, resilience, and the ability to evolve based on new data and technologies. Furthermore, transparency and interoperability among systems and actors are critical elements for a data ecosystem's success.

Guggenberger *et al.* (2020) note that data ecosystems comprise several interdependent components, including data as a central resource, where its quality and accessibility are fundamental for effective functioning. The literature also emphasizes the use of data for analyses, modelling, and decision-making by ecosystem participants (Xu & Pero, 2023). Another essential aspect involves technological infrastructure, which provides the foundation for data collection, storage, processing, and dissemination. Platforms and solutions based on artificial intelligence often leverage data ecosystems (Nikiforova *et al.*, 2024; Gupta *et al.*, 2020). Weber *et al.* (2024) demonstrate that well-structured ecosystems transform data into strategic insights, fostering value generation.

Nikiforova *et al.* (2024) propose an evolutionary model of data ecosystems identifying six distinct generations, ranging from systems focused on raw data to intelligent ecosystems leveraging emerging technologies like artificial intelligence and machine learning. Oliveira and Lóscio (2018) distinguish between open ecosystems, emphasizing unrestricted data sharing among participants, and orchestrated ecosystems, characterized by a central actor regulating interactions and establishing norms. This typology is particularly useful for understanding complex ecosystems like the Brazilian Judiciary, where the CNJ acts as an orchestrator by promoting data integration through DataJud (CNJ, 2022).

The creation of DataJud, as part of the Justice 4.0 Program, demonstrates the potential of data ecosystems to centralize information, promote integrated analyses, and enhance administrative efficiency. This initiative reveals the significance of inter-institutional collaboration and technological interoperability in modernizing judicial services (CNJ, 2023; Barreto & da Costa, 2020). The concept of a judicial data ecosystem, as employed in this study, is a domain-specific, orchestrated data ecosystem (Oliveira & Lóscio, 2018; Gelhaar *et al.*, 2021), characterized by regulated interactions among institutions under a central orchestrator—the CNJ. This setting aligns more closely with the structured ecosystem model discussed by Nikiforova *et al.* (2024), in contrast to fully open data ecosystems (Weber *et al.*, 2024).

Having established the foundations of data ecosystems, particularly the typology emphasizing orchestrated data ecosystems, the discussion follows to the concept of data orchestration.

2.3 Data Orchestration

Data orchestration, as defined in this study, is based on Resource-Orchestration Theory (ROT) and refers to the strategic coordination of data-related resources, actors, and processes to generate value within a data ecosystem (Salerno & Maçada, 2024b; Zhang *et al.*, 2022). Rather than focusing on the technical automation of data flows, as seen in IT-based data orchestration, this perspective emphasizes how organizations structure, bundle, and leverage data resources to improve decision-making and policy implementation (Schreieck *et al.*, 2022; Queiroz *et al.*, 2020). This approach is particularly relevant in data ecosystems, where multiple stakeholders interact through shared data infrastructures. In such environments, orchestration helps to align goals, foster collaboration, and address common challenges—such as data fragmentation and lack of interoperability (Guggenberger *et al.*, 2020).

Within the framework of ROT, the processes of structuring, bundling, and leveraging are interdependent elements that enable value creation from data (Schreieck *et al.*, 2022). Structuring in data orchestration involves identifying, organizing, and allocating resources to ensure that data is accessible, relevant, and aligned with objectives (Queiroz *et al.*, 2020). Bundling refers to integrating and combining complementary data sources, enabling interactions among different information sources and systems. Leveraging denotes the strategic use of these resources to achieve organizational or collective goals within the data ecosystem (Salerno & Maçada, 2024a; Lin *et al.*, 2023).

These three processes, when coordinated effectively by an orchestrator, foster the ecosystem's dynamism, enhancing the strategic potential of data while strengthening value creation capabilities (Cui & Han, 2022; Schreieck *et al.*, 2022). Based on these assumptions, data orchestration comprises four primary dimensions: data strategy, data governance, synergy, and technological infrastructure. The selection of these dimensions of data orchestration was grounded in the core processes of ROT (structuring, bundling, and leveraging) and informed by empirical studies on data orchestration in digital and public ecosystems (Schreieck *et al.*, 2022; Cui & Han, 2022; Queiroz *et al.*, 2020). These dimensions are explored in detail in subsequent sections.

2.3.1 Data Strategy

Data strategy refers to a plan that guides how data will be used to achieve organizational objectives, setting priorities, guidelines, and promoting alignment between organizational goals and data, thereby integrating data into decision-making processes (Gür *et al.*, 2021; Marr, 2021). According to Vayyavur (2024), an effective data strategy requires not only planning for data use and related objectives but also alignment among stakeholders. In the context of orchestration, focusing on specific informational resources is important to explore the effects of integration and strategic coordination (Zhang *et al.*, 2022). This alignment is particularly relevant in public institutions where the common goal is to deliver services to the population.

In this context, data strategy becomes particularly important due to the complexity of interactions among different actors, aiming to guide how goals and objectives can be achieved through data (Schreieck *et al.*, 2022; Curry *et al.*, 2021). From this perspective, data orchestration is relevant for spreading and amplifying the benefits of a data strategy, enabling ecosystem participants to act collectively towards achieving objectives (Queiroz *et al.*, 2020). Orchestration facilitates the integration of efforts, enhancing the generation of value through data exchanges within the ecosystem.

As Gür *et al.* (2021) indicate, data strategy encompasses dimensions such as strategic declarations, internal and external data sources, ecosystem alignment, and strategy implementation. Through this lens, data orchestration leverages data strategy to promote alignment on how data contributes to achieving goals and objectives, establishing it as a central element of data orchestration by directing actors to work cohesively. Therefore, data strategy is adopted as one of the dimensions of data orchestration.

2.3.2 Data Governance

Data governance serves as a foundation for data orchestration by establishing norms, policies, and practices governing ecosystem data, widely recognized as a key element for maximizing the value of data within ecosystems (Lis *et al.*, 2023). Abraham *et al.* (2019) define data governance as a set of processes necessary to ensure that data is handled reliably and complies with legal and institutional requirements. According to Otto *et al.* (2011), data governance not only regulates the use of information but also maximizes its value by defining roles, authorities, and decision-making structures.

In this sense, Kim and Cho (2019) highlight that data governance enhances data strategy by setting the conditions needed to achieve proposed objectives. Thus, data governance integrates ecosystem actors by defining guidelines that promote collaboration among stakeholders and alignment regarding data-related practices. This interaction is particularly relevant in collaborative environments, such as the Judiciary, where clear role definitions and data quality assurance are fundamental to collective success (Salerno & Maçada, 2024b).

The literature explores the role of data governance as a facilitator for orchestration in ecosystems. Lin *et al.* (2023) argue that governance is fundamental for ensuring the proper flow of data within ecosystems, while Schreieck *et al.* (2022) add that orchestrators can leverage governance at three mechanisms—structural, procedural, and relational—to optimize this flow. The orchestrator adapts governance rules to accompany ecosystem transformations. This implies not only proposing new guidelines but also continuously reevaluating existing mechanisms to ensure that the ecosystem remains efficient, collaborative, and capable of generating value in a dynamic environment.

From the perspective of Resource-Orchestration Theory, governance establishes conditions for ecosystem actors to utilize their partners' data integrally, defining clear boundaries about what can or cannot be shared. Therefore, data governance emerges as a dimension of data orchestration by enabling ecosystem actors to understand their responsibilities and desired standards, establishing norms, policies, and practices for ecosystem data.

2.3.3 Synergy

Synergy is one of the core dimensions of data orchestration, reflecting the ability to align and integrate various actors within a data ecosystem to achieve outcomes that exceed the sum of individual contributions (Fredriksson & Hagberg, 2023). Guggenberger *et al.* (2020) argue that synergy is a fundamental element in complex ecosystems, enabling strategic collaboration and effective sharing of informational and technological resources. In data orchestration, synergy promotes the integration and alignment among actors, information flows, and technologies comprising the ecosystem. Thus, data orchestration relies on synergy to foster a cohesive environment and alignment in data-related initiatives.

The literature emphasizes that synergy does not occur spontaneously, requiring deliberate efforts for its development. Lin *et al.* (2023) stress that elements such as trust and effective communication are important for maximizing collaboration among actors. Zhang *et al.* (2022) argue that synergy involves aligning contributions and efficiently integrating resources, enhancing collaboration among stakeholders. This perspective links synergy with other dimensions of data orchestration, such as data governance, data strategy, and technological infrastructure, creating a complementarity that optimizes value generation. By encouraging data sharing and integration among actors, synergy enables the use of advanced data analysis tools, such as big data and artificial intelligence, thereby generating value through data (Vafaei-Zadeh *et al.*, 2020).

In summary, synergy as a dimension of data orchestration is instrumental in fostering collaboration among actors, technologies, and data flows within the ecosystem. Its integration with other dimensions (data governance, data strategy, and technological infrastructure) reveals its importance in creating a cohesive and aligned environment necessary for effective orchestration. By facilitating the complementarity of informational resources, synergy enhances the value of ecosystem data.

2.3.4 Technological Infrastructure

Technological infrastructure can be defined as the set of systems, platforms, devices, and networks that support data collection, storage, processing, and sharing within ecosystems (Otto *et al.*, 2019). According to Chiang *et al.* (2023) and Sirmon *et al.* (2011), technological infrastructure supports and enables orchestration processes by connecting resources, systems, and actors, facilitating integration. From the perspective of data orchestration, technological infrastructure acts as an enabler that integrates different data sources and systems.

Otto *et al.* (2019) emphasize that the interoperability provided by technological infrastructure is vital for data to flow seamlessly within ecosystems. Furthermore, technological infrastructure supports the implementation of standards defined by data governance, ensuring, for instance, consistent data storage and quality standards (Solomonides, 2023). It also offers the flexibility necessary to adapt to changes in data ecosystems, accommodating increases in data volume and complexity. Garg *et al.* (2018) and Ranjan *et al.* (2017) highlight that scalability is a fundamental attribute of technological infrastructure, allowing ecosystems to expand their capacities as new technologies and demands emerge.

Finally, Vafaei-Zadeh *et al.* (2020) stress that technological infrastructure supports data integration, enabling diverse applications and creating conditions to maximize the value of data. Thus, technological infrastructure becomes a core dimension of data orchestration by facilitating the wide use and sharing of data among ecosystem actors (Zhang *et al.*, 2022; Otto *et al.*, 2019).

3. Contextualization to the Brazilian Judiciary

The Brazilian Judiciary comprises a diverse structure, including superior, federal, state, and district courts, designed to ensure the independence and autonomy as outlined in the 1988 Federal Constitution (Brazil, 1988).

While this multiplicity is necessary to address the specificities of various jurisdictions, it also poses challenges related to data integration, process standardization, and administrative efficiency (Barreto & da Costa, 2020).

In this context, the National Council of Justice (CNJ) acts as the orchestrator of the judicial ecosystem, fostering administrative uniformity, establishing guidelines, and monitoring court performance (CNJ, 2023). Reliable and high-quality data are necessary for the CNJ to perform its functions effectively, motivating its role as the data orchestrator of this ecosystem (CNJ, 2009). Key CNJ initiatives involving orchestrated data include DataJud, the Judiciary Digital Platform (PDPJ), and the Justice 4.0 Program, which illustrate the application of data orchestration principles in the judicial ecosystem.

For instance, DataJud centralizes data from all Brazilian courts, creating an integrated database for analyses supporting administrative decisions and public policies. Meanwhile, the PDPJ promotes collaborative development among courts to offer multiservice solutions utilizing shared resources and collaborative tools within the judiciary. Finally, the Justice 4.0 Program incorporates emerging technologies like artificial intelligence and big data into judicial management, aiming to optimize procedural workflows and modernize service delivery (CNJ, 2022, 2023; Vivian, 2020).

By linking these CNJ-led initiatives with the theoretical concepts, important intersections with Resource-Orchestration Theory emerge, motivating further exploration of data orchestration in the judicial ecosystem, particularly through the four dimensions representing data orchestration (data strategy, data governance, synergy, and technological infrastructure). Regarding data strategy, CNJ initiatives outline objectives to be achieved through data, such as creating dashboards with quality information on court activities (CNJ, 2020). For data governance, it is observed that it manifests primarily through CNJ resolutions, such as Resolution No. 331/2020, which provides norms and guidelines for using ecosystem data (CNJ, 2020). Synergy, in turn, can be exemplified by the creation of the Judicial Research Network through Resolution No. 462/2022 (CNJ, 2022), promoting collaboration and alignment among ecosystem actors in data-related initiatives. Finally, technological infrastructure fosters interoperability and data flow among actors, exemplified by the Codex platform, developed to consolidate procedural databases and facilitate data input for technological applications used in the judiciary (CNJ, n.d.).

Therefore, data orchestration within the judicial ecosystem can be observed through the four theoretical dimensions developed under Resource-Orchestration Theory, wherein data strategy, data governance, synergy, and technological infrastructure promote data orchestration to maximize data value. This perspective positions the CNJ as the primary orchestrator of the judicial ecosystem's data, leveraging data resources to meet the ecosystem's and society's demands, as an example of the typology of orchestrated ecosystems (Gelhaar *et al.*, 2021; Oliveira & Lóscio, 2018).

With the contextualization of the judicial data ecosystem understood, the next section presents the methodology used to address the research question: What is the impact of data orchestration on data value generation in the Judicial Data Ecosystem?

4. Research Methods

This section outlines the methodology employed to investigate the proposed research question, focusing on measuring the impact of data orchestration on data value generation. A quantitative approach was adopted, detailed in the subsequent sections, encompassing the development of a questionnaire, its validation, and the statistical techniques applied.

4.1 Development of the Research Instrument

To measure the impact of data orchestration on value generation in the Judicial Data Ecosystem, a survey was conducted with specialists in the judicial ecosystem using a questionnaire. The choice of a questionnaire as a data collection instrument is justified by its ability to systematically and uniformly capture perceptions from the target population (Pinsonneault & Kraemer, 1993). The questionnaire was developed by a multidisciplinary team of researchers and judicial experts with proven experience in managing and analyzing data in the Brazilian Judiciary. The item construction was informed by prior theoretical frameworks, particularly Resource-Orchestration Theory (Zhang *et al.*, 2022), and operationalized through constructs derived from literature on data ecosystems and orchestration (Guggenberger *et al.*, 2020; Schreieck *et al.*, 2022). The final instrument contained 33 items to represent each orchestration dimension (data strategy, data governance, synergy, and technological infrastructure) and data value. Items were designed using a Likert scale of agreement ranging from 1 (strongly disagree) to 7 (strongly agree) to capture the intensity of perceptions regarding the proposed statements. The full questionnaire is available upon request from the authors.

4.2 Face and Content Validity

After the initial draft, a card sorting exercise was conducted with 10 data orchestration specialists to validate the structure and organization of the questionnaire's constructs (Spencer, 2009). The results indicated that the items were consistently organized and aligned with the proposed theoretical dimensions, with minor adjustments made to improve question phrasing. Subsequently, the Content Validity Index (CVI) was calculated based on evaluations from eight experts who assessed the clarity, relevance, and representativeness of the items concerning the constructs, ensuring the instrument's content validity. One item scored below the CVI threshold of 0.8 and was revised for clarity. The remaining items scored above 0.80, indicating an acceptable level of content validity (Alexandre & Coluci, 2011).

4.3 Data Collection

The questionnaire was available from October 15 to December 20, 2024, and distributed to all Brazilian courts and councils via the Judicial Research Network. It was also shared with Judicial Schools, Innovation Laboratories, and IT Departments within courts. A total of 35 responses were received from experts with in-depth knowledge of the judicial data ecosystem, representing segments such as state, federal, labour, and electoral justice, as well as superior courts and councils. Among respondents, 34.2% worked in strategic management, 45.8% in technology, and the remaining 20% in other technical data fields, ensuring broad representation of the Brazilian judicial data ecosystem.

4.4 Instrument Validation

The instrument's validity was assessed using principal component analysis (PCA) to verify the unidimensionality of the dimensions comprising data orchestration (data strategy, data governance, synergy, and technological infrastructure) and data value as constructs. Each dimension was analyzed individually, ensuring significant item contributions. One item (DGP1) scored below 0.7 and was excluded from the analysis (Hair *et al.*, 2019). Internal consistency for the four dimensions of data orchestration and data value was evaluated using Cronbach's alpha, confirming the instrument's reliability. Results are presented in Tab. 1, showing values exceeding literature standards (>0.7), supporting internal consistency (Cronbach & Meehl, 1955).

Tab. 1 - Cronbach's Alpha Result

Dimension	Cronbach's Alpha	
Data Strategy	0.942	
Data Governance	0.952	
Structural		0.943
Procedural		0.924
Relational		0.930
Synergy	0.925	
Technological Infrastructure	0.900	
Data Value	0.966	

4.5 Calculation of Latent Scores

To create a single score per respondent representing data orchestration across its four theoretical dimensions, principal component analysis (PCA) was again applied, extracting scores related to the first component. PCA is a statistical technique for dimensionality reduction that synthesizes shared variance among analyzed items into a reduced set of principal components (Jolliffe, 2002). In this case, the first component, which explained 58.43% of the variance, was selected as the single score to represent data orchestration, summarizing the four theoretically developed dimensions. A similar procedure was applied to the items representing data value, where the first component explained 88.62% of the variance.

4.6 Linear Regression

Using the standardized scores obtained from PCA, a linear regression analysis was conducted to examine the relationship between data orchestration (independent variable) and data value (dependent variable), assessing the significance of the beta coefficient (β) and the percentage of variance explained by the model (R^2). Linear regression is a statistical technique used to identify and quantify relationships between a dependent variable and one or more independent variables, widely used to understand associations between variables (Darlington &

Hayes, 2017). Assumptions of regression analysis (linearity, homoscedasticity, normality of residuals, and overall model fit) were graphically evaluated using R software.

5. Results

This section presents the findings from the methodological procedures performed to assess the impact of data orchestration on data value generation within the judicial data ecosystem.

5.1 Linear Regression Results

Based on the standardized scores obtained through PCA, the regression model results are presented in Tab. 2 and Tab. 3. Assumption diagnostics were graphically assessed in Fig. 1, suggesting that all assumptions were met (Darlington & Hayes, 2017).

The results indicate that data orchestration has a positive and statistically significant impact ($p < 0.05$) on data value ($\beta = 0.687$, $p < 0.001$). Interpreting the coefficient obtained, each additional unit of data orchestration corresponds to an average increase of 0.687 units in data value, based on the standardized scale (mean = 0, standard deviation = 1) derived from PCA (Darlington & Hayes, 2017; Jolliffe, 2002). Tab. 3 reveals that the overall model was significant ($p < 0.05$), explaining a substantial proportion of total variance. The adjusted R^2 value was 0.456, meaning that 45.6% of the variance in data value can be explained by data orchestration. This result indicates that data orchestration has a moderately significant impact on data value (Darlington & Hayes, 2017), aligning with theoretical perspectives presented in Resource-Orchestration Theory (Cui & Han, 2022).

Tab. 2 - Regression Results

Variable	Coefficient (β)	Standard Error	t-Statistic	p-Value
Data Orchestration	0.687	0.127	5.429	< 0.001

Tab. 3 - Analysis of Variance

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Statistic	p-Value
Regression	16.04	1	16.04	29.473	< 0.001
Residual	17.96	33	0.544	-	-
Total	34.00	34	-	-	-

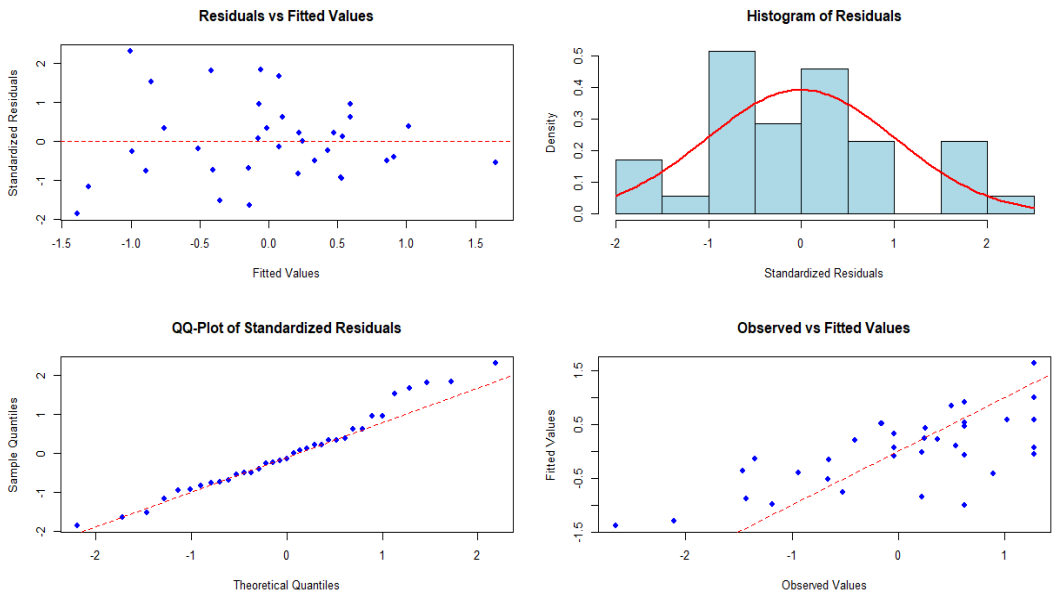


Fig. 1 – Graphical Analysis of Regression Model Assumptions.

5.2 Theoretical Implications

In the theoretical context of data orchestration, the results suggest that the processes of structuring, bundling, and leveraging proposed by Resource-Orchestration Theory can be operationalized through four dimensions: data strategy, data governance, synergy, and technological infrastructure. The leveraging process is represented by the observed increase in data value. These findings corroborate the theoretical framework presented in Section 2, confirming that data orchestration has a significant impact on data value within the judicial ecosystem. This relationship emphasizes the CNJ's role as the ecosystem's orchestrator, coordinating resources, actors, and processes, reflecting orchestrated ecosystems identified in the literature (Gelhaar *et al.*, 2021; Oliveira & Lóscio, 2018).

The results also provide empirical evidence that complements existing literature, contributing to a better understanding of how data orchestration influences data value generation in ecosystems. Addressing the research question directly, the impact of data orchestration on data value generation in the judicial data ecosystem was 0.687, meaning that each additional unit of data orchestration corresponds to an average increase of 0.687 units in data value (standardized scale). Resource-Orchestration Theory suggests that value creation results from the interdependent processes of structuring, bundling, and leveraging resources (Sirmon *et al.*, 2011; Zhang *et al.*, 2022), which, in the context of orchestrated data ecosystems, could be operationalized through data orchestration and its dimensions (Schreieck *et al.*, 2022; Queiroz *et al.*, 2020).

For instance, the impact of data strategy may be increased by strengthening alignment between organizational goals and data practices (Gür *et al.*, 2021), while data governance can evolve through the refinement of procedural and relational mechanisms to better accommodate dynamic ecosystem needs (Schreieck *et al.*, 2022; Lin *et al.*, 2023). Enhancing synergy depends on fostering trust and inter-organizational collaboration (Zhang *et al.*, 2022; Guggenberger *et al.*, 2020). Improvements in technological infrastructure may result from expanding interoperability and scalability to mitigate data fragmentation (Vafaei-Zadeh *et al.*, 2020; Otto *et al.*, 2019). Thus, while the regression model demonstrates the aggregate effect of data orchestration, a conceptual analysis indicates that each dimension has a distinct capacity to influence data value and may require targeted strategies for enhancement.

However, this study was not designed to isolate and test the individual effects of each dimension. While the findings offer initial empirical support for the Brazilian judicial data ecosystem, caution is warranted when generalizing to other institutional or national contexts. Governance structures, data policies, and the degree of central coordination in Brazil may differ significantly from those in other judicial or public data ecosystems. Moreover, the limited sample size constrained the analytical depth, particularly in assessing dimension-specific impacts. Future research with larger and more diverse samples could address these limitations by disaggregating the data orchestration construct and offering a more granular understanding of how each dimension contributes to data value across different settings.

6. Conclusion

Recent technological advancements in the Brazilian Judiciary, particularly the creation of DataJud, have fostered the development of a judicial data ecosystem, presenting opportunities to enhance court management and decision-making processes (CNJ, 2023). In this context, data orchestration has emerged as a strategic approach to optimize data value generation and improve judicial services (Salerno & Maçada, 2024a; Cui & Han, 2022; Schreieck *et al.*, 2022). Through a survey with experts from Brazilian courts and councils, linear regression results revealed that data orchestration positively and significantly impacts data value ($\beta = 0.687$, $p < 0.001$) on the judicial data ecosystem, with the model explaining 45.6% of the variance in data value.

The findings support Resource-Orchestration Theory's emphasis on the role of orchestration in value generation, highlighting the importance of data orchestration in effectively structuring, bundling and leveraging data resources (Lin *et al.*, 2023; Zhang *et al.*, 2022). The dimensions of data strategy, data governance, synergy, and technological infrastructure effectively represent data orchestration, which positively impacts data value generation in the judicial ecosystem, complementing prior studies (Salerno & Maçada, 2024a). These results also reinforce the significance of integration and collaboration among multiple actors to maximize the benefits of shared information in data ecosystems (Fredriksson & Hagberg, 2023; Guggenberger *et al.*, 2020). In addition, the finding aligns with previous studies highlighting the importance of strategic coordination of informational resources in value generation within ecosystems (Autio, 2022; Queiroz *et al.*, 2020).

The significant relationship between data orchestration and data value demonstrates the potential for judicial data ecosystems to adopt orchestration practices as a strategic approach to enhance their operations. By emphasizing coordinated data practices within ecosystems, this study establishes data orchestration as a structured approach to addressing challenges such as fragmented data and inefficiencies in information flow (Guggenberger *et al.*, 2020). This perspective reinforces the growing recognition that ecosystems benefit from orchestration practices

that balance resource alignment with collaborative engagement (Cui & Han, 2022). Furthermore, the judicial context call attention to the unique contribution of these practices in supporting public policies aimed at enhancing service delivery and accountability (Vivian, 2020). These insights provide a foundation for further exploration of how data orchestration can address challenges beyond the judiciary, particularly in data ecosystems where coordination among stakeholders is critical.

In summary, this research demonstrated the significant impact of data orchestration on data value generation, contributing to the academic understanding of how coordinated data practices enhance value creation within data ecosystems. While the research achieved its objective, it faced certain limitations. The primary limitation was the restricted number of respondents, which constrained the application of more advanced statistical techniques and limited the generability of the findings. Subsequent studies could address these limitations by incorporating larger sample sizes, exploring the applicability of data orchestration in diverse ecosystems, or employing advanced quantitative methodologies, such as PLS-SEM, to further validate and refine the construct. These efforts would offer deeper insights into the role of data orchestration in enhancing data value within ecosystems.

Acknowledgement

- **Funding or Grant:** Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq, Projects 406045/2021-6 and 310099/2022-6; and Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES. We thank the *Grupo de Pesquisas Judiciárias* of the Court of Justice of the State of Rio Grande do Sul for their operational support.
- **Contributor Statement**: Author 1: Conceptualisation, Methodology, Formal analysis, Writing-Original Draft. Author 2: Resources, Supervision. Author 3: Project administration.
- **Use of AI**: During the preparation of this work, the author(s) used Grammarly and ChatGPT in order to translate the manuscript from Portuguese to English. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Abraham, R., Schneider, J., & vom Brocke, J. (2019). Data governance: A conceptual framework, structured review, and research agenda. *International Journal of Information Management*, 49, 424-438. https://doi.org/10.1016/j.ijinfomgt.2019.07.010

Alexandre, N. M. C., & Coluci, M. Z. O. (2011). Validade de conteúdo nos processos de construção e adaptação de instrumentos de medidas. *Ciência & Saúde Coletiva*, *16*(7). https://doi.org/10.1590/S1413-81232011000800006

Autio, E. (2022). Orchestrating ecosystems: A multi-layered framework. *Innovation, 24*(1), 96–109. https://doi.org/10.1080/14479338.2021.1919120

Barreto, G. L., & Costa, V. R. M. (2020). O impacto das novas tecnologias na administração da justiça em breve perspectiva comparada e internacional: A experiência brasileira e europeia. *Revista CNJ, 6*(2). https://www.cnj.jus.br/ojs/revistacnj/article/view/400/228

Brazil. (1988). Constituição da República Federativa do Brasil de 1988. Retrieved from https://www.planalto.gov.br/ccivil_03/constituicao/constituicao.htm

Castro, G. P. V. (2022). Desafios do Poder Judiciário do futuro: comunicação criativa. *Revista Judicial Brasileira*, *2*, 135–163. https://doi.org/10.54795/RejuBespecial.InvJud.219

Chiang, Y., Zhang, Y., Luo, H., Chen, T.-Y., Chen, G.-H., Chen, H.-T., Wang, Y.-J., Wei, H.-Y., & Chou, C.-T. (2023). Management and Orchestration of Edge Computing for IoT: A Comprehensive Survey. *IEEE Internet of Things Journal*, 1–1. https://doi.org/10.1109/JIOT.2023.3245611

Conselho Nacional de Justiça (CNJ). (2009). Resolução Nº 76 de 12 de maio de 2009. *Dispõe sobre os princípios do Sistema de Estatística do Poder Judiciário, estabelece seus indicadores, fixa prazos, determina penalidades e dá outras providências*. Disponível em https://atos.cnj.jus.br/atos/detalhar/atos-normativos?documento=110

Conselho Nacional de Justiça (CNJ). (2020). Resolução Nº 333 de 21 de setembro de 2020. *Determina a inclusão de campo/espaço denominado Estatística na página principal dos sítios eletrônicos dos órgãos do Poder Judiciário.* Disponível em https://atos.cnj.jus.br/atos/detalhar/3488

Conselho Nacional de Justiça (CNJ). (2022a). *Relatório de diagnóstico dos tribunais nas atividades de saneamento de dados do Datajud*. https://bibliotecadigital.cnj.jus.br/jspui/bitstream/123456789/546/1/pnud-relatorio-v2-2022-06-14.pdf

Conselho Nacional de Justiça (CNJ). (2022b). *Relatório final Gestão Ministro Luiz Fux - Programa Justiça 4.0*. https://www.cnj.jus.br/wp-content/uploads/2022/09/af-pnud-relatorio-v3-web.pdf

Conselho Nacional de Justiça (CNJ). (2023a). *Relatório de entregas do Programa Justiça 4.0 - Gestão da ministra Rosa Weber*. https://www.cnj.jus.br/wp-content/uploads/2023/09/relatorio-de-entregas-gestao-ministra-rosa-weber-26-9-23.pdf

Conselho Nacional de Justiça (CNJ). (2023b). *Acompanhamento Datajud*. https://acompanhamento-datajud.cloud.cnj.jus.br/acompanhamento_datajud/

Conselho Nacional de Justiça (CNJ). (s.n.). *Plataforma Codex*. Disponível em https://www.cnj.jus.br/sistemas/plataforma-codex/

Cronbach, L. J., & Meehl, P. E. (1955). Construct validity in psychological tests. *Psychological Bulletin, 52*(4), 281–302, https://doi.org/10.1037/h0040957.

Cui, M., & Han, Y. (2022). Resource orchestration in the ecosystem strategy for sustainability: A Chinese case study. *Sustainable Computing: Informatics and Systems, 36.* https://doi.org/10.1016/j.suscom.2022.100796

Curry, E., Metzger, A., Zillner, S., Pazzaglia, J.-C., & García Robles, A. (Eds.). (2021). *The Elements of Big Data Value*. Springer International Publishing. https://doi.org/10.1007/978-3-030-68176-0

Darlington, R. B., & Hayes, A. F. (2017). *Regression Analysis and Linear Models: Concepts, Applications, and Implementation*. New York: The Guilford Press.

Fredriksson, A., Hagberg, J. *From Strategy to Execution Bridging the Gap between Data Strategy and Data Governance*. Master's Thesis. Department of Technology Management and Economics. Division of Entrepreneurship and Strategy. Chalmers University of Technology, 2023. http://hdl.handle.net/20.500.12380/306275

Gao, Y., Yang, X., & Li, S. (2022). Government Supports, Digital Capability, and Organizational Resilience Capacity during COVID-19: The Moderation Role of Organizational Unlearning. *Sustainability*, 14(15), 9520. https://doi.org/10.3390/su14159520

Garg, S., Wang, S., & Ranjan, R. (2018). Orchestration Tools for Big Data. In S. Sakr & A. Zomaya (Eds.), *Encyclopedia of Big Data Technologies*. Springer. https://doi.org/10.1007/978-3-319-63962-8_43-1

Gelhaar, J.; Groß, T. & Otto, B. (2021) A Taxonomy for Data Ecosystems. *Proceedings of the 54th Hawaii International Conference on System Sciences*, 6113-3123. https://hdl.handle.net/10125/71359

Guggenberger, T. M., Altendeitering, M., & Otto, B. (2020). Challenges in the emergence of data ecosystems. *Proceedings of the Twenty-Third Pacific Asia Conference on Information Systems.* https://doi.org/10.17705/1CAIS.04310

Gupta, A., Panagiotopoulos, P. & Bowen, F. (2020) An orchestration approach to smart city data ecosystems. *Technological Forecasting and Social Change*, 153. https://doi.org/10.1016/j.techfore.2020.119929.

Gür, I., Spiekermann, M., Arbter, M., & Otto, B. (2021). Data Strategy Development: A Taxonomy for Data Strategy Tools and Methodologies in the Economy. *Wirtschaftsinformatik Proceedings*. https://aisel.aisnet.org/wi2021/YGeneralTrack/Track02/1

Hair Jr, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Thousand Oaks, CA: Sage Publications.

Hair, J.F., Risher, J.J., Sarstedt, M. and Ringle, C.M. (2019) When to use and how to report the results of PLS-SEM. *European Business Review*, 31(1), 2-24. https://doi.org/10.1108/EBR-11-2018-0203

Jolliffe, I. T. (2002). *Principal Component Analysis*. In *Springer Series in Statistics*. Springer-Verlag. https://doi.org/10.1007/b98835

Kim, H. E. & Cho, J. (2018). Data governance framework for big data implementation with NPS Case Analysis in Korea. *Journal of Business & Retail Management Research*, 12(3). https://doi.org/10.24052/JBRMR/V12IS03/ART-04

Lin, J., Lin, S., Benitez, J., Luo, X., & Ajamieh, A. (2023). How to build supply chain resilience: The role of fit mechanisms between digitally-driven business capability and supply chain governance. *Information & Management, 60*(2). https://doi.org/10.1016/j.im.2022.103747

Lis, D., Gelhaar, J., & Otto, B. (2023). Data Strategy and Policies: The Role of Data Governance in Data Ecosystems. In I. Caballero & M. Piattini (Eds.), *Data Governance,* 1–13. Springer. https://doi.org/10.1007/978-3-031-43773-1_2

Marr, B. (2021). *Data Strategy: How to Profit from a World of Big Data, Analytics and the Internet of Things* (2nd ed.). London: Kogan Page Ltd.

Mikalef, P., Krogstie, J., Pappas, I. O., & Giannakos, M. N. (2023). Information Governance in the Big Data Era: Aligning Organizational Capabilities. *Hawaii International Conference on System Sciences*. https://hdl.handle.net/10125/50504

Nikiforova, A., Lnenicka, M., Milić, P., Luterek, M., & Rodríguez Bolívar, M. P. (2024). From the evolution of public data ecosystems to the evolving horizons of the forward-looking intelligent public data ecosystem empowered by emerging technologies. In *International Conference on Electronic Government,* 402-418. https://link.springer.com/chapter/10.1007/978-3-031-70274-7_25

Oliveira, M. I. S.; Lóscio, B. F. (2019) Ecossistemas de Dados na Web: da teoria aos desafios. *Tópicos em Gerenciamento de Dados e Informações*, Outubro. https://sol.sbc.org.br/livros/index.php/sbc/catalog/download/62/273/515-1?inline=1

Otto, B. (2011). A morphology of the organisation of Data Governance. *ECIS 2011 Proceedings*, Paper 272, http://aisel.aisnet.org/ecis2011/272

Otto, B., Lis, D., Jürjens, J., Cirullies, J., Howar, F., Meister, S., Spiekermann, M., Pettenpohl, H., Möller, F., Rehof, J. & Opriel, S. (2019). Data Ecosystems. Conceptual Foundations, Constituents and Recommendations for Action. *Fraunhofer-Institut für Software- und Systemtechnik ISST*.

Pinsonneault, A., & Kraemer, K. (1993). Survey Research Methodology in Management Information Systems: An Assessment. *Journal of Management Information Systems*, 10(2), 75–105. https://doi.org/10.1080/07421222.1993.11518001

Queiroz, M., Coltman, T., Sharma, R., Tallon, P. P., & Reynolds, P. (2020). Aligning the IT portfolio with business strategy: Evidence for complementarity of corporate and business unit alignment. *Journal of Strategic Information Systems, 29*(1). https://doi.org/10.1016/j.jsis.2020.101623

Ranjan, R., Garg, S., Khoskbar, A., Solaiman, E., James, P., & Georgakopoulos, D. (2017). Orchestrating Big Data Analysis Workflows. *IEEE Cloud Computing*, *4*(4), 20–28. https://doi.org/10.1109/MCC.2017.55

Salerno, F. F., & Maçada, A. C. G. (2024a). The impact of data quality orchestration in data ecosystems: Quantitative evidence from the Brazilian Judiciary. *MCIS 2024 Proceedings*, *10*. https://aisel.aisnet.org/mcis2024/10

Salerno, F. F., & Maçada, A. C. G. (2024b). Opportunities Arising from Data Orchestration: A Case Study of the Educational Data Ecosystem of a Brazilian State. *Anais do XXVII Seminários em Administração – XXVII SemeAd 2024.* https://login.semead.com.br/27semead/anais/arquivos/204.pdf

Schreieck, M., Wiesche, M., & Krcmar, H. (2022). From Product Platform Ecosystem to Innovation Platform Ecosystem: An Institutional Perspective on the Governance of Ecosystem Transformations. *Journal of the Association for Information Systems, 23*(6), 1354–1385. https://doi.org/10.17705/1jais.00764

Sirmon, D. G., Hitt, M. A., Ireland, R. D., & Gilbert, B. A. (2007). Managing Firm Resources in Dynamic Environments to Create Value: Looking Inside the Black Box. *Academy of Management Review*, *32*(1), 273–292. https://doi.org/10.5465/AMR.2007.23466005

Sirmon, D. G., Hitt, M., Ireland, R. D. & Gilbert, B. A. (2011). Resource Orchestration to Create Competitive

Advantage: Breadth, Depth, and Life Cycle Effects. *Journal of Management*, 7(5), 1390-1412. https://ssrn.com/abstract=1994489

Solomonides, A. (2023). Research Data Governance, Roles, and Infrastructure. In R. L. Richesson, J. E. Andrews, & K. Fultz Hollis (Eds.), *Clinical Research Informatics* , 1–11. Springer. https://doi.org/10.1007/978-3-031-27173-1_11

Spencer, D. (2009). *Card Sorting: Designing Usable Categories*. Brooklyn, NY: Rosenfeld Media.

Tabachnick, B. G., & Fidell, L. S. (2019). *Using Multivariate Statistics* (7th ed.). Boston, MA: Pearson.

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*, 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Teece, D. J. (2020) Hand in Glove: Open Innovation and the Dynamic Capabilities Framework. *Journal of Software Maintenance and Evolution: Research and Practice*, 1, 233-253. http://dx.doi.org/10.1561/111.00000010

Vafaei-Zadeh, A., Ramayah, T., Hanifah, H., Kurnia, S. & Mahmud, I. (2020) Supply chain information integration and its impact on the operational performance of manufacturing firms in Malaysia. *Information & Management*, 57(8). https://doi.org/10.1016/j.im.2020.103386

Vayyavur, R. (2024). Effective Data Strategy for AI and Big Data Implementation: Insights from Industry Applications. *International Journal of Research*, *11*(9), 151–155. https://doi.org/10.5281/zenodo.13767694

Vivian, S. G. (2020). Transformação digital e o Poder Judiciário. *Revista de Direitos Fundamentais e Tributação – RDFT*, 123-145. https://doi.org/10.47319

Weber, P., Hiller, S., Kurrle, S., Werling, M. & Werth, D. (2024) Evolutionary Milestones in the Development of Data Ecosystems. *AMCIS 2024 Proceedings*. 4. https://aisel.aisnet.org/amcis2024/data_eco/data_eco/4

Xu, J. & Pero, E. P. (2023) A resource orchestration perspective of organizational big data analytics adoption: evidence from supply chain planning. *International Journal of Physical Distribution & Logistics Management*, 53(11), 71-97. https://www.emerald.com/insight/content/doi/10.1108/ijpdlm-04-2022-0118/full/html

Zhang, C., Han, Y., Wang, J., & Pero, J. (2022). Orchestrating big data analytics capability for sustainability: A study of air pollution management in China. *Information & Management, 59*(1). https://doi.org/10.1016/j.im.2021.103231

Unpacking Digital Public Infrastructures: Foundational Capabilities for Public-Interest Digital Value Creation.

Luca T. Bauer[a*], *Konrad* Degen[b], *Sofie* Schönborn[c], *Björn* Niehaves[d]

[a]Digital Public, University of Bremen, Bremen, Germany, bauerl@uni-bremen.de, 0009-0003-6140-9918

[b]Digital Service Engineering, Technical University of Berlin, Berlin, Germany, konrad.degen@campus.tu-berlin.de, 0009-0003-7515-1102.

[c]Department of Governance, Technical University of Munich, Munich, Germany, sofie.schoenborn@tum.de, 0009-0006-9806-9306.

[d]Digital Public, University of Bremen, Bremen, Germany, niehaves@uni-bremen.de, 0000-0002-2682-6009.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. Digital Public Infrastructures (DPIs) are an emerging concept for building foundational digital capabilities—such as digital identity, data sharing, and payments—designed and governed in the public interest to foster generative value creation. Although DPIs are increasingly promoted as instruments for enabling collaboration among governments, citizens, and organizations, the concept remains underdefined in both academic and policy discourse. This study addresses that gap by applying the Technology-Organization-Environment (TOE) framework and a grounded theory approach to analyze 143 academic and non-academic sources published between 2011 and 2024, including work from international organizations, think tanks, and philanthropic entities. We offer three primary contributions: First, we define DPIs as socio-technical systems with modular and layered architectures, governed through public-private collective action to support value creation and multi-actor interaction at scale. Second, we develop a conceptual framework structured around technological, organizational, and environmental dimensions. This framework identifies governance architecture and functional modularity, stakeholder orchestration, and public-private governance, as well as policy context and public rationale, as critical characteristics of emerging DPIs. Third, we position DPIs as an evolution of digital infrastructure and platform models, reoriented toward public interest objectives. We conclude with a call for interdisciplinary research to examine the design, implementation, and governance of DPIs across diverse regional contexts. Emphasizing their potential to deliver inclusive, interoperable, and scalable infrastructure capabilities, we argue that DPIs offer a promising foundation for addressing complex societal challenges.

Keywords. digital infrastructure, digital platforms, digital public infrastructure, digital public good, data ecosystems, public data spaces, government as a platform, platform regulation
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1065

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1. Introduction

The swift digital transformation of governments, economies, and societies has underscored digital public infrastructure (DPI) as essential for value creation and social advancement (Mergel et al., 2019; Yoo et al., 2024). In September 2024, the UN's Global Digital Compact committed to strengthening DPI to close digital divides and accelerate progress on the Sustainable Development Goals (United Nations, 2024), a pledge echoed under India's G20 Presidency (UN Development Programme, 2023a). The G20 agree that DPIs facilitate seamless ecosystem interactions among governments, citizens, and private organizations, addressing societal challenges while promoting inclusivity (UN Development Programme, 2023b). In doing so, they play a foundational role in shaping the ongoing digital transformation in line with a public interest paradigm, aiming to promote efficient value creation, improve citizen satisfaction, and promote decentralization (Henfridsson and Bygstad, 2024; Mergel et al., 2019).

Existing research on digital infrastructures highlights their dynamic, open, and heterogeneous nature, which has increasingly intertwined with digital platforms, enabling interactions that extend beyond organizational boundaries (Constantinides et al., 2018; Tilson et al., 2010). Digital infrastructures are evolving into platforms, while large digital platforms simultaneously function as infrastructures, increasing their foundational role in driving innovation and facilitating collaboration (Bygstad and Hanseth, 2018; Plantin et al., 2018). However, much of this research focuses on private digital platforms, which, in cases like hybrid conglomerate platforms such as Apple, Amazon, or Microsoft, have increasingly transitioned into quasi-public infrastructures due to their societal relevance (Degen and Gleiss, 2025; Gleiss et al., 2023). This shift has sparked debate around emerging regulatory issues leading to calls for digital sovereignty, inclusivity, and accountability of these private actors (Heimburg and Wiesche, 2023; von Scherenberg et al., 2024; Yoo et al., 2024). The emerging discourse on DPIs redefines these foundational digital infrastructures in the context of data sharing, digital identity, and payment by embedding public values such as transparency, interoperability, and accountability in their design and governance (Möller et al., 2024; UN Development Programme, 2023b).DPIs also leverage government-built digital assets and public data ecosystems, now open to third-party collaboration to deepen public-private impact and foundational relevance(Degen and Teubner, 2024; Degen et al., 2025).

Against this background, we conduct a literature review in Information Systems and Public Management, complemented by a grounded theory analysis, to develop a more systematic understanding of the emerging DPI concept. In doing so, we collected and analyzed through inductive coding more than 143 publications from scholars, think tanks, international organizations, and philanthropic entities addressing DPIs within the timeframe 2011 to 2024. We conceptualize DPIs as a socio-technical system with a modular and layered architecture, initiated and governed by public and private stakeholders through collective action. They serve as a shared foundation for value creation with large-scale societal impact, enabling interactions of multiple actors in the digital realm while advancing the public interest. Our research aims to contribute to the emerging field of DPIs by addressing the research gap in its conceptualization. Using the TOE framework as a theoretical lens, we explore the challenges DPIs face in generating impact (Tidd, 2001). Specifically, we examine the technological, organizational, and environmental dimensions that shape the "*DPI black-box*" and influence the design, governance and adoption. The central research question guiding our study is twofold:

How can digital public infrastructures (DPIs) be conceptualized and what technological, organizational, and environmental challenges shape their implementation and governance?

The remainder of the paper is organized as follows: Section 2 outlines the conceptual and theoretical background. Section 3 details research design, data collection and methodology. Section 4 presents the results and introduces the DPI framework. Section 5 offers a discussion and reflection on the findings. Finally, Section 6 concludes and provides an outlook for future research along the limitations of this study.

2. Conceptual and Theoretical Background

2.1. Digital Infrastructures and Platforms

IS research has conceptualized digital infrastructures as "*shared, unbounded, heterogeneous, open, and evolving socio-technical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities*" (Hanseth and Lyytinen, 2004, p.4). These infrastructures are inherently

layered and complex, evolving through generative mechanisms such as adoption (through actor engagement), innovation (through new functionalities), and scaling (through stakeholder integration) (Hanseth and Monteiro, 1997; Henfridsson and Bygstad, 2013). Digital infrastructures can be broadly categorized into "heavyweight" systems, such as the internet or cloud computing, and "lightweight" systems, including smartphones and wearables (Bygstad, 2017). These infrastructures provide essential computing power and foundational services, thereby enabling digital innovation (Bygstad, 2017; Yoo et al., 2010). Their nature means they often become noticeable only during disruptions (Star and Ruhleder, 1996; Tilson et al., 2010).

In recent years, digital infrastructures have increasingly opened to third parties beyond organizational boundaries, undergoing a process that can be termed "*platformization*" (Bygstad and Hanseth, 2018). Simultaneously, private digital platforms built on these infrastructures have transformed governments, economies, and societies (Constantinides et al., 2018). Platforms employ modular architectures, with owners establishing value-creation mechanisms that shape interactions among ecosystem actors(Baldwin and Woodard, 2009; de Reuver et al., 2018; Hein et al., 2020). Prominent platforms, such as Apple, Microsoft, Alphabet, Amazon, and Meta, have undergone a process of "*infrastructurization*" (Plantin et al., 2018), evolving into de facto digital infrastructures that support conglomerate ecosystems through centralized governance structures (Degen and Gleiss, 2025). These entities now offer foundational services, including cloud computing, interaction channels (e.g., smartphone and messaging platforms), and matchmaking capabilities (e.g., app stores and marketplaces), thus shaping societal norms, values, and value-creation mechanisms (Gleiss et al., 2023). Despite their value proposition, these platforms face increasing criticism due to growing dependence on their services and governance challenges (Heimburg and Wiesche, 2023; Henfridsson and Bygstad, 2024).

Public discourse highlights a demand for greater "*digital sovereignty*" among citizens, organizations, and policy makers, focusing on resource control, fairness in value creation and distribution, and addressing power asymmetries (Pohle and Thiel, 2020; von Scherenberg et al., 2024). Moreover, it underscores the growing desire for increased public oversight and government involvement in shaping digital infrastructure platforms to better align with public interests (Degen and Gleiss, 2025; Gleiss et al., 2023). Repeatedly, the importance of developing scalable public-sector-led alternatives to address the shortcomings of current digital realities are highlighted (Zuckerman, 2020). These efforts represent a form of public innovation, often initiated and guided by governments in collaboration with private and civic actors (Klievink et al., 2016). The goal is to tackle complex societal challenges, such as digital inclusion and equitable access, while providing foundational infrastructural capabilities that enable value creation and drive societal progress (Zuckerman, 2020).

2.2. Public Innovation and Public Interest

Public sector-driven innovation has become a focus of academic and policy debates (Mazzucato, 2011; Panagiotopoulos et al., 2019). This interest is particularly notable in the context of public-private cooperation and partnerships, which are recognized as key drivers of innovation aimed at creating public value (Shiva et al., 2024). Building on foundational frameworks such as Moore's Public Value Theory (Moore, 1997), the concept of public value encompasses three main dimensions: accountability, service quality, and citizen engagement (Hartley et al., 2017). While these principles are widely endorsed, their application within highly collaborative and regulated environments, such as platforms and digital infrastructures, remains limited (Gleiß et al., 2023; Hermes et al., 2022). Despite challenges, DPI policy discourse strongly emphasizes three core promises of public innovation: solving complex societal challenges, enhancing service delivery through digital transformation, and increasing transparency and inclusivity Mergel et al., 2019; Panagiotopoulos et al., 2019. Public innovation is an undirected form of innovation that seeks to address systemic issues, such as climate change and digital exclusion, through collaborative efforts and technological advancements (Kankanhalli et al., 2017).

Public innovation is built upon three core components: technology, organizational processes, and citizen cocreation (Hartley et al., 2017; Moore, 1997). Together, these elements form the foundation for generating public value across economic, social, and political measures. Economic value includes cost savings, efficiency gains, and economic growth driven by public-private collaboration. Social value emphasizes enhanced equity, inclusivity, and access to essential services. Political value strengthens trust, transparency, and democratic participation. As such public technology innovation has to face harsh public evaluation. A critical aspect for selling public innovation investments to stakeholders is the feedback loop between innovation and value creation (Scott et al., 2016). Innovations drive public value, which, in turn, fosters support for further innovation. However, there are relatively few successful examples of public innovation that have not been at least partially privately sponsored. A trade-off becomes visible: while private actors are often necessary for achieving

economies of scale and delivering high-quality services, they require adequate returns on investment, creating potential tensions in balancing public and private interests.

Public innovation policy faces additional challenges, including balancing citizen demands to ensure that innovations meet the needs of diverse populations while maintaining political neutrality (Edler et al., 2023). It must also navigate preexisting legal complexities, addressing national and international regulatory frameworks, including data protection, trade agreements, and intellectual property regimes. Furthermore, creating incentives for public-private partnerships is essential to encourage private sector participation without compromising public accountability and equity. To overcome these challenges, public innovation must adopt a collaborative and multi-stakeholder approach (Hodge and Greve, 2007). Governments must create enabling environments that balance the at times competing demands of citizens, private partners, and regulatory frameworks. By fostering public-private partnerships and leveraging co-creation processes, public innovation can fulfill its potential to deliver meaningful and sustainable public value (Zuiderwijk and Janssen, 2014). In this a cornerstone are shared visions and transparency often only delivered by neutral third parties.

2.3. Digital Public Infrastructure and Digital Public Goods

DPI is a highly recent phenomenon emerging in policy and public discourse only over the last five years (Hadavand et al., 2021; Zuckerman, 2020). Its development is closely linked to the concept of digital public goods, a relationship that has been explored in the historical emergence of these systems. However, the academic community often experiences a lag in addressing newly emerging topics (Rosa and Scheuermann, 2008). Consequently, literature on DPI remains sparse and both theoretical frameworks and empirical studies are highly diverse and unstructured. In general, DPI refers to foundational digital systems that enable governments, businesses, and individuals to interact within a digital ecosystem (UN Development Programme, 2023b). Examples include digital identity systems, interoperable payment platforms, and open data initiatives. These systems are designed to facilitate access to services, enhance economic participation, and improve governance. Digital public goods (DPGs) are characterized as digital assets and resources such as data that are universally accessible and serve the public good (UN Development Programme, 2023a). These include open-source software, open data, and algorithms that promote equitable access to digital services (Kankanhalli et al., 2017). The United Nations (UN) defines DPGs as systems that adhere to open standards and principles, ensuring inclusivity and transparency (UN Development Programme, 2023a). Throughout a pre-clustering of available sources, a degree of interchangeable use of the two terms in discourse has been identified, not represented in empiric research. Because of this, we approach the relationship between DPI and DPGs as symbiotic in accessible publications. DPI is portrayed as relying on DPGs to ensure scalability, interoperability, and openness. For instance, a digital identity system may leverage open-source technologies (DPGs) to ensure cost-effectiveness and adaptability (Degen and Teubner, 2024).

Tab. 1 – Literature Representation of Digital Public Infrastructure

Research Stream	Brief Summary	Example Case	Example References
data exchange	Data exchange layers (or platforms) enable the transfer of information between stakeholders, e.g. companies, citizens, government.	India Stack x-Road Euro Stack	Aca-IS-22 Aca-S-40
identity	Digital identity systems provide individuals and organizations with verifiable means of identification without the need for further third-parties.	Aadhaar Diia PhylSis	Aca-S-31 Aca-S-22
payment	Payment systems facilitate digital transactions between citizens, businesses, and governments.	Pix UPI m-Pesa	Aca-S-18 Aca-S-42
public goods	Digital public goods encompass open-source software, data sets, algorithms, and platforms that are universally accessible and meant to benefit society as a whole.	eSanjeevani D-CENT	Aca-S-8 Aca-S-36

To achieve an initial overview of how the academic community has approached the topic, this study conducted a systematic literature review oriented at vom Brocke et al., 2009. Using the search operators "*digital public infrastructure*" OR "*digital public good*", we queried all fields in Scopus, AISeL, and AoM, resulting in a total of 82 publications (45 from Scopus, 35 from AISeL, and 2 from AoM). The findings from this review provide a

foundational understanding of how DPIs and DPGs have been academically treated and clustered, see Table 1. Information is accessible under: https://tinyurl.com/bdf8wet6. Although policy interest is rising, academic literature still lacks theoretically grounded definitions, empirical studies, and theory-driven research on DPIs. Insights stem mainly from lighthouse projects in India, Brazil, Estonia, and Singapore (UN Development Programme, 2023b), offering practical lessons but limited theory and often conflating DPI with DPG. While digital infrastructures and public–private partnerships have been studied (Ceccagnoli et al., 2012), no research has explicitly conceptualized DPI as a distinct phenomenon.

2.4. Theoretical Lens: Technology Organization Environment Theory

The Technology-Organization-Environment (TOE) theory provides a theoretical framework to understand how organizations, especially under high degrees of uncertainty (Tidd, 2001), adopt and implement new technologies (Awa et al., 2017; Baker, 2012). The TOE framework examines the interplay of three key contexts — *technology*, *organization*, and *environment* — and can be applied to explicate decision-making processes, particularly in the context of digital (public) infrastructure and data exchange (de Reuver et al., 2024). Originally introduced by Tornatzky and Fleischer in 1990 Baker, 2012, the TOE framework has gained widespread application in analyzing technology adoption and innovation Awa et al., 2017. TOE is foremost used to analyze the interplay between technological advancements, organizational dynamics, and environmental factors (Tsou and Hsu, 2015). This is particularly relevant in highly cooperative and regulated contexts (Yang et al., 2021), making it an appropriate theoretical lens to explore the complexities of public-private partnership dynamics in DPIs (Naithani and Agrahari, 2023). DPI serves as a prominent example of a highly complex system involving multi-actor stakeholders. These stakeholders include traditional public-private partnerships and extend to public-private-civic collaborations (Amard et al., 2024). For instance, the role of nongovernmental contributors, such as open source software (OSS) communities, is increasingly visible in the debate (Malgonde et al., 2023), alongside ongoing coordination challenges between BigTech entities and governmental institutions.

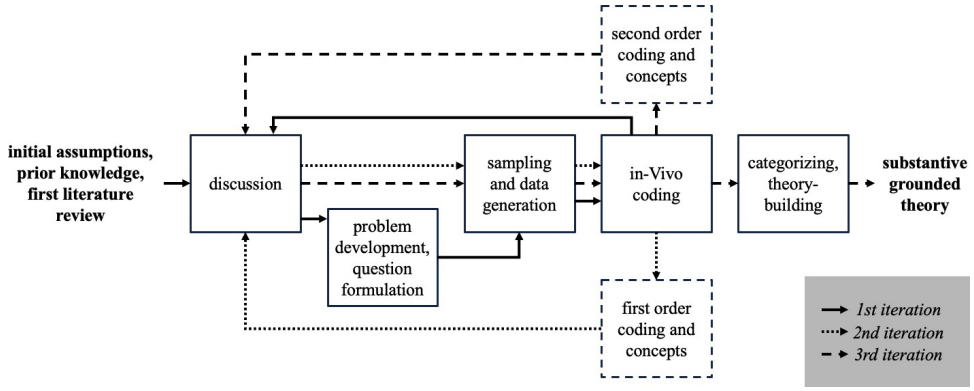
Within the TOE framework, DPI can be analyzed through three distinct lenses (Awa et al., 2017; Baker, 2012):

1. *Technological Foundations*: The technological characteristics of DPI, such as interoperability, scalability, openness, and cost-effectiveness, significantly influence its adoption and implementation. Examples include general digital platform foundations, digital identity systems, and payment gateways.
2. *Organizational Implementation and Management*: Governments, BigTech companies, non-profits, interest groups, and citizens all act as organizational actors with their own agendas, with distinct roles and interests.
3. *Environmental Influence in Cooperation, Legislation, and Regulation*: The broader environment, which includes collaboration, regulation, and competition, exerts a significant influence on DPI. Regulatory factors such as standards, modularity, law, and transnational regulation play a role in the formation of DPIs.

3. Data and Methods

3.1. Grounded Theory

Fig. 1 – Grounded Theory Research Process



DPI has gained significant attention, especially since India's G20 presidency (G20 India, 2023). Despite increased interest, definitions and theoretical work remain limited. To enable deeper analysis (Gregor, 2006), we used a grounded theory research design (Grover and Lyytinen, 2015; Wiesche et al., 2017), suitable for developing insights where theoretical foundations are weak (Corbin and Strauss, 1990). DPI's governance, mission, and scope implications make it ideal for grounded theory analysis (Birks et al., 2013; Urquhart et al., 2010). To reduce bias and reflect structural discourse, we examined academic work from management, law, and information systems, along with think tank reports and international organization publications. Our method involved iterative coding and constant comparison to identify key themes. By analyzing diverse materials, we aim to clarify DPI's conceptual and practical implications. This helps explain its multi-actor character and supports a structured understanding of DPI's role in governance and society. Figure 1 illustrates our process: team discussions, sampling, and data generation through in-Vivo coding repeated over three cycles.

3.2. Data Collection

Using the terms "digital public infrastructure" OR "digital public good", we retrieved 82 academic publications (2011–2024). Additionally, 61 non-academic sources—briefs, papers, blogs, reports, and practice research—were identified, with the earliest from 2020 (see Table 2). Non-academic searches focused on "digital public infrastructure" across the top 15 think tanks from the 2020 Global Go-To Think Tank Index (McGann, 2020) and top 10 from the 2024 Academic Influence rankings. Given DPI's emerging and policy-focused nature, including leading think tanks ensured timely, practice-driven insights that often precede academic theorization. A forward and backward citation analysis added relevant sources. All materials were open-access, English, and treated without quality differentiation. Data analysis involved in-Vivo coding to extract first-order concepts, which were iteratively grouped into broader categories. Second-order coding refined these categories into a grounded theory, supported by repeated review and abstraction cycles to ensure empirical depth and explanatory value. The TOE framework was applied following Gregory et al., 2018. Three researchers systematically reviewed all sources and conducted in-Vivo coding, see Figure 1.

Tab. 2 – Sources Used for Theory Development

Type	Outlets	n
academic article	SCOPUS, AoM, AISeL	82
blog	New America Foundation, Gates Foundation, Atlantic Council, Carnegie Endowment on International Peace, AI Now Institute, World Economic Forum, Council on Foreign Relations (CFR),	
brief	Atlantic Council, Open Knowledge Foundation, Konrad Adenauer Foundation, Fundação Getúlio Vargas (FGV)	7
paper	Brookings Institution, Carnegie Endowment on International Peace, Open Future, Chatham House (Royal Institute of International Affairs), Brookings Institution	7
report	Konrad Adenauer Foundation, Milken Institute, Center for Strategic and International Studies (CSIS), Project Liberty	6
commentary	Carnegie Endowment on International Peace, Chatham House (Royal Institute of International Affairs), Institut Montaigne	3
other	European Partnership for Democracy, Gates Foundation, Center for International Governance Innovation	6
Total		**143**

Data analysis involved in-Vivo coding to derive first-order concepts directly from the data, which were then iteratively categorized and abstracted into broader patterns and relationships. Through second-order coding, the team refined these relationships to develop a substantive grounded theory. The iterative nature of the process, highlighted by repeated cycles of data re-engagement, coding refinement, and theory abstraction, ensure that the resulting theory is both explanatory and empirically rooted.

4. Results

Employing the TOE framework (Baker, 2012), this research structures inductive findings around the technical, organizational and environmental context, proposing a comprehensive DPI framework. Additionally, to advance the conceptualization of DPIs, our study examines the challenges facing them in generating impact.

4.1. Technological Context: Governance Architecture and Functional Modularity

Tab. 3 – Example Sources DPI Technology Context

Context	Dimension	Practice Reference	Academic Reference
Technology	Governance Architecture	Pra-B-15, Pra-BA-4	Aca-S-1, Aca-S-5
	Functional Modularity	Pra-A-2, Pra-B-12	Aca-S-14, Aca-S-42

DPIs technological context can be understood through two key dimensions: the design of the governance architecture and the functional modularity of the DPI (Henfridsson and Bygstad, 2013). The design of the governance architecture describes the chosen technological innovation approach and the configuration of the infrastructure, which determines how centralized or distributed the DPI components and interfaces are. Functional Modularity refers to the feature set of the DPI system, which can be categorized into two key components: core infrastructure and enabling applications. Table 3 provides an overview of the technological context of DPIs, distinguishing the key aspects of governance architecture and functional modularity.

The technological innovation approach focuses on the trade-off between building upon legacy infrastructures and platforms, which often have established user bases, or developing entirely new infrastructure systems from scratch (Ozalp et al., 2018). Leveraging legacy systems enables the incremental enhancement of existing infrastructures by building upon established operational knowledge and the current user base. This approach facilitates the integration of new innovations, seamlessly embedding them into the core of the digital infrastructure to modernize it, a process that can be defined as DPI evolution. Conversely, developing an entirely new approach may replace existing offerings and components, potentially generating additional value, increasing efficiency, and reducing complexity through replacements. However, this approach necessitates building and operating the infrastructure from the ground up, a process referred to as DPI invention. For instance, the EUDI Wallet exemplifies a DPI that builds upon existing national EU electronic identification (eID) schemes (Degen and Teubner, 2024). It enhances functionality by introducing a new interface that broadens access for citizens and integrates multiple public and private identity data providers. This approach creates a robust identity data ecosystem through collaboration between public and private organizations, extending the scope and reach of existing digital identity infrastructures. In contrast, India's Aadhaar system represents a DPI developed entirely from scratch. It was designed to address the unique challenges of providing foundational digital identity verification to a diverse and large population (Desai and Manoharan, 2024).

The infrastructure configuration of DPIs impacts its technical architecture and governance. Centralized DPIs consolidate control under a single authority, enabling streamlined decision-making, standardization, and technical and organizational enforcement. This model is ideal for scenarios requiring regulatory oversight or uniformity. However, it introduces risks such as single points of failure, limited adaptability to diverse contexts, and heightened concerns around data privacy, surveillance, and abuse. Decentralized DPIs distribute control across multiple systems and organizations, promoting resilience, inclusivity, and local autonomy(Henfridsson and Bygstad, 2024). This approach distributes control through modularity, reducing risks such as single points of failure and limited adaptability through more flexibility. However, it requires robust frameworks for interoperability, resource allocation, and conflict resolution, which add to system complexity and can increase operational costs. DLT or Blockchain-based digital infrastructures, like Bitcoin, highlight the struggle to develop and govern decentralized infrastructures (De Filippi and Loveluck, 2016). Therefore, the choice between centralized and decentralized configurations is context-dependent, with hybrid models frequently combining both approaches to address diverse needs to achieve scalability, reliability, and inclusivity.

The functional modularity of DPIs can be differentiated into core infrastructure components and enabling application components, emphasizing the modular and layered characteristics of DPIs. This structure facilitates the recombination of capabilities and the seamless integration of functional layers, collectively forming the DPI foundations that enable generative interactions.DPI core infrastructure components include data storage systems designed to store and reuse data resources from diverse sources, enabling seamless data exchange across interconnected systems and organizations. These components extend beyond traditional sectoral boundaries, encompassing domains such as healthcare, financial services, and education. The European Gaia-X initiative in the cloud segment and the Estonian X-Road data exchange infrastructure exemplify these characteristics (Lips et al., 2023). As the foundational layer of DPIs, data exchange infrastructures deliver essential capabilities for large-scale data processing, connectivity, and interoperability (Pra-A-1). Cloud computing is a pivotal element of this foundational layer, providing the computational resources required to facilitate scalable and efficient

data exchange via data exchange standards and infrastructures. This foundation supports the deployment of enabling applications, which build on the core infrastructure to extend its functionality and tailor the DPI to specific usage contexts.

Enabling applications to provide advanced functionalities by bridging foundational infrastructure capabilities with the specific needs of diverse actors. These applications include components such as digital identity components (e.g., Singpass in Singapore), digital payment systems (e.g., Pix in Brazil), and increasingly, AI infrastructure capabilities (e.g. AI Commons) that align with the evolving technological advancements prevalent in the private sector (Pra-A-1). Enabling applications to operate across both heavyweight and lightweight infrastructures, leveraging their computational capabilities to deliver dynamic value tailored to user interactions (Bygstad, 2017). From an infrastructure configuration perspective, enabling applications are typically more distributed and decentralized compared to core infrastructure components. While core infrastructures are optimized for scalability, efficiency, and uniformity, enabling applications to prioritize flexibility and adaptability, making them more suited to address diverse and context-specific requirements. This more decentralized nature of enabling applications reflects their role in fostering generative innovation and enhancing the utility of DPIs within a variety of operational contexts.

4.2. Organizational Context: Public-Private Partnerships and Stakeholder Orchestration

Tab. 4 – Example Sources DPI Organizational Context

Context	Dimension	Practice Reference	Academic Reference
Organization	Public-Private Partnership	Pra-B-22, Pra-BA-4	Aca-IS-22, Aca-S-40
	Stakeholder Orchestration	Pra-B-11, Pra-B-4	Aca-S-14, Aca-IS-3

The organizational context of DPIs plays an important role in their initiation, governance, and operational effectiveness. Two key dimensions within this context are the structure of public-private partnerships and the orchestration of diverse stakeholders. Table 4 provides an overview of the organizational context in the two dimensions of public-private partnership and stakeholder orchestration.Public-Private Partnerships (PPPs) are fundamental to the organizational contexts of DPIs, necessitating strong collaboration among governments, private sector organizations, and civic actors (Stiglitz and Wallsten, 1999). The successful initiation, scaling, and development of a DPI requires not only technical capabilities and organizational resources but also the widespread adoption of DPI offerings by various stakeholders. Engaging the actors who will utilize the DPI is essential for fostering adoption, as it enhances the generation of tangible impact and demonstrates the societal relevance of the DPI to all stakeholders involved. For analytical clarity, two primary PPP models can be identified, though in practice, various hybrid combinations often exist and evolve over time to meet the demands of different contexts and life-cycle phases of a DPI.

In the first model, publicly owned – privately utilized, the DPI is owned by public entities but utilized by private organizations to leverage essential services that address existing organizational needs and build a foundation for value creation. Examples include government-owned digital identity infrastructures or health data-sharing platforms. This approach aims to ensure public oversight and is typically government-initiated, with digital infrastructures opened to private and other actors for broader collaboration and societal benefit. In the second model, privately owned – publicly regulated, the DPI is developed and owned by private entities but operates under public regulation to ensure alignment with societal and governmental objectives. Examples include privately developed digital payment systems (VISA, Mastercard) mandated to comply with public interest regulations. This scenario balances private investment and operational efficiency with public accountability, and typically, these privately owned DPIs emerge and are later regulated to ensure that public interests are strengthened.

Effective orchestration of stakeholders is essential for ensuring that DPI initiatives are inclusive, transparent, and aligned with shared goals to achieve collective action (Addo, 2022). Stakeholder orchestration can be conceptualized through two primary approaches: In the first scenario, the government leads the development and governance of DPIs, setting strategic objectives, regulatory frameworks, and operational guidelines. This approach is particularly effective in scenarios requiring strong public oversight, such as the case of government-provided digital IDs. However, it may face challenges in fostering innovation and adaptability due to constraints to control and avoid risks. In the second scenario, private sector stakeholders initiate and drive the development of DPIs, often in response to market demands or technological advancements. Governments

typically engage in a regulatory capacity, ensuring that the DPI aligns with public interest goals. Bottom-up models are highly adaptable and innovation-driven, exemplified by the emergence of private digital platforms such as Apple or Amazon that provide essential services for digital interactions. However, they require robust regulatory mechanisms to address risks such as monopolization or exclusion (Degen and Gleiss, 2025).

4.3. Environmental Context: Policy Environment and Public Rationales

Tab. 5 – Example Sources DPI Environmental Context

Context	Dimension	Practice Reference	Academic Reference
Environment	Policy Context	Pra-A-3, Pra-B-10	Aca-S-22, Aca-IS-3
	Public Rationale	Pra-O-1, Pra-O-3	Aca-S-6, Aca-S-10

Two key dimensions influence DPI beyond their technical and organizational context. First, DPI is promoted and shaped by emerging national and international initiatives and policies. Beyond this, public and policy discourse, especially about characteristics and objectives, influence perception and expectations towards DPI. Table 5 provides an overview of these two key environmental dimensions.

Recent national and international DPI initiatives have emerged, often focusing on their role in digital development. Prominently, India's G20 presidency in 2023 elevated DPI to the global stage by advocating for the concept, and citing domestic examples like Aadhaar and the UPI as models (Desai and Manoharan, 2024). International organizations like World Bank and the UN also recently embrace DPI to address challenges in different domains. Furthermore, the Global Digital Compact - adopted by the UN General Assembly in 2024 - emphasizes the need for collaboration to establish standards and systems for DPI (UN Development Programme, 2023b). These efforts demonstrate how DPI emerges as a recognized concept on national and international policy stages, understood as a tool aligning with different national and international objectives. Policy objectives range from equitable access to digital offerings, empowerment of citizens and organizations to participate in the digital economy and society, to ensuring privacy and security for various stakeholders in the interaction with core digital services. For example, digital identity components within a DPI stack can facilitate secure processes like e-voting, enabling widespread digital participation while maintaining trust and security (Egodawele et al., 2024). In addition, open data and data exchange capabilities (e.g. European Data Space Initiative) within DPIs ensure that public data is accessible and usable by multiple actors. Additionally, DPI is leveraged by early-adopter countries to showcase their national digital competence and success. Nations such as Estonia (e.g. X-Road), India (e.g. IndiaStack), and Ukraine (e.g. Diaa app), are frequently cited as examples for DPI benefits that leverage their achievements not only to strengthen their global position but also as an integral part of their national identity (Aurazo and Gasmi, 2024). For instance, Estonia proudly identifies itself as a "digital state," highlighting its pioneering role in the digital transformation arena (Lips et al., 2023). DPI solutions and components developed by national private sector players are actively promoted for export, showcasing a country's digital capabilities and fostering business opportunities abroad.

Objectives and rationales in policy and public discourse circle around themes of digital transformation, while also addressing concerns such as digital inclusion, privacy, security, and digital sovereignty (Zuckerman, 2020). DPIs are expected to provide a foundational framework that enables innovation, transformation, and value-creation across sectors. From a governmental perspective, DPIs contribute to modernizing public administrations not only internally but also in critical public service domains such as healthcare, education, and agriculture (Sandhu et al., 2023). By doing so, they can redefine and enhance digital interactions with citizens and organizations, creating more accessible, efficient, and user-friendly transactions. For instance, the Indian Unified Payment Interface (UPI) reshapes digital payments by creating a real-time, interoperable, and cost-effective infrastructure (Desai and Manoharan, 2024). Moreover, DPIs provide digital infrastructures to tackle issues that the private sector either cannot address (e.g., a foundational digital identity) or does not sufficiently prioritize (e.g., financial inclusion). This underscores the importance of offering public alternatives to enhance choice and sovereignty, reduce dependency on private-sector solutions, or motivate private actors to align more closely with public interests, such as fostering transparency and accountability.

Moreover, DPIs play an important role in empowering actors and strengthening digital sovereignty by ensuring equitable access, safeguarding rights, and promoting openness and alternatives. First, DPIs can enable access to essential services and foster civic participation by removing barriers to engagement through their legal and governance frameworks that support foundational offerings (Pra-B-15). By offering foundational

capabilities such as digital identity and secure data exchange, DPIs can enable access for all individuals, regardless of socioeconomic status, to vital services such as healthcare, education, and financial systems (e.g. Huduma Namba digital identity infrastructure in Kenya). Second, DPIs can contribute to the protection of digital rights and security. By embedding principles such as data privacy, transparency, and accountability into their design, DPIs can provide a secure ecosystem for digital interactions of multiple actors. Third, DPIs - depending on their design - offer open, publicly governed alternatives to privately initiated digital infrastructures and platforms. These alternatives reduce dependency on private platform infrastructure offerings, enabling nations to retain control and power over critical digital infrastructure capabilities (Pohle and Thiel, 2020). Finally, it may be argued that by promoting openness and interoperability, DPIs create an ecosystem that encourages competition and innovation. For example, India's Aadhaar system, integrated with other DPI layers like UPI, exemplifies how public digital infrastructure can foster self-reliance and sovereignty while simultaneously enabling private sector innovation (Desai and Manoharan, 2024). This innovation delivers value to citizens and drives a more inclusive economic growth, benefiting society as a whole.

Fig. 2 – Digital Public Infrastructure Framework

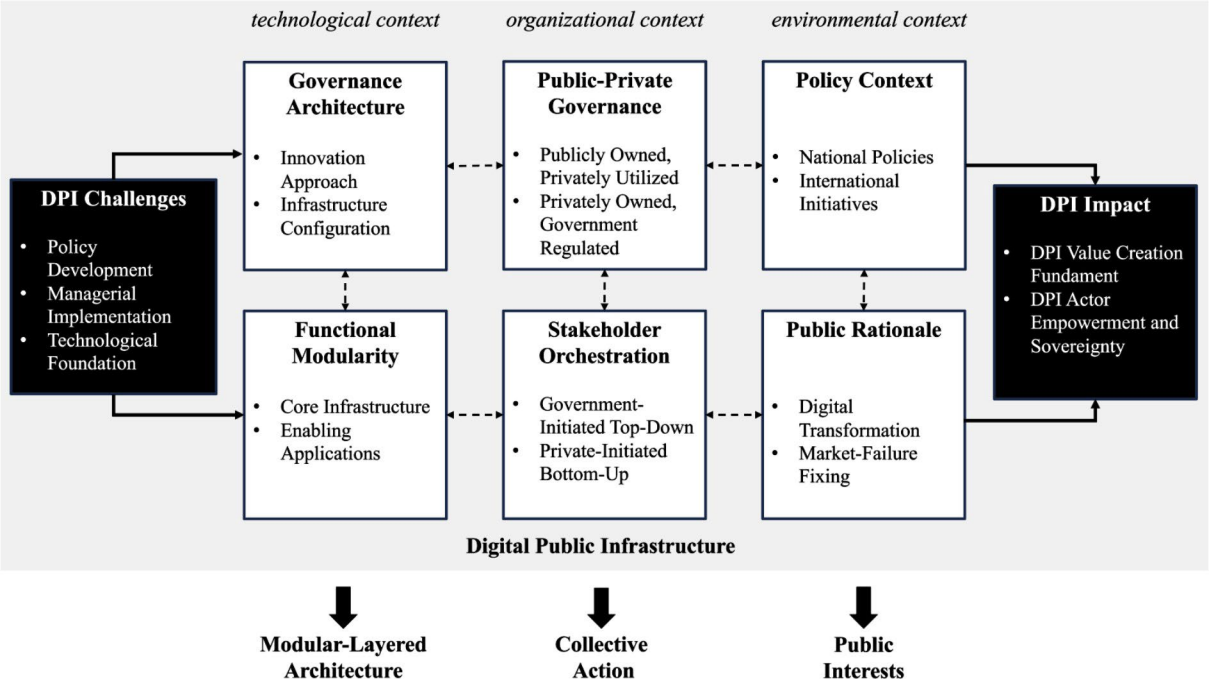


Figure 2 presents our DPI framework, highlighting the key characteristics of DPIs from technological, organizational, and environmental perspectives, and summarizes challenges faced in generating meaningful impact.

5. Discussion

DPI represents an emerging concept advocated especially by governments, international organizations, and philanthropic entities to reimagine the foundational digital frameworks that underpin public and private value creation (Panagiotopoulos et al., 2019; Zuckerman, 2020). DPI aims to facilitate seamless interactions among governments, citizens, and organizations, driving the evolution of digital infrastructures (UN Development Programme, 2023b). To function effectively as a socio-technical system with modular, layered architecture, DPIs must be governed through public–private collective action that embeds public-interest principles into their design and operation. Key imperatives include openness, interoperability, accountability, and inclusive access to ensure value creation and scalable multi-actor engagement in the public interest (Mensah, 2024).

From a technical perspective, standardization and interoperability represent challenges in establishing the foundational infrastructure required for the public-private, modular, and layered nature of DPIs. Given global discourse and necessity for interoperability across countries, achieving global standardization becomes a prerequisite for DPIs. While research on standardization, collaboration, and adoption of infrastructure standards is well-established in fields like information systems (Hanseth and Monteiro, 1997; Tilson et al., 2010), the

scale and global context of DPIs demand an extension of this knowledge. For example, there is a need to investigate processes and challenges associated with DPI standardization, as well as collaboration dynamics among diverse stakeholders.DPIs may necessitate the development of entirely new standards, which highlights the importance of research focused on the barriers to adopting such standards, strategies for overcoming these obstacles, and the role of international organizations and institutions in promoting standardization initiatives (such as the DPI Safeguards working group). Third, the politicization of standards—shaped by national interests, geopolitical tensions, and power dynamics—requires critical study to understand its impact on standard creation and diffusion(Blind, 2025). Technical standards and interoperability are essential in upholding the open and inclusive nature of DPIs, ensuring they remain accessible, adaptable, and capable of fostering value creation.

From a managerial perspective, aligning and orchestrating multiple actors and stakeholders present hurdles to developing, launching, and operating DPIs. Orchestration requires alignment of efforts among governments, private sector, and civil society to establish shared objectives and pool resources efficiently (Hermes et al., 2022) Furthermore, DPIs are not static; they evolve through dynamic processes and generative, reinforcing mechanisms driven by interaction with the using actors (Constantinides et al., 2018; Henfridsson and Bygstad, 2013). Consequently, orchestration emerges as a central managerial capability for DPIs. A critical area for further exploration is how to balance inherent tensions in DPI governance and management. These include reconciling control with fostering innovation, ensuring security while promoting actor acceptance, and aligning public interests with private value creation (Degen and Teubner, 2024; Panagiotopoulos et al., 2019). Furthermore, developing DPIs demands significant upfront investment, but their adoption and generative evolution can create opportunities for reinvestment as utilization increases (Constantinides et al., 2018; Scott et al., 2016). However, identifying sustainable financing models remains a challenge. Hybrid investment strategies that leverage existing components, promote reuse, and foster shared open-source development offer a promising pathway to reduce the financial burden on individual actors through collaborative efforts. Research should focus on identifying frameworks and strategies to effectively navigate these tensions and challenges.

From a policy perspective, our results highlight the need to consider the evolving context surrounding the technical and organizational embedding of DPIs, whose development, implementation, and governance are co-shaped by expectations and discourse around them. Consequently, multilateral cooperation is indispensable for aligning initiatives across regions and sectors. International organizations, e.g. the UN Development Programme (UN Development Programme, 2025), and agreements, e.g. UN Global Digital Compact (United Nations, 2025), play a key role in facilitating dialogue, establishing shared norms, and fostering collaboration among governments, public, private and civic stakeholders, and academia. Achieving harmonization requires striking a balance between concerns over privacy, security, and sovereignty with needs for collective action. However, a "one-size-fits-all" approach to DPIs is likely impractical due to the diverse contexts of their origins, designs, and applications. Given that DPIs transcend national boundaries, harmonizing policies and standards is crucial for ensuring interoperability and equitable access (UN Development Programme, 2023b). Divergent regulatory frameworks often lead to fragmented policy objectives and implementations, undermining the foundational character of these digital infrastructures. While high-level policy goals such as inclusiveness, openness, privacy, and security are widely endorsed, their practical operationalization and prioritization within specific contexts pose significant challenges. The policy context and public rationale for DPIs highlight their dual role: DPIs are envisioned to provide foundational infrastructure capabilities, such as identity, data exchange, and payments, to accelerate the digital transformation of governments, the private sector, and society. At the same time, they have to address diverse objectives, including value creation and digital inclusivity.

Furthermore, ongoing debates about DPIs reveal a shift from a passive regulatory role of governments in the digital realm and their increasingly active provision of digital infrastructures and services designed to reshape markets and actor interactions. The example of traditional infrastructures and networked industries demonstrates that, similar to emerging DPIs, governments have historically played a critical role in ensuring that essential infrastructure services are available to society (Finger and Montero, 2023; Hermes et al., 2022) Additional research should explore which emergent patterns might be identifiable to further conceptualize DPIs and help practitioners grasp this emerging concept. DPIs overlap with various emerging concepts in practice, such as GovTech (Bharosa, 2022), Government-/Countrystack (e.g. EuroStack), Government as a Platform (Cordella and Paletti, 2019), and calls for greater digital sovereignty (Couture and Toupin, 2019) through data spaces and data ecosystems (Möller et al., 2024) as well as the need to address existing digital divides (Vassilakopoulou and Hustad, 2023). This research set out to unpack the conceptual ambiguity surrounding DPIs by grounding the analysis in a structured socio-technical empirical perspective. Through the application of the

TOE framework, the study moves beyond the existing policy discourse to offer a deeper understanding of how technological design, organizational orchestration, and policy environments interact in shaping DPIs. In doing so, it offers a holistic view of DPIs as evolving digital infrastructures that deliver foundational capabilities through public-private collaboration aligned with the public interest.

6. Conclusion and Outlook

Digital public infrastructure (DPI) aims to reimagine foundational digital infrastructures with large-scale societal impact through public-private collaboration, guided by governance that integrates public interest principles—such as openness, interoperability, accountability, and inclusivity—while addressing technological, organizational, and environmental dimensions to ensure societal impact (UN Development Programme, 2023b). By systematically applying the TOE framework to examine the technological, organizational, and environmental dimensions of DPIs, we develop a DPI framework that offers conceptual clarity and a structured approach to understanding and advancing this emerging phenomenon (Awa et al., 2017; Baker, 2012). Positioned as socio-technical systems governed through collective action, DPIs hold the potential to deliver scalable, modular, and public interest-driven digital infrastructure capabilities. With foundational infrastructure components such as digital identity, data exchange, and digital payment systems, DPIs enable value creation and collaboration among diverse actors that aim to serve society.

Our findings show that DPIs encompass governance architecture and modular functionalities within the technological dimension, supported by public-private governance and effective stakeholder orchestration within the organizational dimension. In the environmental dimension, we sketched the motivations driving government engagement and the regulatory context surrounding DPIs. Key objectives include advancing the digital transformation of governments, economies, and societies, alongside addressing market failures that result in under-served groups (e.g., lack of digital inclusion) or power imbalances (e.g. between users and private digital infrastructure providers) caused by privately governed digital offerings. DPIs aim to empower interacting actors by enhancing access rights, safeguarding privacy, and strengthening sovereignty to serve more common public interests. To achieve this, standardization and interoperability are important factors in the technological dimension, while orchestration becomes the critical capability to initiate, adopt, and scale DPIs. In the environmental dimension, which encompasses regulations and policy goals, it is crucial to clearly define the boundaries of policy initiatives and regulatory scopes to avoid fragmentation and conceptual overlap with related terms like DPGs, GovTech, or data spaces and ecosystems. A well-defined DPI concept enhances the alignment and orchestration of relevant stakeholders, enabling the establishment of the capabilities required for DPIs to provide essential infrastructure capabilities to public, private, and civic actors.

Our study comes with limitations. First, the development of our DPI framework is based on the authors' analytical and coding capabilities, providing an initial conceptualization of DPIs within academic research. While this contribution advances both scholarly and practice-oriented discourse, it is subject to potential biases in the analysis. For instance, all authors reside and engage with DPI-related initiatives primarily in the Global North. This perspective enables deep insights but may inadvertently overlook environmental and contextual differences, as DPIs are particularly prominent in the Global South, where they operate under distinct socio-economic and political conditions. Second, while our grounded theory research design draws extensively from academic literature and publications by international organizations, think tanks, and philanthropic entities, it relies on secondary data often optimized to promote the concept of DPIs to a broad, international audience. To address this limitation, we plan a follow-up research project involving qualitative interviews with diverse experts recruited to represent public, private and civic stakeholders. This approach will enable us to extend upon our insights into DPIs, uncovering differences and commonalities across geographical, socio-economic, and political contexts, while addressing the limitations of our study.

DPIs are a timely and emerging concept that seeks to address multiple societal transformations and current challenges. Our study underscores that DPIs are highly context-specific, and a "*one-size-fits-all*" approach is not possible. These large-scale digital infrastructures not only shape societies but are also deeply influenced by them. We call for interdisciplinary research to examine DPIs across varied contexts and across implementation phases. Based on our academic literature review, we urge researchers and practitioners to view DPIs not as entirely novel phenomena but as an evolution of existing digital infrastructures and platforms. DPIs should be characterized as a progression toward more open, interoperable, and accountable foundational capabilities for public-interest value creation.

References

Addo, A. (2022). Orchestrating a digital platform ecosystem to address societal challenges: A robust action perspective. *Journal of information technology*, *37*(4), 359–386.

Amard, A., Hartwich, E., Höß, A., Rieger, A., Roth, T., & Fridgen, G. (2024). Designing digital identity infrastructure: A taxonomy of strategic governance choices. *Proceedings of the Annual Hawaii International Conference on System Sciences*.

Aurazo, J., & Gasmi, F. (2024). Digital payment systems in emerging economies: Lessons from kenya, india, brazil, and peru. *Information Economics and Policy*, *69*, 101113.

Awa, H. O., Ojiabo, O. U., & Orokor, L. E. (2017). Integrated technology-organization-environment (t-o-e) taxonomies for technology adoption. *Journal of Enterprise Information Management*, *30*, 893–921.

Baker, J. (2012). The technology–organization–environment framework. In S. S. Y. Dwivedi M. Wade (Ed.).

Baldwin, C. Y., & Woodard, C. J. (2009). *The architecture of platforms: A unified view*, Edward Elgar Publishing Limited.

Bharosa, N. (2022). The rise of govtech: Trojan horse or blessing in disguise? a research agenda. *Government Information Quarterly*, *39*(3), 101692.

Birks, D. F., Fernandez, W., Levina, N., & Nasirin, S. (2013). Grounded theory method in information systems research: Its nature, diversity and opportunities. *European Journal of Information Systems*, *22*, 1–8.

Blind, K. (2025). Standardization and standards: Safeguards of technological sovereignty? *Technological Forecasting and Social Change*, *210*, 123873.

Bygstad, B. (2017). Generative innovation: A comparison of lightweight and heavyweight it. *Journal of Information Technology*, *32*, 180–193.

Bygstad, B., & Hanseth, O. (2018). Transforming digital infrastructures through platformization. *Twenty-Sixth European Conference on Information Systems (ECIS2018)*, 1–13.

Ceccagnoli, Forman, Huang, & Wu. (2012). Cocreation of value in a platform ecosystem! the case of enterprise software. *MIS Quarterly*, *36*, 263.

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Introduction—platforms and infrastructures in the digital age. *Information Systems Research*, *29*, 381–400.

Corbin, J., & Strauss, A. (1990). Grounded theory research: Procedures, canons and evaluative criteria. *Zeitschrift für Soziologie*, *19*, 418–427.

Cordella, A., & Paletti, A. (2019). Government as a platform, orchestration, and public value creation: The italian case. *Government Information Quarterly*, *36*(4), 101409.

Couture, S., & Toupin, S. (2019). What does the notion of "sovereignty" mean when referring to the digital? *New media & society*, *21*(10), 2305–2322.

De Filippi, P., & Loveluck, B. (2016). The invisible politics of bitcoin: Governance crisis of a decentralized infrastructure. *Internet policy review*, *5*(4).

de Reuver, M., Ofe, H. A., Gasco-Hernandez, M., Rukanova, B., & Gil-Garcia, J. R. (2024). Data economy in a globalized world, opportunities and challenges for public and private organizations. *Electronic Markets*, *34*, 53.

de Reuver, M., Sørensen, C., & Basole, R. C. (2018). The digital platform: A research agenda. *Journal of Information Technology*, *33*, 124–135.

Degen, K., & Gleiss, A. (2025). Time to break up? the case for tailor-made digital platform regulation based on platform-governance standard types. *Electronic Markets*, *35*(1), 1–23.

Degen, K., Lutzens, R., Beschorner, P., & Lucke, U. (2025). Public education data at the crossroads of public and private value creation: Orchestration tensions and stakeholder visions in germany's emerging national digital education ecosystem. *Electronic Markets*, *35*(1), 19.

Degen, K., & Teubner, T. (2024). Wallet wars or digital public infrastructure? orchestrating a digital identity data ecosystem from a government perspective. *Electronic Markets*, *34*(1), 50.

Desai, A., & Manoharan, A. P. (2024). Digital transformation and public administration: The impacts of india's digital public infrastructure. *International Journal of Public Administration*, *47*, 575–578.

Edler, J., Blind, K., Kroll, H., & Schubert, T. (2023). Technology sovereignty as an emerging frame for innovation policy. defining rationales, ends and means. *Research Policy*, *52*, 104765.

Egodawele, M., Hovorka, D., & Boell, S. (2024). Embracing context: Reframing digital inequality.

Finger, M., & Montero, J. (2023). Digitalizing infrastructure, digital platforms and public services. *Competition and Regulation in Network Industries*, *24*(1), 40–53.

G20 India. (2023). Logo & theme [https://www.g20.in/en/g20-india-2023/logo-theme.html Accessed: 2023-12-10]. https://www.g20.in/en/g20-india-2023/logo-theme.html

Gleiß, A., Degen, K., Knoth, A., Pousttchi, K., & Lucke, U. (2023). Governance principles and regulatory needs for a national digital education platform. *Public Policy and Administration*, 09520767231202327.
Gleiss, A., Degen, K., & Pousttchi, K. (2023). Identifying the patterns: Towards a systematic approach to digital platform regulation. *Journal of Information Technology*, *38*, 180–201.
Gregor. (2006). The nature of theory in information systems. *MIS Quarterly*, *30*, 611.
Gregory, R. W., Kaganer, E., Henfridsson, O., & Ruch, T. J. (2018). It consumerization and the transformation of it governance. *MIS Quarterly*, *42*, 1225–1253.
Grover, V., & Lyytinen, K. (2015). New state of play in information systems research: The push to the edges. *MIS Quarterly*, *39*, 271–296.
Hadavand, A., Hamermesh, D., & Wilson, W. (2021, August). Publishing economics: How slow? why slow? is slow productive? fixing slow?
Hanseth, O., & Lyytinen, K. (2004). Theorizing about the design of information infrastructures: Design kernel theories and principles. *Sprouts: Working Papers on Information Environments, Systems and Organizations*, *4*, 207–241.
Hanseth, O., & Monteiro, E. (1997). Inscribing behaviour in information infrastructure standards. *Accounting, Management and Information Technologies*, *7*, 183–211.
Hartley, J., Alford, J., Knies, E., & Douglas, S. (2017). Towards an empirical research agenda for public value theory. *Public Management Review*, *19*, 670–685.
Heimburg, V., & Wiesche, M. (2023). Digital platform regulation: Opportunities for information systems research. *Internet Research*, *33*, 72–85.
Hein, A., Schreieck, M., Riasanow, T., Setzke, D. S., Wiesche, M., Böhm, M., & Krcmar, H. (2020). Digital platform ecosystems. *Electronic Markets*, *30*, 87–98.
Henfridsson, O., & Bygstad, B. (2013). The generative mechanisms of digital infrastructure evolution. *MIS Quarterly*, *37*, 907–931.
Henfridsson, O., & Bygstad, B. (2024). Time for a decentralization journey of digital infrastructures? reflections on the 2023 impact award. *Management Information Systems Quarterly*, *48*, ix–xiv.
Hermes, S., Schreieck, M., & Thatcher, J. (2022). Essential platform infrastructure and the need for regulation. *Hawaii International Conference on System Sciences 2022*.
Hodge, G. A., & Greve, C. (2007). Public–private partnerships: An international performance review. *Public Administration Review*, *67*, 545–558.
Kankanhalli, A., Zuiderwijk, A., & Tayi, G. K. (2017). Open innovation in the public sector: A research agenda.
Klievink, B., Bharosa, N., & Tan, Y.-H. (2016). The collaborative realization of public values and business goals: Governance and infrastructure of public–private information platforms. *Government information quarterly*, *33*(1), 67–79.
Lips, S., Tsap, V., Bharosa, N., Krimmer, R., Tammet, T., & Draheim, D. (2023). Management of national eid infrastructure as a state-critical asset and public-private partnership: Learning from the case of estonia. *Information Systems Frontiers*, *25*(6), 2439–2456.
Malgonde, O. S., Saldanha, T. J. V., & Mithas, S. (2023). Resilience in the open source software community: How pandemic and unemployment shocks influence contributions to others' and one's own projects. *MIS Quarterly*, *47*(1), 361–390.
Mazzucato, M. (2011). The entrepreneurial state. *Soundings*, *49*, 131–142.
McGann, J. G. (2020). *2020 global go to think tank index report* (tech. rep.). Think Tanks and Civil Societies Program, University of Pennsylvania. https://repository.upenn.edu/handle/20.500.14332/48577
Mensah, S. (2024). The role of public-sector-led inclusive instant payment systems for growing the digital payments industry in africa. *Journal of Payments Strategy & Systems*, *18*(3), 291–308.
Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. *Government information quarterly*, *36*(4), 101385.
Möller, F., Jussen, I., Springer, V., Gieß, A., Schweihoff, J. C., Gelhaar, J., Guggenberger, T., & Otto, B. (2024). Industrial data ecosystems and data spaces. *Electronic Markets*, *34*(1), 41.
Moore, M. H. (1997). *Creating public value: Strategic management in government*. Harvard university press.
Naithani, C., & Agrahari, A. (2023). Affordance actualization of digital public infrastructures. *GlobDev 2023*, (11). https://aisel.aisnet.org/globdev2023/11
Ozalp, H., Cennamo, C., & Gawer, A. (2018). Disruption in platform based ecosystems. *Journal of Management Studies*, *55*, 1203–1241.
Panagiotopoulos, P., Klievink, B., & Cordella, A. (2019). Public value creation in digital government. *Government Information Quarterly*, *36*, 101421.
Plantin, J.-C., Lagoze, C., Edwards, P. N., & Sandvig, C. (2018). Infrastructure studies meet platform studies in the age of google and facebook. *New Media & Society*, *20*, 293–310.

Pohle, J., & Thiel, T. (2020). Digital sovereignty. *Internet Policy Review*, *9*.
Rosa, H., & Scheuermann, W. E. (2008). *High speed society: Social acceleration, power and modernity* (1st ed., Vol. 1). Pennsylvania University Press.
Sandhu, K., Dayanandan, A., & Kuntluru, S. (2023). India's cbdc for digital public infrastructure. *Economics Letters*, *231*, 111302.
Scott, M., DeLone, W., & Golden, W. (2016). Measuring egovernment success: A public value approach. *European Journal of Information Systems*, *25*, 187–208.
Shiva, M., FitzGerald, C., Carter, E., & Airoldi, M. (2024). Beyond "make" or "buy": Evaluating value for money in public service delivery. *Annals of Public and Cooperative Economics*.
Star, S. L., & Ruhleder, K. (1996). Steps toward an ecology of infrastructure: Design and access for large information spaces. *Information Systems Research*, *7*, 111–134.
Stiglitz, J. E., & Wallsten, S. J. (1999). Public-private technology partnerships. *American Behavioral Scientist*, *43*, 52–73.
Tidd, J. (2001). Innovation management in context: Environment, organization and performance. *International Journal of Management Reviews*, *3*, 169–183.
Tilson, D., Lyytinen, K., & Sørensen, C. (2010). Digital infrastructures: The missing is research agenda. *Information Systems Research*, *21*, 748–759.
Tsou, H.-T., & Hsu, S. H.-Y. (2015). Performance effects of technology–organization–environment openness, service co-production, and digital-resource readiness: The case of the it industry. *International Journal of Information Management*, *35*, 1–14.
UN Development Programme. (2023a). Digital public goods for the sdgs [https://www.undp.org/publications/digital-public-goods-sdgs Accessed: 2023-12-10]. https : / / www . undp . org / publications / digital-public-goods-sdgs
UN Development Programme. (2023b). Digital public infrastructure [https://www.undp.org/digital/digital-public-infrastructure Accessed: 2023-12-10]. https : / / www . undp . org / digital / digital - public - infrastructure
UN Development Programme. (2025). Undp - united nations development programme [https://www.undp.org Accessed: 2025-01-15]. https://www.undp.org
United Nations. (2024). *Global digital compact* [Accessed: 2025-01-22]. https://www.un.org/global-digital-compact/sites/default/files/2024-09/Global%20Digital%20Compact%20-%20English_0.pdf
United Nations. (2025). Global digital compact - office of the secretary-general's envoy on technology [Accessed: 2025-01-15]. https://www.un.org/techenvoy/global-digital-compact
Urquhart, C., Lehmann, H., & Myers, M. D. (2010). Putting the 'theory' back into grounded theory: Guidelines for grounded theory studies in information systems. *Information Systems Journal*, *20*, 357–381.
Vassilakopoulou, P., & Hustad, E. (2023). Bridging digital divides: A literature review and research agenda for information systems research. *Information Systems Frontiers*, *25*(3), 955–969.
vom Brocke, J., Simons, A., Niehaves, B., & Cleven, A. (2009). Reconstructing the giant: On the importance of rigour in documenting the literature search process. *17th European Conference on Information Systems (ECIS)*.
von Scherenberg, F., Hellmeier, M., & Otto, B. (2024). Data sovereignty in information systems. *Electronic Markets*, *34*, 15.
Wiesche, M., Jurisch, M. C., Yetton, P. W., & Krcmar, H. (2017). Grounded theory methodology in information systems research. *MIS Quarterly*, *41*, 685–701.
Yang, J., Blount, Y., & Amrollahi, A. (2021). Factors that influence the adoption of artificial intelligence by auditing firms. *ICIS 2021 Proceedings*, (5).
Yoo, Y., Henfridsson, O., Kallinikos, J., Gregory, R., Burtch, G., Chatterjee, S., & Sarker, S. (2024). The next frontiers of digital innovation research. *Information Systems Research*, *35*(4), 1507–1523.
Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, *21*, 724–735.
Zuckerman, E. (2020). *What is digital public infrastructure?* (Report) (Available online at: https : / / static1 . squarespace . com / static / 5efcb64b1cf16e4c487b2f61 / t / 5fb41b6aac578321b0c50717 / 1605639019414/zuckerman-digital-infrastructure-cjl-nov2020.pdf, Accessed: January 7, 2025). The Center for Journalism and Liberty.
Zuiderwijk, A., & Janssen, M. (2014). Open data policies, their implementation and impact: A framework for comparison. *Government information quarterly*, *31*(1), 17–29.

Acknowledgement

- **Data/Software Access Statement**: Data supporting research results can be found under References, or per request to authors.
- **Contributor Statement**: Luca T. Bauer: Conceptualization, Methodology, Data analysis, Writing – Reviewing and Editing, Final approval; Konrad Degen: Conceptualization, Data analysis, Writing - Original draft, Final approval; Sofie Schönborn: Conceptualization, Data collection, Writing – Reviewing and Editing, Final approval; Björn Niehaves: Supervision, Final approval
- **Use of AI**: During the preparation of this work, the authors used ChatGPT and Grammarly in order to enhance style and readability. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

Track 20: Digital Government: Bachelor's and Master's Student Track

Track Description

This track aimed to provide Bachelor's and Master's students with a first-hand experience of how research works and to deepen their interest in academia. The idea was to attract original work and facilitate a constructive, developmental, double-blind peer-review process.

Track Chairs

H. Scholta, German University of Administrative Sciences, Germany
C.-P. Lee, National Taipei University, Taiwan
G. C. Wiedenhöft, Federal University of Rio Grande, Brazil

Contents

Driving Public Values through LinkedIn: Insights from the EU Digital & Tech Account 1269
L. Weller, S. Mahula, and J. Crompvoets

Lessons Learned for Local Cybersecurity: Practical Implications of a Public Sector Cyberattack for Small and Medium-Sized Municipalities 1283
J. M. Schmidt, S. Mahula, and J. Crompvoets

Practitioners' Perceptions on Human-Centered Design Techniques in Digital Government Development 1295
V. de O. G. Coutinho, C. Hazan, M. R. de A. Souza, and A. P. Freire

Virtual Visions: An Exploratory Comparative Analysis of EU and US Metaverse Governance Approaches 1310
S. Boucher-Robinson, S. Mahula, and J. Crompvoets

Driving Public Values through LinkedIn: Insights from the EU Digital & Tech Account

Lukas Weller [a*], *Stanislav* Mahula [b], *Joep* Crompvoets [c]

[a] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, lukas.weller@student.kuleuven.be, 0009-0002-4151-6620

[b] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, 0000-0003-0568-9604

[c] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, 0000-0003-1077-597X

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. As digital transformation progresses, platforms such as LinkedIn present unique opportunities for professional engagement in public governance and sustaining public values, yet their potential remains underexplored. This study analyses the communication practices of the EU Digital & Tech LinkedIn account – a channel for promoting Europe's digital transformation initiatives led by the European Commission. By analyzing 159 posts with their engagement metrics and user comments over a six-month period in 2024, we identified key patterns in content type, sentiment, and thematic focus. Informational posts dominate the account's feed, with an emphasis on topics such as artificial intelligence, cybersecurity, and data governance. These posts generate the highest interaction scores, reflecting LinkedIn's suitability for professional and policy-driven discussions and reinforcing the platform's value in generating thoughtful, substantive exchanges. LinkedIn is likely to promote public values such as transparency, inclusivity, and collaboration effectively when communication strategies prioritize detailed content and meaningful stakeholder interaction. However, the analysis also reveals missed opportunities for direct engagement, such as responding to user comments, posing open-ended questions, or leveraging other interactive features like polls or events, possibly allowing users to take on more active roles as prosumers. By embracing more participatory formats, public sector accounts could foster richer interaction and co-ownership of policy narratives. Ultimately, we underscore LinkedIn's underused potential as a dynamic platform for collaborative innovation in digital public governance, offering actionable insights into how communication strategies can strengthen trust, responsiveness, and legitimacy in the public sector.

Keywords. Public Sector Communication, Public Values, Transparency, Inclusivity, LinkedIn, Stakeholder Engagement, Social Media Strategy, Policy Communication, Professional Networking

Research paper, DOI: https://doi.org/10.59490/dgo.2025.996

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1 Introduction

Although the latest innovations like artificial intelligence (AI), blockchain, and big data become more advanced each day, their successful implementation depends on technological infrastructure, regulatory frameworks, and organizational readiness (F. Davis, 1989; Rogers, 1983; Tornatzky & Fleischer, 1990). Integrating and managing these novel tools into governmental processes and services has become an indispensable part of advancing digital public governance (DPG). Public sector's key stakeholders, i.e., citizens and businesses, may have various perceptions of digital transformation. While the private sector is often seen as more tech-savvy and fast-adopting modern tools, individual users sometimes require more intensive mentoring to ensure everyone participates. An important aspect of DPG's external perception is its communication with these stakeholders.

The tools and platforms used to explain or simply make these innovations public often determine whether they are adopted or rejected in everyday life. In recent years, much of the focus has been on the technologies themselves, but an increasingly overlooked factor is the medium through which their purpose and impact are expressed (Milakovich, 2021). This is where communication plays a vital role. While its core principles – such as e.g., information transmission and audience engagement – remain intact, the rise of Facebook and other social media platforms since the mid-2000s has altered the traditional gatekeeping role of journalists (Gilardi et al., 2022; Valenzuela et al., 2019). Communication has evolved into a complex web of digital interactions that span borders, disciplines, and sectors, mediated increasingly by platforms and algorithms rather than professional editors (Grewal et al., 2022).

Therefore, as AI systems become more integrated into DPG, as questions of digital sovereignty gain attention, and as citizens demand more transparency in government operations, how these messages are communicated determines their societal values (Chen et al., 2023; Mergel, 2012). Public trust in these processes is not only about the content of policies but also about how governments articulate their intentions, engage stakeholders, and invite dialogue through, e.g., events (Boulianne, 2019) or social media interaction (Wukich, 2021). This makes it a fundamental and well-suited solution for building trust and collaboration and driving informed decision-making.

Social media has played a key role in digital transformation. Platforms like Twitter and Facebook have long been recognized for their ability to connect governments with citizens in real-time by spreading information widely and quickly (Haro-de-Rosario et al., 2018). Numerous examples of how public organizations use social media to create public value include, e.g., early disaster warnings through Indonesia's Twitter Tsunami Early Warning Network (est. in 2012), citizen engagement via participatory budgeting in American city councils (2013), and coordinating emergency relief during Hurricane Sandy through real-time social media mapping (Criado et al., 2013; Muniz-Rodriguez et al., 2020). However, private platforms are often criticized for increasing interactions and reactive behaviors resulting in extended time spent on the platform (Haro-de-Rosario et al., 2018).

Moreover, the lack of algorithmic transparency – particularly regarding the use of personal data – raises concerns. In the context of political discourse, these issues have been linked to increased exposure to radicalized content, targeted political advertising, and the spread of misinformation and fake news (Lewandowsky & Siri, 2023; Zerres, 2024). Conversely, LinkedIn has a slightly different emphasis on a professional and focused alternative uniquely suited for deeper, more thoughtful engagements.

With its audience of professionals, academics, and decision-makers, LinkedIn claims to be less about viral trends and more about substantive discussions on policy, strategy, and innovation (Graziano et al., 2023; Mergel, 2012). While this does not entirely reflect present conditions, as LinkedIn, too, follows a basic social media strategy, stakeholders are interested in a more professional environment (Graziano et al., 2023; Mergel, 2012). For example, public organizations worldwide have already actively engaged on LinkedIn, including major bodies such as the United Nations (5.8 million followers), the U.S. Department of State (1.4 million), and the European Commission (2.2 million) (European Commission, 2025b; United Nations, 2025; U.S. DOS, 2025). The content shared by these organizations is generally strategic, emphasizing professional engagement, policy advocacy, and targeted stakeholder interactions within a network which has been built on trust (Macnamara & Zerfass, 2012; Rus et al., 2021). Moreover, user interactions on LinkedIn tend to reflect more targeted inquiries and specific attitudes towards these public institutions (J. Davis et al., 2020).

However, despite its potential, the use of LinkedIn as a communication tool for leveraging public values has received limited academic attention yet to be explored. Therefore, this paper adopts a case study approach and focuses on a particular LinkedIn account, examining its potential to contribute to advancing public values using quantitative and qualitative research methods. Specifically, it investigates the communication strategies of the EU Digital & Tech account (EUDT), a key channel for promoting Europe's digital transformation initiatives. Though substantially smaller in following (51,000) than the parent account, the EUDT is used to share critical updates on topics such as AI governance, data privacy, and cybersecurity, engaging professionals in shaping the future of European digital governance (European Commission, 2025a). Examining the EUDT account, rather than the

broader EC account, allows for a more focused and detailed analysis of strategic communication tailored specifically to digital governance stakeholders.

The EUDT can only be considered an indicative case study, given that engagement patterns and user demographics may vary for different institutional contexts. However, the EUDT still offers a compelling illustration of the EC's primary digital governance messages, making it a valuable case for exploring LinkedIn's broader potential in public sector communication. Hence, the research is guided by the following question: *How can LinkedIn be effectively leveraged to promote audience engagement, support professional communication and uphold public values in digital governance?*

We also pose three sub-questions to guide our research processes:

1. *SQ1. What types of activity generate the highest engagement on the EU Digital & Tech LinkedIn account?*
2. *SQ2. What themes and sentiments emerge in audience comments on these posts?*
3. *SQ3. How can the EU Digital & Tech LinkedIn account enhance engagement with professional stakeholders such as policymakers, digital industry actors, and academic experts in the context of digital governance?*

By addressing these questions, this paper aims to contribute to the broader understanding of the role of communication in navigating the developing complexities of the digital age. It then explores how LinkedIn can serve as a professional engagement tool and build trust, inclusivity, and innovation in digital public governance.

The relevance of this research is multifold. First, LinkedIn's ability to facilitate discussions on AI governance reflects its alignment with the focus on promoting technology responsibly. Similarly, by analyzing interactions with the public, this research contributes to understanding how communication strategies promote public governance values like transparency, inclusivity, and responsiveness. LinkedIn's professional audience makes it a substantial platform for taking discussions on digital sovereignty and cybersecurity, ensuring that technical policies are effectively communicated to industry experts and, finally, decision-makers.

The following chapter offers insights into related works bridging stakeholder engagement and public values at the intersection of social media and explores frameworks for unlocking the full strategic potential. Then, the data source and preprocessing pipeline, as well as the topic modeling methodologies used, are assessed. This study combines a social science approach with a methodology from information sciences. Afterwards, all finalized results for this paper are discussed. Lastly, all findings are summarized, and further research is suggested.

2 Related Work

When digital transformation shapes governance, the role of social media platforms in addressing the gap between policymakers and stakeholders has become increasingly significant. While traditional forms of communication remain vital, the immediacy, accessibility, and interactivity of social media offer reliable opportunities for promoting dialogue, transparency, and collaboration. Among these platforms, LinkedIn has emerged as a space aimed at professionals from different fields to discuss governance, policy innovation, and digital transformation and drive interaction.

2.1 Public Engagement in Digital Public Governance

Social media platforms, which have been integrated into governmental communication strategies over the last decade, remain key tools for informing citizens and encouraging dialogue between diverse stakeholders. DPG increasingly relies on these effects on effective communication, primarily to promote transparency, participation, and collaboration among users. Mergel and colleagues (2012) highlight that digital tools have transformed communication from a unidirectional process to *"bidirectional exchanges"*, enabling governments to build trust and accountability in ways previously unavailable, similar to turning *consumers* into so-called *prosumers* (Bartosik-Purgat & Filimon, 2022).

Despite their transformative potential, not all platforms are equally effective for engaging professional stakeholders. Studies from different fields within public sector communication identify significant limitations in widely used platforms such as Twitter and Facebook, which – though effective for real-time updates and mass dissemination – often only drive superficial interactions (Lai & Fu, 2020; Rauchfleisch et al., 2023). Additionally, their reliance on broad audiences limits meaningful discussions on complex topics, such as digital governance policies, which require depth and nuance (Rauchfleisch et al., 2023).

LinkedIn, however, serves as a professional (and policy-driven) engagement platform. Unlike competitors with larger user numbers, LinkedIn specifically targets *"the world's professionals to make them more productive and successful"*, home to an environment with discussions on society, strategy, and innovation (LinkedIn Ireland Unlimited Company, 2016). Gestel and Grotenbreg (2021) argue that LinkedIn's features, such as longer-form content and a professional tone, make it particularly suited for driving sustained interactions and collaborative dialogue, which is essential in the context of public governance.

2.2 Governance and Policy (Non-Profit) Communication

Policy communication, especially in areas that require particular or expertise understanding, depends on the ability to express complex ideas clearly and effectively to the relevant audiences. Social media platforms are useful tools in this process, providing the reach and prompt action necessary to inform and get feedback. Studies on risk and crisis communication underscore the utility of platforms like Twitter and Facebook in disseminating policy updates, such as during the COVID-19 pandemic (Wang et al., 2021). However, their focus on mass communication limits their ability to engage technical and professional audiences on specific policy matters (Wang et al., 2021; Wukich, 2020).

In this narrower context, LinkedIn has also been recognized as a platform uniquely positioned to address these limitations. Its professional user base and tools like targeted advertising, event promotion, and long-form posts enable governments to communicate more effectively with industry experts, policymakers, and researchers. Faber (2022) emphasizes that LinkedIn's professional structure opens the door for thoughtful exchanges and professional engagement. It serves as a key channel for policy dissemination and collaboration in the public sector, particularly focusing on governance-related topics. This aligns with municipalities' strategies, as their LinkedIn content predominantly focuses on *"governance and general support*" (Faber, 2022).

Analyzing how different types of posts perform on social media platforms has been a recurring focus in the literature. Lovejoy & Saxton (2012) categorize social media posts from governments and non-profit organizations into three broad types: informational, interactive (communal), and action-oriented. Informational posts, i.e. those sharing detailed reports or policy updates, often generate high engagement due to LinkedIn's emphasis on large-format content. Interactive posts, including those encouraging comments or discussions, also perform well, as LinkedIn users are often motivated by the opportunity to share expertise and network with peers. Action-oriented posts, such as promoting events, can also succeed on LinkedIn when they align with the platform's professional tone and audience (Lovejoy & Saxton, 2012). Understanding the impact of these post types on engagement levels helps refine communication strategies, the authors specify.

2.3 Optimizing LinkedIn for Digital Governance Purposes

LinkedIn's features offer well-thought-out opportunities for enhancing stakeholder engagement, yet they remain underutilized in many governance contexts. Mergel (2012) notes that public agencies often underutilize professional tools like analytics and audience targeting, which are critical for maximizing the potential of platforms like LinkedIn to enhance governance-related communication. Studies examining LinkedIn's use in governance highlight several best practices. Faber (2022) found that posts combining detailed, relevant content with clear calls to action generate the highest levels of engagement. Similarly, targeted hashtags and audience segmentation significantly enhance post visibility and relevance. Along with other platforms, video content, as well as on LinkedIn, performs better than text content (Du et al., 2020). These findings suggest that advanced digital platforms, such as LinkedIn, can likely be strategically employed to engage professional audiences and drive interactions that align with public governance values like transparency and inclusiveness (Chen et al., 2023).

While LinkedIn remains underexplored in the literature, insights from studies of other platforms help contextualize its potential. Özdemir et al. (2025), in their analysis of EU executive communication on Twitter, identify a shift from neutral output reporting toward more participatory and engagement-oriented practices, which they term *opinionated communication*. This strategy combines reporting on institutional actions with individual framing, responsiveness, and inclusivity cues. These elements are increasingly important in public sector communication and point to untapped potential in LinkedIn's own interactive features, such as polls, comment replies, or stakeholder mentions. Studies also show that polls generate higher engagement rates than standard posts, as they invite direct participation and provide immediate feedback (Edney et al., 2018; Mergel, 2012).

Moreover, Özdemir et al. (2025) offer a useful distinction between four forms of legitimacy – input, throughput, output, and identity – which can help conceptualize communication strategies. Transparency and responsiveness support throughput legitimacy, while inclusive and participatory tools strengthen input legitimacy. Within this framework, LinkedIn's professional user base, structured format, and engagement tools could be leveraged to support trust and legitimacy in DPG. Despite emerging best practices, academic evidence on LinkedIn's role in this area remains limited, highlighting the need for further empirical research into how public organizations

communicate professionally and meaningfully on the platform.

3 Data and Methodology

This study adopts a mixed-method data approach to analyze LinkedIn's role as an effective communication tool in adhering to public values. Using the primary data collected directly from the EU Digital & Tech account on LinkedIn, this study investigates engagement patterns, thematic trends, and sentiment in professional interactions (Batrinca & Treleaven, 2015). The aim of the analysis is also to explore ways in which the platform could be optimized for public-sector communication. The selected research method provides a comprehensive and nuanced evaluation for more accurate results, and it was chosen due to its flexibility and potential for reliable results, which will be further explained in the following subchapters (Olteanu et al., 2018).

3.1 Data Collection

The dataset for this study has been drawn from LinkedIn posts, including all interactions with various users on the **EU Digital & Tech** account and the associated posts. Data collection focuses on activities shared between July 1 and December 31, 2024, capturing current trends and discussions relevant to digital transformation, AI integration, and cybersecurity. This 6-month period ensures the analysis reflects up-to-date practices and audience interactions in a dynamic landscape.

Accessing social media data is commonly facilitated through public APIs and open-source programmable frameworks (Batrinca & Treleaven, 2015). However, due to increasingly restricted API accessibility by private corporations, **PhantomBuster** – a tool which uses LinkedIn's API to extract contents automatically – was used (Perriam et al., 2020). Hence, the data extracted contains:

(1) post content (text used as content, multimedia and links shared within posts),

(2) engagement metrics (quantitative measures including likes, comments and shares)

(3) audience interactions (text data from user comments and potential replies)

(4) metadata (date- and timestamps).

PhantomBuster is primarily utilized to generate leads in a marketing environment and might include biases of commercial data extraction tools that are not specifically optimized for research purposes. Moreover, as PhantomBuster does not capture content updates or deletions, the dataset cannot reflect real-time changes, potentially affecting the accuracy of insights. Another concern is the authenticity of engagement: user interactions may include inputs from bots or inactive accounts, which can distort patterns of actual stakeholder involvement. However, a manual spot-check procedure was adopted to mitigate the risk of incomplete or erroneous data and improve the robustness of the findings. Specifically, 5% of the extracted posts and comments were randomly selected to verify their accuracy against the live LinkedIn interface. This approach provides a level of quality control that strengthens the reliability of the dataset, though it does not guarantee the total elimination of automated extraction anomalies (Olteanu et al., 2018).

3.2 Data Preprocessing

To ensure the data is suitable for analysis, preprocessing is conducted via Natural Language Processing (NLP) in several structured steps (Egger & Gokce, 2022; Pradha et al., 2019). This is standard practice in information science to ensure that textual data is cleaned, standardized, and ready for further, primarily qualitative, examination (Batrinca & Treleaven, 2015). To automate this process efficiently, Python-based software and databases *NLTK* and *spaCy* were used, both of which are widely recognized for their NLP capabilities and open source (ExplosionAI GmbH, 2024; NLTK Project, 2024). NLTK was applied for tokenization, stop word removal, and stemming, while spaCy supported part-of-speech tagging (assigning a grammatical category like noun, verb, adjective, etc.) and named entity recognition to assist in filtering personal names and non-English content. The combined use of both tools ensured the employment of complementary strengths in this structured approach.

The preprocessing steps, including their description, are as follows:

1. **Data Cleaning**: Non-text elements such as emojis, special characters, and URLs are removed to eliminate noise from the dataset – only textual content remains.

2. **Tokenization**: Text is split into individual units (tokens), such as words or phrases. Sentences like "AI governance is essential!" are tokenized into "AI", "governance", "is", and *"essential"* – removing periods and exclamation marks.

3. **Stop Word Removal**: Commonly used words (e.g., "and," "the," "is") that do not contribute to the thematic or sentiment analysis are filtered out using pre-defined lists. For this research, a specific list of words suiting LinkedIn's professional language has been chosen, including terms like "via", "regarding," and conjunctions like "therefore," which appear frequently in formal or policy-related posts but contribute little to semantic depth.

4. **Stemming**: Words are reduced to their word stem to ensure consistency and suitability for comparison. For example, variations such as *"governing"* and *"governed"* are standardized to *"govern*".

5. **Normalization**: All text is converted to lowercase to unify the dataset and avoid treating variations like "AI" and "ai" as different words.

6. **Data Structuring**: Preprocessed text is finally structured into a relational database, ensuring each post or comment is linked to its associated metadata (e.g., engagement metrics, hashtags, and timestamps). Non-English language and individual names are then excluded from further analysis due to the often unreliable automatic distinction between individual names (persons) and the correct identification of other languages (Keraghel et al., 2024).

This organization facilitates efficient retrieval and analysis (Egger & Gokce, 2022). The resulting clean and standardized text fits advanced analyses such as topic modeling, sentiment scoring, and engagement evaluation. If not mentioned otherwise, all general data is evaluated using Microsoft Excel.

3.3 Integrated analysis

Content analysis is conducted to categorize LinkedIn posts and assess their engagement performance (Batrinca & Treleaven, 2015). Posts are divided into three main types: informational, interactive, and action-oriented posts (Lovejoy & Saxton, 2012). For example, a post to invite stakeholders to contribute to a "*Call for Evidence on the Protection of Minors Online*" would be categorized as an action-oriented post, as it encourages direct participation from the audience in the policymaking process. By contrast, a post announcing the launch of the Digital Maturity Assessment tool ("*A new tool [...] is now available*!")(European Commission, 2024b), developed by the European Digital Innovation Hubs Network, would be classified as an informational post. Then, all engagement metrics (likes, comments, shares) are analyzed for each category to determine those types of posts generating the highest interaction scores.

Additionally, the use of features, such as visuals and multimedia, is assessed to understand their impact on engagement. For example, an informational post detailing an AI ethics report might include a visual infographic and relevant images. Its engagement metrics are then compared with those of an interactive post of another category that, e.g., aims at starting a discussion about AI governance. Patterns recognized can be used to identify effective communication strategies for LinkedIn's professional user base. To be able to compare the three categories of posts in terms of engagement, the **interaction score** *(I)* was calculated as follows:

$$I = L + C + R$$

There, L stands for the number of likes on the post, C for the number of comments and R for the number of times the post was shared. *Thematic analysis* identifies key topics and recurring themes in LinkedIn posts and audience comments, shedding light on stakeholder priorities (Batrinca & Treleaven, 2015). After preprocessing the text, Latent Dirichlet Allocation (LDA) is used to uncover clusters of related topics. This is done via Python-based software and associated libraries and is an established method for social media analysis (Ostrowski, 2015). For example, comments on AI governance posts may reveal themes like *"ethics," "accountability,"* and *"transparency,"* while cybersecurity discussions may center around *"data breaches"* and *"privacy concerns."* In addition to topic modeling, keyword analysis validates LDA results by highlighting frequently used terms reflecting users' interests (Ostrowski, 2015). Themes in these comments can be used in the recommendations to align post's contents better with users' interests, showing how effectively LinkedIn posts address professional concerns.

The *analysis* of audience/con-/prosumer *sentiment* is another critical aspect of evaluating social media communication strategies. This method provides insights into the emotional tone of audience responses, enabling organizations to understand public perception of their messages (Thelwall, 2018). Studies highlight that sentiment analysis might help governments identify areas of public support or discontent, providing a foundation for refining communication strategies (Zavattaro et al., 2015). Therefore, **TextBlob** (https://github.com/sloria/textblob), a

tool within a Python framework, was used to classify comments as positive, neutral, or negative. For instance, "*Love this! Video games are […] a great way for parents to learn with their kids!*" would be positive, while "*The problem is that the EU doesn't understand the problem...*" would be referred to as negative.

4 Results

This study offers actionable insights for improving the EC's LinkedIn communication strategy. In this section, we highlight how stakeholders engage and how their emotional responses may align with governance objectives, ensuring communication strategies remain foundational on trust and inclusivity, which is a common practice in successful long-term communication.

4.1 Content Analysis

Over the chosen six-month period between July 1 and December 31, 2024, the EU Digital & Tech account on LinkedIn made 159 postings, accounting for almost daily activity. The posts can be divided into three categories: informational (109 posts), interactive (10 posts), and action-oriented (40 posts). The posts collectively summed up 30,662 likes, 596 comments, and 3,887 shares (reposts), resulting in a total of 35,145 interactions.

The weighted average interaction score (I) across all post categories equals 221.1. Informational posts demonstrated the highest average interaction score, followed by interactive and action-oriented posts. Table 1 below presents the interaction scores:

Tab. 1. Interaction Scores per Category

Post category	No.	Share (%)	Average Interaction Score (I)
Informational	109	68.55	243.4
Interactive	10	6.29	198.6
Action-oriented	40	25.16	165.7

Furthermore, no postings assessed were published as text-only, as they all included either an image, document or video. Image-based posts demonstrated the best performance, 3.28% above the average. Document-based posts had a lower interaction score of 182, representing a 17.69% decrease compared to the average. Video posts performed the worst, falling 55.76% below the average. Table 2 below presents the distribution and engagement of posts per attachment type.

Tab. 2 - Interaction Scores per Feature Type

Post type	No.	Share (%)	Interaction Score (I)
Image	143	89.94	228.35
Document	11	6.92	182
Video	5	3.14	97.8

4.2 Thematic Posting Analysis

The standalone keyword distribution among postings directly by the EUDT account (conducted with stemmed terms), without addressing comments, highlights a strong emphasis on digital and European themes used by the LinkedIn account. The term "*ai*" appears most frequently, underscoring a central focus on artificial intelligence. There is a noticeable distinction between "*EU*" and "*European*" in the account's postings as well. Although often used interchangeably in the daily language, the term "*EU*" likely emphasizes the European Union's role as a regulatory and legislative authority as the account focuses on policies, laws, and frameworks that specifically target

different stakeholders from the tech sector. In contrast, "European" may highlight a sense of community and shared identity, rather focused on collaboration, inclusivity, and collective progress.

The table below illustrates the frequency of the terms mentioned.

Tab. 3 - Account posting frequency

Stemmed term	Mentions
ai	260
digit	256
eu	224
european	128

A more holistic insight comes from the LDA analysis conducted on the stemmed text data from LinkedIn posts. It identifies key topics, each characterized by the five most significant words.

Tab. 4 - Integrated LDA Results of Topic Modeling from Original Posts

Topic	Word 1	Word 2	Word 3	Word 4	Word 5
Topic 1P	infrastructur	european	eu	support	connect
Topic 2P	eu	ukrain	digit	cybersecur	digitaleu
Topic 3P	ai	eu	act	european	euro
Topic 4P	digit	eu	onlin	digitaleu	data
Topic 5P	data	eu	regist	event	simpl

These topics provide an overview of the dominant themes that the account uses and can thus be compared to the themes that users mention the most. Topic 1P emphasizes terms like "*infrastructure,*" "*European*," and "*support,*" indicating a focus on connectivity, European initiatives, and collaborative efforts. Topic 2P highlights words such as "*cybersecurity*," "*Ukraine*," and "*digital*," pointing to discussions surrounding digital security, geopolitical concerns, and professional technology-related themes. Furthermore, Topic 3P centers around terms reflecting a focus on artificial intelligence and highlights this together with regulatory frameworks and the broader European digital strategy. Topic 4P emphasizes discussions on digital transformation, online platforms, and data-driven initiatives, while Topic 5P includes terms such as "*data*," "*register*," and "*event*," pointing to themes of data governance, event participation, and possibly simplified processes for digital engagement.

4.3 Thematic Comments Analysis

The dataset consists of 596 comments containing 12,728 stemmed terms, of which 92.6% were identified as written in English. The remaining 7.4% were categorized as individual names (approximately 75%) and other languages (approximately 25%). The latter two have not been considered within the analysis (see chapter 3.2). Only five comments were written by EUDT moderators.

The keyword distribution highlights the dataset's focus on European themes (*"eu")* and artificial intelligence (*"ai"*). Other often-mentioned terms emphasize digital transformation and reflect the also technological orientation of the account. Additionally, terms like *"innov", "data", "ethic",* and *"discuss"* suggest nuanced discussions around innovation, ethics, and policymaking in digital and AI contexts. This distribution underscores the centrality of technology and governance themes in the dataset.

Tab. 5 - User comments frequency

Stemmed term	Mentions
eu	80
ai	76
digit	41
tech	35
onli	32

The following table highlights the results of the LDA analysis conducted on the stemmed text data from user comments.

Tab. 6 - Integrated LDA Results of Topic Modeling from User Comments

Topic	Word 1	Word 2	Word 3	Word 4	Word 5
Topic 1U	good	tech	eu	time	new
Topic 2U	ai	great	data	eu	digit
Topic 3U	ai	eu	european	europ	digit
Topic 4U	ai	data	protect	eu	innov
Topic 5U	europ	ai	cybersecur	digit	act

Topic 1U emphasizes terms like "*good*," "*tech*," and "*time*," likely indicating a focus on technological advancements and positive developments. Topic 2U highlights words such as "*ai*," "*great*," and "*data*," pointing to discussions on artificial intelligence, its potential, and data-driven innovations. Topic 3U focuses on AI in the European context, possibly focused on its alignment with regional priorities and broader EU initiatives. Moreover, Topic 4U highlights data protection and innovation themes, underscoring the importance of implementing digital advancements. Lastly, Topic 5U mentions cybersecurity and AI, particularly emphasizing Europe's efforts to act decisively concerning digital security and resilience.

4.4 Sentiment analysis

The sentiment analysis of the LinkedIn comments provides insights into the discussion's tone and nature. The breakdown of comments based on their tone is presented in the figure below.

Tab. 7 - Sentiment analysis of users' comments

Sentiment	Count	Share
Positive	287	48%
Neutral	270	45%
Negative	39	7%

Most comments (287) were categorized as positive, reflecting optimism or enthusiasm. For instance, this comment expresses positivity by highlighting progress and ethical considerations in AI: *"Thinking about AI, which is not only tech and engineering but also requires ethics and responsibility. It's inspiring to see progress in this area."*

Meanwhile, neutral sentiments indicate that much of the discourse was factual or was missing a strong emotional undertone. This comment, for example, poses a question without an explicit emotional tone: *"Is it possible to see who submitted these proposals and what are they about?"*

Negative sentiments were the least frequent. In a negative comment, e.g., the user expresses a strong emotional reaction to perceived setbacks in equity: *"It gives me chills down my spine that we're regressing when it comes to basic equity."*

All in all, we observe that the LinkedIn discussion, based on the data of the EUDT account, is predominantly neutral to positive, suggesting a constructive and balanced engagement. Only a tiny fraction of the comments reflects dissatisfaction or criticism. It is important to mention that comments or contents that may have been deleted before extracting data have not been included in the analysis.

5 Discussion

Overall, elevated levels of engagement across various types of posts, along with the mostly positive or neutral sentiment observed throughout the comments, suggest that LinkedIn can likely help facilitate a balanced exchange on topics such as AI governance, cybersecurity, and digital transformation, which the account aims at. To fully appreciate these insights, however, several important considerations and limitations should be explored in more detail, which will be closely linked to the respective sub-questions.

5.1 Informative Content: High Interaction or Just High Frequency?

There are distinct engagement patterns among different post categories. Informational posts consistently generated higher interaction scores than action-oriented or interactive content, revealing the importance of sharing detailed, in-depth information with LinkedIn's professional user base. This can be interpreted as a success for the account's strategy. Additionally, this finding can be confirmed with existing literature suggesting that posts with substantive content are more likely to result in thoughtful commentary on LinkedIn than more superficial calls to action like on other platforms (Lai & Fu, 2020; Rauchfleisch et al., 2023).

One possible explanation is that informative content meets LinkedIn's audience's expectations of acquiring knowledge and staying current on emerging digital governance trends. In contrast, action-oriented posts do tend to focus on promoting events or driving immediate participation on other platforms, which may not always result in sustained discourse on LinkedIn itself. Nonetheless, on the same point, an important factor to note is the imbalance within the collected dataset: informational posts far outnumbered action-oriented (greater factor 10), and interactive ones (greater factor 2). As a result, it remains difficult to conclusively state whether their content type alone drove higher engagement.

5.2 Keeping it positive while catching up with expectations

Comparing the LDA results for official posts and user comments further underscores some of the core themes driving professional engagement. On the official side, topics such as "*infrastructure*," "*cybersecurity*," and "*data*" – all closely associated with the European Commission's forward-looking digital strategies – appear strong. The repeated references to "*EU*," "*European*," and "*digitaleu*" confirm that the Commission's communication aligns well with policy goals: the content is directly tied to European digital initiatives and events, highlighting large-scale connectivity, cybersecurity collaboration, and data privacy.

User comments, on the other hand, reveal a slightly broader set of interests, often clustered around "*tech,*" "*AI*" and "*ethics*". While the first two terms align closely with the account's focus, the latter should be considered more often in future posts and could result in more active engagement, representing user interests. The presence of terms in multiple languages, e.g., Polish and Italian, would highlight the account's broad reach and remind users of regional differences across policies.

Sentiment analysis showed that most user responses remained positive or neutral, with relatively few explicitly negative comments. While these findings suggest an overall favorable reception, the neutral sentiments often took the form of information requests, indicating that users were keen to gather more facts before forming strong opinions, which should be considered for future posts. On this note, it stood out that in the results, only five comments out of 596 had been posted by the EUDT account itself over the selected six-month period. This aligns with the overall account focus, which appears to aim at providing news only. However, it shows unused potential for user engagement.

Negative comments mostly referenced matters like equitable access and perceived failings in addressing social or ethical dimensions of digital governance, offering an opportunity for policymakers to address these concerns in more detail. Notably, the standard sentiment analysis tool used here cannot reliably detect sarcasm or irony, which may hold back subtler criticisms or discontent. Therefore, the largely optimistic tone in the data must be interpreted cautiously – although checked manually – acknowledging potential shortcomings that simple polarity classification might not capture.

5.3 Optimizing LinkedIn Use for Governance

LinkedIn's professional user base appears drawn to thorough, information-focused content, but there remains unexplored room for experimenting with features that can further stimulate engagement. Although, as stated on the account itself, *"[w]e bring you the latest news"* (European Commission, 2024b), it seems the EUDT strategy focuses on conveying information only; elements within their posts actively channel discussions with open-ended questions. It can be inferred that the overall strategic approach should be streamlined. Once that has been completed, encouraging more interactive elements, such as polls or structured Q&A sessions, could offer valuable insights into stakeholder concerns and attract more sustained discussions. Similarly, leveraging document-sharing options might help deliver detailed policy reports or guidelines while simultaneously inviting comments from academics, industry representatives, and policy experts.

Moderation guidelines encouraging the EU Digital & Tech team to respond directly to user queries or questions could help bridge the gap between policy announcements and community feedback. By explicitly inviting subject matter experts or other stakeholders to engage in LinkedIn Live events, for instance, the account could generate a more interactive culture reflecting DPG's emphasis on inclusivity and modern-times responsiveness.

The thematic consistency in user comments, centered on AI, ethics, data governance, and cybersecurity, suggests that messaging focused on these areas resonates strongly. By blending substantive updates with open-ended conversation prompts, the EU Digital & Tech account could refine its strategy for reaching a broader, diverse audience. Ultimately, optimizing LinkedIn as a platform for digital governance should extend beyond increasing engagement metrics. It must also reflect fundamental public values, including transparency, inclusivity, and accessibility. This applies not only to the substance of the content but also to the modes of communication. Ensuring that materials are accessible, inviting participation from diverse user groups, and encouraging open, dialogic interaction across sectors and regions are essential steps toward aligning communication practices with the broader objectives of DPG.

6 Conclusion

This study presents a compelling case that LinkedIn can act as a relevant – although in this case underutilized – tool for communication in digital public governance. It is important to note that focusing on the EU Digital & Tech account does provide an in-depth view of one influential channel but cannot fully capture the diversity of communication approaches across other public sector accounts or national government profiles. While different content strategies result in varying degrees of engagement, the main trends suggest that the user base is indeed willing to engage thoughtfully with policy-related content on this platform, which might be useful for all parties involved. These themes resonate with core values of transparency, accountability, and innovation, signaling that the account's existing content strategy already addresses some fundamental principles of modern digital governance.

Looking ahead, a more comprehensive and improved participatory governance approach on LinkedIn would involve experimenting with additional media formats, such as short videos, infographics, real-time webinars, etc. While the account shows promise in posting regular, informative updates, more interactive strategies could help activate participation and make communication more dialogic. Through such strategies, followers can evolve into active prosumers, directly contributing to content creation and policy dialogue. This includes actively responding to user comments, conducting regular LinkedIn polls on current regulatory questions, using pinned posts to invite stakeholder feedback, or organizing periodic LinkedIn Live sessions with European Commission representatives or digital experts. These approaches are relatively low-cost and can stimulate recurring engagement across a more dynamic communication environment.

To then assess the impact of such measures, LinkedIn's built-in analytics tools (e.g., comment sentiment, viewer retention, and demographic breakdowns) could be systematically used. Metrics like comment-to-like ratios, average poll participation, or reply to rates to open questions could serve as benchmarks for interaction quality over time. These evaluation practices would allow communication teams behind such accounts to adjust their strategies iteratively and tailor them to different stakeholder groups, aligning digital governance communication with ongoing expectations of transparency, responsiveness, and user engagement.

Such strategies align directly with core DPG values – transparency, accessibility, and collaborative decision-making – thus positioning LinkedIn not merely as a news distribution tool but as a dynamic platform enabling followers to become prosumers actively participating in policy co-creation and shared innovation across the EU.

Future research might explore whether a more balanced content strategy – combining informational depth with invitations for audience participation – would result in different engagement patterns or emotional responses, particularly among different demographic segments. Moreover, comparing the engagement dynamics of the EUDT account with those of the broader European Commission may clarify whether observed trends are specific to stakeholders actively seeking updates on digital policy or whether they reflect more general patterns across the institution's social media landscape. Additionally, future research might apply the legitimacy framework introduced by Özdemir et al. (2025) to evaluate which types of institutional communication contribute most effectively to different dimensions of public legitimacy in digital governance contexts.

6.1 Limitations

This study found that LinkedIn might be an effective communication channel for DPG, yet various limitations shape the extent to which the findings can be generalized. First, focusing on the EU Digital & Tech account as a single channel reduces representativeness, as different organizations or agencies might have contrasting objectives, audiences, and communication styles.

Selection bias is another concern, as this study analyzed only the posts and comments that remained publicly visible during data extraction. Certain user contributions might have been deleted, flagged, or set to restricted visibility, potentially distorting the larger conversation around the topics. The reliance on automated data extraction tools, too, introduces possible inaccuracies if LinkedIn's interface changes or if connectivity issues interrupt the data collection process, which cannot be fully declined. Moreover, repeated mentions (of other people's names or tags) and replies can lead to partially duplicated entries. Even though the account and its contents are publicly accessible to all users, individual names and other personal information have been removed to comply with the EU's GDPR, addressing ethical concerns about data handling and privacy.

Language diversity further complicates sentiment and topic analyses since the chosen methodologies rely heavily on English-centric tools that do not always account for slang or other languages, e.g., Polish and Italian, as seen in the data set. Reliably including this data in future studies will account for a more inclusive approach, as this limitation causes multilingual users' sentiments or nuanced criticisms to go undetected.

Finally, the automated sentiment detection (TextBlob) cannot easily interpret sarcasm or subtle humor, possibly categorizing a critical comment's tone as neutral or positive. This limitation was, to an extent, addressed through manual spot reviews of selected comments. Expanding the analysis to multiple LinkedIn accounts, refining sentiment-detection methods and tools, systematically incorporating manual reviews as well as integrating machine learning tools with contextual understanding could employ richer and more precise insights.

7 Acknowledgements

Data/Software Access Statement: All GDPR-compliant data used in the study can be found at https://github.com/socialmatchbox/LinkedInovation/.

8 Bibliography

Bartosik-Purgat, M., & Filimon, N. (2022). *European Consumers in the Digital Era: Implications of Technology, Media and Culture on Consumer Behavior* (1st ed.). Routledge. https://doi.org/10.4324/9781003263685

Batrinca, B., & Treleaven, P. C. (2015). Social media analytics: A survey of techniques, tools and platforms. *AI & SOCIETY*, *30*(1), 89–116. https://doi.org/10.1007/s00146-014-0549-4

Boulianne, S. (2019). Building Faith in Democracy: Deliberative Events, Political Trust and Efficacy. *Political Studies*, *67*(1), 4–30. https://doi.org/10.1177/0032321718761466

Chen, Y.-C., Ahn, M. J., & Wang, Y.-F. (2023). Artificial Intelligence and Public Values: Value Impacts and Governance in the Public Sector. *Sustainability*, *15*(6), 4796. https://doi.org/10.3390/su15064796

Criado, J. I., Sandoval-Almazan, R., & Gil-Garcia, J. R. (2013). Government innovation through social media. *Government Information Quarterly*, *30*(4), 319–326. https://doi.org/10.1016/j.giq.2013.10.003

Davis, F. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*, 319. https://doi.org/10.2307/249008

Davis, J., Wolff, H.-G., Forret, M. L., & Sullivan, S. E. (2020). Networking via LinkedIn: An examination of usage and career benefits. *Journal of Vocational Behavior*, *118*, 103396. https://doi.org/10.1016/j.jvb.2020.103396

Du, X., Yin, H., Chen, L., Wang, Y., Yang, Y., & Zhou, X. (2020). Personalized Video Recommendation Using Rich Contents from Videos. *IEEE Transactions on Knowledge and Data Engineering*, *32*(3), 492–505. IEEE Transactions on Knowledge and Data Engineering. https://doi.org/10.1109/TKDE.2018.2885520

Edney, S., Looyestyn, J., Ryan, J., Kernot, J., & Maher, C. (2018). Posts, pics, or polls? Which post type generates the greatest engagement in a Facebook physical activity intervention? *Translational Behavioral Medicine*, *8*(6), 953–957. https://doi.org/10.1093/tbm/iby006

Egger, R., & Gokce, E. (2022). Natural Language Processing (NLP): An Introduction. In R. Egger (Ed.), *Applied Data Science in Tourism: Interdisciplinary Approaches, Methodologies, and Applications* (pp. 307–334). Springer International Publishing. https://doi.org/10.1007/978-3-030-88389-8_15

European Commission. (2024a). *Digital transition—European Commission*. https://reform-support.ec.europa.eu/what-we-do/digital-transition_en

European Commission. (2024b). *Post | Feed | LinkedIn* [LinkedIn Post]. EU Digital & Tech Page. https://www.linkedin.com/feed/update/urn:li:activity:7225081652304052224/

European Commission. (2025a). *EU Digital & Tech: Posts | LinkedIn* [Linkedin Profile]. https://www.linkedin.com/showcase/digital-eu/posts/?feedView=all

European Commission. (2025b). *European Commission: Posts | LinkedIn* [Linkedin Profile]. https://www.linkedin.com/company/european-commission/posts/?feedView=all

ExplosionAI GmbH. (2024). *Trained Models & Pipelines · spaCy Models Documentation*. Trained Models & Pipelines. https://spacy.io/models

Faber, B. (2022). Platforms as distinctive realms and the role of policy discretion: A cross-platform assessment of citizen engagement with Dutch municipalities through Twitter, Facebook, LinkedIn, and Instagram. *Local Government Studies*, *48*(5), 973–994. https://doi.org/10.1080/03003930.2021.2007081

Gestel, N. van, & Grotenbreg, S. (2021). Collaborative governance and innovation in public services settings. *Policy & Politics*, *49*(2), 249–265. https://doi.org/10.1332/030557321X16123785900606

Gilardi, F., Gessler, T., Kubli, M., & Müller, S. (2022). Social Media and Political Agenda Setting. *Political Communication*, *39*(1), 39–60. https://doi.org/10.1080/10584609.2021.1910390

Graziano, E. A., Fattobene, L., Giovando, G., & Pellicelli, A. (2023). Contacts on LinkedIn: Equity crowdfunding platforms' networks and creators' innovation performance. *European Journal of Innovation Management*, *27*(7), 2351–2372. https://doi.org/10.1108/EJIM-03-2022-0125

Grewal, D., Herhausen, D., Ludwig, S., & Villarroel Ordenes, F. (2022). The Future of Digital Communication Research: Considering Dynamics and Multimodality. *Journal of Retailing*, *98*(2), 224–240. https://doi.org/10.1016/j.jretai.2021.01.007

Haro-de-Rosario, A., Sáez-Martín, A., & del Carmen Caba-Pérez, M. (2018). Using social media to enhance citizen engagement with local government: Twitter or Facebook? *New Media & Society*, *20*(1), 29–49. https://doi.org/10.1177/1461444816645652

Keraghel, I., Morbieu, S., & Nadif, M. (2024). *Recent Advances in Named Entity Recognition: A Comprehensive Survey and Comparative Study* (No. arXiv:2401.10825). arXiv. https://doi.org/10.48550/arXiv.2401.10825

Lai, C.-H., & Fu, J. S. (2020). Organizations' Dialogic Social Media Use and Stakeholder Engagement: Stakeholder Targeting and Message Framing. *International Journal of Communication*, *14*(0), Article 0.

Lewandowsky, M., & Siri, J. (2023). Populismus und Digitalisierung. In N. Kersting, J. Radtke, & S. Baringhorst (Eds.), *Handbuch Digitalisierung und politische Beteiligung* (pp. 1–16). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-31480-4_53-1

LinkedIn Ireland Unlimited Company. (2016). *About LinkedIn*. https://about.linkedin.com/

Lovejoy, K., & Saxton, G. D. (2012). Information, Community, and Action: How Nonprofit Organizations Use Social Media*. *Journal of Computer-Mediated Communication*, *17*(3), 337–353. https://doi.org/10.1111/j.1083-6101.2012.01576.x

Macnamara, J., & Zerfass, A. (2012). Social Media Communication in Organizations: The Challenges of Balancing Openness, Strategy, and Management. *International Journal of Strategic Communication*, *6*(4), 287–308. https://doi.org/10.1080/1553118X.2012.711402

Mergel, I. (2012). *Social Media in the Public Sector: A Guide to Participation, Collaboration and Transparency in The Networked World*. John Wiley & Sons.

Milakovich, M. E. (2021, September 27). *Digital Governance | Applying Advanced Technologies to Improve Public*. https://www.taylorfrancis.com/books/mono/10.4324/9781003215875/digital-governance-michael-milakovich

Muniz-Rodriguez, K., Ofori, S. K., Bayliss, L. C., Schwind, J. S., Diallo, K., Liu, M., Yin, J., Chowell, G., & Fung, I. C.-H. (2020). Social Media Use in Emergency Response to Natural Disasters: A Systematic Review With a Public Health Perspective. *Disaster Medicine and Public Health Preparedness*, *14*(1), 139–149. https://doi.org/10.1017/dmp.2020.3

NLTK Project. (2024). *NLTK :: Natural Language Toolkit*. https://www.nltk.org/

Olteanu, A., Kıcıman, E., & Castillo, C. (2018). A Critical Review of Online Social Data: Biases, Methodological Pitfalls, and Ethical Boundaries. *Proceedings of the Eleventh ACM International Conference on Web Search and Data Mining*, 785–786. https://doi.org/10.1145/3159652.3162004

Ostrowski, D. A. (2015). Using latent dirichlet allocation for topic modelling in twitter. *Proceedings of the 2015 IEEE 9th International Conference on Semantic Computing (IEEE ICSC 2015)*, 493–497. https://doi.org/10.1109/ICOSC.2015.7050858

Özdemir, S. F., Graneng, K., & De Wilde, P. (2025). EU executives on social media: Assessing the potential and trajectories of legitimation via public communication on Twitter. *European Union Politics*, 14651165251320881. https://doi.org/10.1177/14651165251320881

Perriam, J., Birkbak, A., & Freeman, A. (2020). Digital methods in a post-API environment. *International Journal of Social Research Methodology*, *23*(3), 277–290. https://doi.org/10.1080/13645579.2019.1682840

Pradha, S., Halgamuge, M. N., & Tran Quoc Vinh, N. (2019). Effective Text Data Preprocessing Technique for Sentiment Analysis in Social Media Data. *2019 11th International Conference on Knowledge and Systems Engineering (KSE)*, 1–8. https://doi.org/10.1109/KSE.2019.8919368

Rauchfleisch, A., Kao, J.-J., Tseng, T.-H., Ho, C.-T., & Li, L.-Y. (2023). Maximizing Science Outreach on Facebook: An Analysis of Scientists' Communication Strategies in Taiwan. *Media and Communication*, *11*(1), 228–239. https://doi.org/10.17645/mac.v11i1.6080

Rogers, E. M. (1983). *Diffusion of innovations* (3. ed). Free Press [u.a.].

Rus, M., Tasente, T., & Camara, V. (2021). Social Media Communication of Public Institutions. Case Study: Representation of the European Commission in Romania. *Technium Social Sciences Journal*, *17*, 119.

Thelwall, M. (2018). Social media analytics for YouTube comments: Potential and limitations. *International Journal of Social Research Methodology*, *21*(3), 303–316. https://doi.org/10.1080/13645579.2017.1381821

Tornatzky, L. G., & Fleischer, M. (1990). *The Process of Technology Innovation*. Lexington Books.

United Nations. (2025). *United Nations: Overview | LinkedIn* [Linkedin Profile]. https://www.linkedin.com/company/united-nations/

U.S. DOS. (2025). *U.S. Department of State: Overview | LinkedIn* [Linkedin Profile]. https://www.linkedin.com/company/doscareers/

Valenzuela, S., Halpern, D., Katz, J. E., & Miranda, J. P. (2019). The Paradox of Participation Versus Misinformation: Social Media, Political Engagement, and the Spread of Misinformation. *Digital Journalism*, *7*(6), 802–823. https://doi.org/10.1080/21670811.2019.1623701

Wang, Y., Hao, H., & Platt, L. S. (2021). Examining risk and crisis communications of government agencies and stakeholders during early-stages of COVID-19 on Twitter. *Computers in Human Behavior*, *114*, 106568. https://doi.org/10.1016/j.chb.2020.106568

Wukich, C. (2020). More Monitoring, Less Coordination: Twitter and Facebook Use between Emergency Management Agencies. *Journal of Homeland Security and Emergency Management*, *17*(3). https://doi.org/10.1515/jhsem-2020-0007

Wukich, C. (2021). Government Social Media Engagement Strategies and Public Roles. *Public Performance & Management Review*, *44*(1), 187–215. https://doi.org/10.1080/15309576.2020.1851266

Zavattaro, S. M., French, P. E., & Mohanty, S. D. (2015). A sentiment analysis of U.S. local government tweets: The connection between tone and citizen involvement. *Government Information Quarterly*, *32*(3), 333–341. https://doi.org/10.1016/j.giq.2015.03.003

Zerres, C. (Ed.). (2024). *Handbuch Social-Media-Marketing*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-45784-6

Lessons Learned for Local Cybersecurity: Practical Implications of a Public Sector Cyberattack for Small and Medium-Sized Municipalities

Johanna Maria Schmidt [a*], *Stanislav* Mahula [b], *Joep* Crompvoets [c]

[a] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, johanna.schmidt@student.kuleuven.be, 0009-0009-9530-3832

[b] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, 0000-0003-0568-9604

[c] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, 0000-0003-1077-597X

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Cybersecurity is an integral part of digital public governance and aims to ensure the confidentiality, integrity and availability of sensitive citizen-, business-, and government-related data. Given the increasing complexity of cyberthreats, driven by the digital transformation of the public sector and emerging technologies, local governments need robust and resilient cybersecurity strategies. This exploratory study examines the October 2023 cyberattack on Südwestfalen IT (SIT), an IT service provider for over 70 municipalities, cities and districts in Germany. As a result of this ransomware attack, for several months, public services were severely disrupted for over 1.6 million citizens. Against the backdrop of the particular challenges that local governments face in managing their cybersecurity, this study identifies lessons that small and medium-sized municipalities and cities derive from this cyberattack. The paper adopts a multi-method qualitative exploratory research approach, combining key informant interviews and document analysis through reflexive thematic analysis. Key findings highlight the importance of thorough implementation of cybersecurity standards such as network segmentation, tighter monitoring practices and two-factor authentication. To mitigate cluster risks, other key lessons include increased focus on top-down decision-making to enforce non-negotiable cybersecurity standards, given the need for IT service collaboration and the use of economies of scale resulting from the resource constraints of smaller local administrations. Further practical implications include an increased focus on staff training and implementing change management strategies to reduce resistance to reform at various stakeholder levels. This exploratory study of the SIT's recent cyber incident also serves as an example for small and medium-sized municipalities that are not part of cooperation networks, encouraging them to reconsider their cost-benefit analysis of independent cybersecurity strategies versus collaborative frameworks. Overall, the study offers valuable insights into the implications of cyberattacks for local administrations of small- and medium-sized municipalities. As such, it aims to contribute to developing more equitable and resilient cybersecurity strategies.

Keywords. Cybersecurity, local cybersecurity strategy, local digital governance, public sector cyberattack.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.994

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1 Introduction

Cybersecurity is an essential aspect of digital public governance, encompassing the confidentiality, integrity and availability of data and information (Möller, 2023). Its societal relevance can be illustrated by the direct impact cybersecurity incidents might have on the daily operations of public administration and citizens respectively, including the disruption of critical public services, the loss of sensitive data of citizens, governments and businesses, as well as financial damage and the erosion of public confidence in government (Roumani & Alraee, 2025; Shandler & Gomez, 2022). The landscape of cyber incidents is broad, including data breaches, ransomware attacks, phishing, and denial-of-service (DoS) attacks. It extends further with the advancements of emerging technologies, such as artificial intelligence, which pose unique and novel risks to data and information security (Ndumbe & Velikov, 2024; Savaş & Karataş, 2022). Therefore, considering various types of cyberthreats is crucial to ensure a comprehensive – adaptive and resilient – cybersecurity strategy for any organisation, and thus, adequate incident response and risk mitigation activities.

Local governments are people's first point of contact: the services they provide can have a significant impact on citizens' satisfaction with, for example, democracy, thereby influencing social cohesion and reducing inequalities (Hunter et al., 2016; Masuku et al., 2022; Meza, 2015; Sabbi et al., 2024). For small and medium-sized municipalities (SMMs) and districts, cybersecurity resilience is particularly important. However, while local governments have formal cybersecurity policies, they fail to integrate cybersecurity practices into their day-to-day operations (Hatcher et al., 2020). Researchers have also found that SMMs lack cybersecurity awareness among staff and officials at all levels (Norris et al., 2019; Norris & Mateczun, 2022).The issue is exacerbated further because SMMs, in particular, struggle to maintain human and financial resources to provide quality services (OECD, 2023). While lack of funding and inadequate training have been identified as key challenges, local governments also face a unique set of institutional, political, historical and cultural barriers that influence their ability to prevent and respond to cyberthreats (Hossain et al., 2025; Preis & Susskind, 2022).

At the same time, according to the European Agency for Cybersecurity (ENISA), the majority of cyberattacks in the EU target public administration organisations (European Agency for Cybersecurity, 2024). In addition, ENISA is seeing an increase in the number and advancement of cyberattacks. These developments could become increasingly relevant for SMMs, given their structural vulnerability in this respect. Still, local governments' cybersecurity strategies and incident responses have not been extensively researched (Hossain et al., 2025; Preis & Susskind, 2022). Therefore, this exploratory research aims to answer the following question: *What lessons may small and medium-sized municipalities derive from cyberattacks?*

This paper focuses on a single case study to explore the experiences of SMMs in Germany, where their municipal IT service provider Südwestfalen IT (SIT), a network cooperation owned by 72 municipalities, cities and districts, recently suffered a massive cyberattack (Südwestfalen IT, 2024a). The SIT's owners are also its customers; thus its strategic development is driven by representatives of the SIT's members (Südwestfalen IT, 2024c). Accordingly, SIT is governed by its association assembly, which is made up of elected officials representing the local governments of its member entities.

Based on key informant interviews (KIIs) and document analysis, this paper aims (1) to identify key lessons learned from the SIT cyberattack, (2) evaluate how they impact cybersecurity strategies, and (3) draw practical implications for cybersecurity strategies of small and medium-sized administrative entities.

This study's relevance is twofold: as the SIT cybersecurity incident is relatively recent, mostly journalistic and forensic assessments have been conducted to date (Brockhues & Boeselager, 2024; r-tec, 2024). Drawing on this recent data, this paper examines the real-world strategies of SMMs to address the evolving cyberthreat landscape. As the cyberattack on SIT can be seen as a high-profile incident, examining its strategic implications is directly relevant for other small and medium-sized administrations and can help improve the robustness and resilience of their cybersecurity strategies.

The remainder of the paper is structured as follows: Section 2 presents an overview of related research, followed by Section 3, which introduces the conceptual framework of this study. The methodology is outlined in Section 4 and the key results are presented in Section 5. Section 6 provides a discussion of the main findings, followed by the conclusion in section 7.

2 Literature review

2.1 Key cybersecurity concepts

The term *'cybersecurity'* generally refers to the protection of internet-connected systems, including both hardware and software, as well as data and information, from threats, i.e. cyberattacks (Srinivas et al., 2019). Cyberattacks can have different intentions, such as compromising the confidentiality, integrity and availability of data and

information of public and private organisations (Möller, 2023). Various types of cyberattacks are commonly identified, including spyware that tracks information or a replicating virus that attaches itself to other software. Other examples include ransomware attacks, which encrypt data on devices and offer decryption upon payment of a ransom, and a zero-day attack, which exploits a vulnerability in software before a security patch can be applied. Data can also be threatened by a brute-force attack, which is a trial-and-error method of gaining access to information such as passwords. According to ENISA ransomware attacks rank among the primary cyberthreats (European Agency for Cybersecurity, 2024). The agency also states that cyberweapons targeting zero-day vulnerabilities are a growing concern.

2.2 Cybersecurity in the public sector

While certain aspects to cybersecurity are common across sectors, peculiarities of the public domain make the issue even more acute. The importance of public cybersecurity has increased significantly over the last decades, mainly due to the increasing interconnection between IT and critical public infrastructure (Wirtz & Weyerer, 2017). While this development leads to many positive effects, the public sector represents an attractive target for cyberattacks: public organisations deal with a wide range of sensitive data of citizens, private sector organisations and public infrastructure (Trautman et al., 2024; Wirtz & Weyerer, 2017). Given this field of tension, public governments and administrations are urged by practitioners and researchers to address the evolving cyberthreats through strategic management of cybersecurity (Wirtz & Weyerer, 2017).

Some authors find that municipal governments need to invest in resources and technical capacity building to prevent cyber incidents; others identify leadership in public administration as critical to implementing up-to-date cyber protection measures (Frandell & Feeney, 2022; Wirtz & Weyerer, 2017). In addition, researchers find that local governments of all sizes have significant gaps in their cybersecurity policies (Hossain et al., 2024b). Other research is mainly concerned with structuring the complex landscape of (public) cybersecurity frameworks, with the aim of helping policymakers and practitioners identify gaps and challenges in framework implementation (Hossain et al., 2024a; Srinivas et al., 2019).

While public sector cybersecurity challenges are generally faced by both smaller and larger administration entities, local governments, as the primary bodies politically and administratively in charge of SMM cybersecurity, may face unique obstacles (Hossain et al., 2025; Preis & Susskind, 2022). Based on a study of US local governments, researchers attest that local governments have significant shortcomings in managing their cybersecurity, such as unawareness of security best practices as well as lacking individual risk audits and implementation of existing measures and policies (Norris et al., 2019). These shortcomings are generally linked to limited financial resources and underinvestment, leading to a self-reinforcing cycle of technological vulnerability that ultimately discourages the innovative efforts needed to keep pace with evolving cyberthreats (Fusi et al., 2023).

In addition, researchers have found that rural municipalities with lower citizen demand for digital services also provide a smaller surface area for cyberattacks, although they note that these findings apply primarily to IT departments that manage their cybersecurity independently (Harry et al., 2025). However, other researchers recommend that local governments consolidate IT networks and form municipal collaborative partnerships to mitigate the cascading effects of budget constraints and reduce the fragmentation and complexity of cybersecurity measures (Hossain et al., 2025). On the other hand, research has shown that cybersecurity incidents can have a significant impact on the relationship between IT providers and local authorities, and that repairing trust is a complex process (Nowak & Distel, 2024). Given this complex and sometimes paradoxical landscape of considerations facing SMMs, it is highly relevant to explore the impact of an actual cybersecurity incident on local cybersecurity strategies.

3 Cybersecurity frameworks

In this section, we introduce and discuss how various available frameworks are operationalised and applied as heuristic lenses within the scope of this study (Abbott, 2004).

3.1 Cybersecurity frameworks overview

Various theoretical frameworks exist to cover and structure relevant aspects of this research topic, including the IT security compendium of the German Federal Office for Information Security (BSI), the international information security standard ISO 27001:2022, the US National Institute of Standards and Technology's Cybersecurity Framework 2.0 (NIST CSF 2.0) and the EU's NIS2 Directive.

NIST CSF 2.0 provides flexible, risk-based guidance for private and public cybersecurity management. Taking an outcome- and practice-oriented approach, NIST CSF 2.0 identifies six core functions of a cybersecurity framework: Govern, Identify, Protect, Detect, Respond and Recover. When compared with other frameworks, NIST CSF offers significant advantages for self-assessment, while at the same time, the framework would benefit from simplified

practical implementation (Ibrahim et al., 2018). Moreover, an earlier version of the NIST CSF has already been applied in a study of cybersecurity levels of local government organisations. Examining the cybersecurity levels of a local government organisation in Western Australia, several recommendations were formulated under the core functions of the NIST CSF, such as increasing cybersecurity awareness across the workforce and establishing a central inventory of assets, which serves as a basis for prioritising security measures based on their classification, criticality and business value (Ibrahim et al., 2018).

Ibrahim et al. (2018) also provide valuable insights into the application of the NIST CSF to a local government case, although this exploratory study can build on this by using a more recent version of the framework, i.e. NIST CSF 2.0, which additionally includes Governance as a core function of cybersecurity frameworks. As this study explicitly aims to identify the broader implications of the SIT cyber incident, it is essential to explore the development of governance approaches in this case of municipal collaboration.

In turn, the EU's NIS2 Directive complements this framework by adding a regulatory perspective, which is essential for analysing a municipal case in the EU. As an alternative, the IT security compendium of the BSI could be used (BSI, 2023). However, it may be considered too technical and detailed for the scope of this study.

3.2 Aggregated conceptual framework

In this study, a chosen heuristic lens comprises NIST CSF 2.0 and NIS2, as they are well-known and established cybersecurity frameworks with several strengths and include a wide range of aspects in a flexible way, which is particularly important for this exploratory study. They are also highly compatible and provide an international standard. Our conceptual framework is presented in the table below:

Tab. 1 – Conceptual framework

NIST CSF 2.0 core functions	NIST CSF 2.0 outcomes associated with core functions	NIS2 Directive focus measures
Govern (GV)	Establishing, communicating and monitoring the organisation's cybersecurity risk management strategy, expectations and policy	Appropriate management policies and clear accountability
Identify (ID)	Understanding the organisation's current cybersecurity risks	Regular and coordinated risk assessments
Protect (PR)	Safeguarding to manage the organisation's cybersecurity risks	Implementation of cyber hygiene baselines, practices and controls
Detect (DE)	Finding and analysing possible cybersecurity attacks and compromises	Early warning systems through appropriate technical measures
Respond (RS)	Taking action regarding a detected cybersecurity incident	Response obligations and reporting protocols
Recover (RC)	Restoring assets and operations affected by a cybersecurity incident	Ensuring process continuity and routine operations, as well as recovery measures

4 Methodology

4.1 Case description

SIT was founded in 2018, when two municipal IT service providers merged into the joint association SIT under the Municipal Cooperation Act of North Rhine-Westphalia, with the aim of consolidating their services for the benefit of their member municipalities, cities and districts. Due to SIT members' diverse size and structure, the cyberattack recovery process has been described as a balancing act (Brockhues & Boeselager, 2024). Within the scope of this paper, only SMMs that are members of the cooperation network SIT are addressed (Südwestfalen IT, 2024a).

During the night of October 29 to October 30 2023, the municipal IT service provider SIT detected a cyberattack on its systems, later described as the largest and most complex attack on the German public sector to date, with

over 1.6 million citizens affected (Südwestfalen IT, 2024d). In the following months, the digital public service landscape in this region in North Rhine-Westphalia was described as being thrown back into the Stone Age (Krischer, 2023). The most basic administrative operations, such as communication by telephone and mail, as well as the payment of social benefits, youth welfare services, the legal marriage of citizens and the issuing of driving licences, were unavailable (Brockhues & Boeselager, 2024). While some municipalities were more affected than others, all were severely hampered in their day-to-day administrative work by the SIT's remit: SIT provides comprehensive IT services such as e-government solutions, software development for administrative applications and network infrastructure (Südwestfalen IT, 2024b).

The cyberattack on the SIT in October 2023 exploited a zero-day vulnerability via a brute-force attack and is furthermore classified as a ransomware attack (r-tec, 2024). While the ransomware group that attacked SIT – a Russian collective called Akira – offered to coordinate modalities for recovering the data in exchange for a ransom, SIT chose not to do so due to valid backup copies of the data and the lack of evidence of data leakage (r-tec, 2024).

4.2 Data collection

This exploratory study adopts a multi-method qualitative research approach by relying on KIIs, complemented by archival and desk research (Bryman, 2012). Data gathered through desk and archival research include primary sources such as official records, reports and legislation, as well as secondary data such as academic journals, online databases and press outputs, providing a detailed description of the context of the study (Bryman, 2012). Two key complementary resources are the evaluation report conducted by the external company r-tec on behalf of SIT and a journalistic podcast series published by publicly-funded news broadcasts (Brockhues & Boeselager, 2024; r-tec, 2024).

By drawing on different data sources, theories and research methods, this study aims to fulfil the data, theory and method triangulation principle originally developed by Denzin (Bryman, 2012; Denzin, 2017). This approach not only allows for cross-comparability of findings but is particularly appropriate for this research topic as it involves different stakeholders with different perspectives and priorities (Bryman, 2012). By combining data from different key informants and sources with two different lenses, i.e. NIST CSF 2.0 and NIS2, triangulation provides a more comprehensive view of the research topic and increases the validity and credibility of the findings (Bryman, 2012).

In order to be able to ask open-ended and follow-up questions, the KIIs adopt a semi-structured approach (Magnusson & Marecek, 2015). As the single case study has not yet been widely researched, while preparing the interview questions guided by our conceptual framework, we remained open to new data and aspects that were not anticipated (Bryman, 2012). Potential interviewees were identified through desk research and network referrals, leading to two interviews in December 2024. The overview of informants is presented below:

Tab. 2 – Key Informant Interviews.

Interview	Role	Relevance	Format	Duration
1	Official of one of the districts affected by the cyberattack	Responsible for managing the district's administrative operations Involved in the SIT's strategic development	Online	45 minutes
	Leading member of the SIT's association assembly	The district consists of several SMMs and holds a total population of approx. 260.000		
2	Member of a city council	Represents the city's interests in the SIT's association assembly	Online	30 minutes
	Member of the SIT's association assembly	The city holds a total population of approx. 31.000, of which 15.000 live in the town centre and the rest in the surrounding villages		

The preliminary questions, which were sent to the interviewees in advance for the purpose of preparation, were developed and worded to cover the themes conceptualised by the aggregated framework consisting of the NIST

CSF 2.0 and the EU's NIS2 Directive. Hence, they were structured into the following blocks: implications for cybersecurity strategies and governance; current cyberthreats and protective measures; and threat detection, response and recovery. For instance, the questions asked what specific cybersecurity risks the attack revealed for SMMs, what specific challenges SMMs face in this regard, what impact the cyberattack had on cooperation between the SIT and its owners, and questions about strategies and actions beyond the SIT.

4.3 Data analysis

The data gathered from the interviews and archival and desk research was examined using Reflexive Thematic Analysis (RTA) (Braun & Clarke, 2006). While thematic analysis (TA) generally entails identifying, analysing and reporting on patterns, called '*themes*', within the data at hand, RTA takes a more interactive research approach. In RTA, themes are (re)developed based on analytical and interpretative reflection on the collected data (Braun & Clarke, 2006). Hence, themes emerge from an organic and reiterating coding process that includes review and reflection cycles during the whole data analysis process (Braun & Clarke, 2021a, 2021b). This iterative reflection on the data collected is particularly suited to the exploratory nature of this research, as the interviews, for instance, led to the identification of further resources.

Although RTA does not usually follow a strictly theory-driven approach or involve a priori coding, both cybersecurity frameworks form the initial basis for the data analysis process (Abbott, 2004). Braun and Clarke argue that research cannot be conducted in an atheoretical environment, so RTA aligns with this approach (Braun & Clarke, 2022). In addition, due to the flexible development of themes, (R)TA can be seen as more interpretive, whereas Qualitative Content Analysis is generally more descriptive (Braun & Clarke, 2021a). According to Braun and Clarke, this distinction arises since most TA methods explicitly rely on a discussion of the research's theoretical background. Given the heuristic lenses used, RTA is a better fit for this research.

The interviews were conducted in German, recorded in an audio format and transcribed with Microsoft Edge software (Bryman, 2012). The transcripts were manually cleaned by correcting transcription errors, but no content was edited (Bryman, 2012). Afterwards, the interviews were translated into English, and the correct information conversion was manually reviewed. The data analysis process was supported by the software NVivo 15 (Bryman, 2012).

5 Results

The following results section is structured according to the aggregated conceptual framework introduced in Section 3, which combines the core functions of NIST CSF 2.0 and focus measures of the NIS2 Directive. Due to the exploratory nature of this research, the developed framework served as a heuristic lens and provided a starting point for the data analysis, in order to systematically organise the findings from both the KIIs and the archival and desk research. The first part of this section presents insights related to the functions Govern and Identify, while the second part covers the functions Protect, Detect, Respond and Recover.

5.1 Key lessons learned on Governance and Identification

When it comes to cybersecurity governance, a key takeaway is the introduction of more top-down decision-making: "*And that was one of the lessons we learned: certain things cannot be discussed democratically within such an organisation. Once the necessity of a measure has been recognised, it must be decided top-down*" (Interview 1). This change in the SIT's approach to governance also includes the following measures identified through the themes of this analysis. The governance structure of the SIT does not provide for the network's leadership to be full-time, which is seen as a weakness, especially in times of crisis. In addition, political oversight of the SIT's strategy development through the association assembly is still quite strong due to its make-up, potentially hindering a quick implementation of reforms. However, the interviewees observe a growing understanding of top-down measures.

Cost considerations have also been identified as an obstacle to governance and decision-making: The SIT is supported by levies, meaning the members bear additional costs, e.g. for the implementation of new measures aimed at achieving minimum security standards. Regarding membership policy, the SIT leadership intends to demand minimum security standards: *"[…] SIT's primary focus is, of course, on securing its services and network. To ensure this, minimum standards will be imposed on members in the future. Only those who implement certain measures will even be allowed access to the network*" (Interview 1). Cost considerations and organisational structures, such as resistance of employees, were named as potential barriers to this membership requirement.

The analysis revealed several different risks identified by the interviewees. In terms of understanding the cybersecurity risks of SMMs within the SIT, the cyberattack has particularly highlighted a cluster risk arising from the nature of a cooperative association, where entities pool resources and data. However, this risk was exacerbated by the lack of network segmentation. In addition, the lack of basic security practices, such as two-factor

authentication and password requirements, was also uncovered. Furthermore, the cyberattack underlined the lack of human and financial resources as a particular risk for SMMs. According to the interviewees, this risk can only be mitigated by taking advantage of economies of scale, i.e. by cooperating in networks such as SIT. Additionally, the support of external parties in identifying individual cybersecurity risks is seen as positive, such as a situation analysis provided by the federal state or the involvement of r-tec in identifying immediate, medium-term and long-term measures.

5.2 Key lessons learned on Protection, Detection, Response and Recovery

To protect organisations from cybersecurity risks, the cyberattack has reinforced and revealed the need for several further measures. Regarding cyberthreat monitoring, network segmentation should be increased, especially against the background of the intention to widen cooperation between SMMs. Furthermore, SIT aims to de-complicate the applications it offers to simplify monitoring and updating security standards. Related to this, when evaluating the recovery, the respondents stated that processes varied from city to city and were complicated by the complexity and customisation of applications. During this phase, most cities learned that consolidating IT services can likely reduce the long-term complexity of daily monitoring and future recovery processes, while some cities also restored functionality on their own.

Two key lessons have been learned about future cybersecurity threat detection: (i) Installing tighter cyberthreat monitoring solutions to prevent attackers from moving freely within the network, regardless of significant ongoing costs. Furthermore, (ii) analysing and prioritising security alerts appropriately, i.e. against the background of the individual security architecture.

Regarding the detection and analysis of security alerts, interview 1 revealed that security alerts received from official authorities should be thoroughly read and analysed to assess their risk to SIT's individual infrastructure. Furthermore, the representative of one administration entity names measures apart from SIT, namely educating employees in cyber hygiene, such as password requirements and auto-locking screens. However, the interviewee notes that administrative staff have a limited understanding of such additional protective measures. In addition, the interviewed member of the city council states that the city aims to build offline redundancies for their most crucial processes, particularly ensuring business continuity. For future responses to cybersecurity incidents, the immediate involvement of external experts such as r-tec would be helpful, as would a rapid system shutdown to prevent the worst-case scenario of data theft.

In addition to confirming the previously developed overarching conceptual themes of lessons learned, increasing centralisation and collaboration were identified as themes strongly connected to cybersecurity governance. Even though these measures are not predominantly driven by small and medium-sized administrative entities, they strongly impact their cybersecurity strategies. Furthermore, strategies leading to this goal are supported by the interviewees, such as a state programme to examine the state of cybersecurity in each municipality, city, and district and increasing top-down dictation of minimum requirements.

6 Discussion

6.1 Top-down approach to cybersecurity standards

Two key lessons from the SIT cyberattack include (1) an increased focus on top-down decision-making to ensure effective development and implementation of cybersecurity measures and (2) significant investment in robust and proactive monitoring and segmentation measures. This adjusted governance strategy appears especially relevant against the background of increased costs of additional measures, such as close meshed monitoring.

In addition, although cluster risks are inherent in the structures of cooperative networks such as the SIT, the financial and human resource limitations of SMMs require the use of synergies and economies of scale. Identifying resource constraints as a key factor driving local cybersecurity constraints is additionally underlined by further research (Hossain et al., 2025; Preis & Susskind, 2022). The cluster risks will be mitigated by increasing the segmentation of IT networks according to national and international standards.

Moreover, the cyberattack highlighted the severe deficits in basic cybersecurity practices at an operational level, such as the lack of password requirements or two-factor authentication and has therefore been identified as a focus area both at the individual and at the SIT management levels and will be addressed for example through employee training. This recognition of shortcomings in basic security practices correlates with previous research that identified these as key risks for local cybersecurity (Norris et al., 2019).

Evaluating key lessons derived from the cyberattack, SMMs are incorporating them into their cybersecurity strategies. While respondents support stronger governance frameworks and the enforcement of minimum security

standards – i.e. members will be excluded if they do not comply – other stakeholders not interviewed in this study may be more critical of this change in strategy. The same may be true for increased costs, which in the past have significantly impacted the strategic prioritisation of cybersecurity measures. Striking a balance between affordability and compliance with minimum standards could be crucial for implementing new measures and updated strategies, which correlates with other research that identifies public administration leadership and financial investment as critical factors in managing cybersecurity (Frandell & Feeney, 2022; Fusi et al., 2023; Preis & Susskind, 2022; Wirtz & Weyerer, 2017).

We found increased segmentation, monitoring, and simplification of services as likely cornerstones of an updated SIT cybersecurity measures. These aspects were already evident but became further exacerbated by the cyberattack. However, the withdrawal of individualised IT solutions could trigger further resistance among SIT members, confirming the need for change and expectation management as an additional strategic priority not mentioned in the interviews.

6.2 Greater centralisation and improved local implementation

Regarding practical implications for the cybersecurity strategies of SMMs, centralisation efforts appear to be the most prominent. This overarching strategic trend, such as centralising IT services and deepening collaboration between administrative units, is particularly supported by SMMs due to their limited financial and human resources to maintain an adequate level of cybersecurity. In this process, SMMs can likely be identified as potentially benefiting the most. As these entities depend on pooling resources, they should also strengthen protective measures, such as making certain standards non-negotiable within the network cooperation. They could also advocate for further centralisation at the federal and state levels, which could further increase benefits from economies of scale, such as redundancy and expertise.

This trend towards increased collaboration and consolidation of IT networks is consistent with the findings and recommendations of other research, which identifies cost savings and less complex cybersecurity measures as key benefits (Hossain et al., 2025). However, these findings are not aligned with the implications of other research, which suggests that IT service providers serving more citizens also provide a larger surface area for cyberattacks and a more attractive target (Harry et al., 2025). On the other hand, the respondents are aware of this increase in cluster risk and, therefore, support the introduction of the necessary cybersecurity standards to mitigate these risks and to be able to take advantage of the economies of scale on which they depend. Moreover, something that could be emphasised more by the SIT but is already being addressed at an individual level is cyber hygiene training for employees, which aims to reduce human-related cybersecurity risks. The need to improve and advocate for the implementation of cyber hygiene practices at a local level is also highlighted by previous research (Hatcher et al., 2020; Norris & Mateczun, 2022; Preis & Susskind, 2022).

6.3 Concluding reflections

While most of the key findings can be grouped according to the conceptual framework developed earlier, it becomes clear that they are highly interrelated. For example, reducing the complexity and customisation of IT services aims to significantly simplify Identification, Detection and Recovery, while it is also a key issue for the Governance of cybersecurity strategies. Therefore, effective change and expectation management measures and the involvement of all relevant stakeholders – such as political leaders, mayors and administrative staff – can be seen as crucial to achieving this strategic goal. A strategic change management approach was not identified during the data analysis but could significantly improve and speed up reform processes. As the specific implications of a complex service and governance landscape, such as the case of the SIT, have not been explicitly discussed in prior research, these findings provide new insights into developing cybersecurity strategies of collaborating local governments. However, researchers have previously found that local governments face a unique set of obstacles depending on their institutional, political and cultural context, which this case also confirms (Preis & Susskind, 2022).

Overall, the data analysis confirms the core functions and focal points of a cybersecurity strategy developed based on NIST CSF 2.0 and the EU's NIS2 Directive. In particular, proactive measures focused on preventing future cyberattacks are emphasised due to the accumulation of lessons learned within the themes of identifying, protecting and detecting cyberthreats. Furthermore, many of the consequences drawn were already observed before the cyberattack, but their urgency increased considerably. This increased sense of urgency against the background of evolving technology and public digital transformation is illustrated not only by the interview respondents but also by existing research (Ndumbe & Velikov, 2024; Roumani & Alraee, 2025; Savaş & Karataş, 2022; Wirtz & Weyerer, 2017).

7 Conclusion

This exploratory qualitative research study finds that SMMs affected by the cyberattack on SIT have learned several

key lessons that ultimately affect the realignment of cybersecurity strategies. Overall, the urgency of implementing a proactive, centralised and standardised approach to IT services and cybersecurity strategies and measures was reinforced. In particular, as small and medium-sized administrations face budgetary and human resource constraints, they rely on a collaborative network, such as the SIT, with robust and up-to-date cybersecurity measures mitigating cluster risks. The SIT's cyberattack highlighted critical gaps in basic requirements, such as lack of monitoring, network segmentation, two-factor authentication and password requirements. Given the lengthy decision-making processes on such measures in the past, the interviewees concluded that there should be more top-down decision-making on implementing non-negotiable cybersecurity standards. Based on the analysis, practical implications include greater emphasis on employee training and developing change and expectation management strategies to mitigate resistance to reform. Other municipalities and local administrations not yet attacked might use these practical implications to evaluate their own state of cybersecurity, carefully ensuring the implementation of their national and international standards, such as segmentation and monitoring.

This case also illustrates the need to involve all relevant stakeholders, such as administrative staff through appropriate training, or political and administrative leadership in raising awareness of the need for action. In addition, this case could prompt other municipalities not involved in a cooperation network to reevaluate their cost-benefit calculation for maintaining cybersecurity standards on their own, and hence, likely improving redundancy, effectiveness, and cost-efficiency.

This study relies on two key informants, which may limit the breadth of perspectives. Nevertheless, for an exploratory analysis, the combination of interviews and document review offers a solid foundation. The interviewees can be considered representative of their own district and municipality, though further interviews and comparisons with other small and medium-sized administrative entities would improve the generalisability and validity of the findings.

Despite the limitations of representativeness, this research can be seen as revealing crucial implications for local cybersecurity governance of SMMs and thus providing a starting point for future research. Further research could explore and compare cybersecurity strategy and preparedness in rural and urban, or smaller and larger communities. For example, it would be interesting to further analyse the role of budgetary and human resource factors, as well as interoperability, in order to inform federal-state efforts to centralise IT services. Further research could also explore the role of change and expectation management measures, for example, by assessing the further implications of top-down governance models.

8 Acknowledgements

Contributor Statement*: Johanna Maria Schmidt: Writing – original draft, Conceptualisation, Data curation, Formal analysis, Investigation, Methodology; Stanislav Mahula: Writing – review & editing, Supervision, Visualisation; Joep Crompvoets – Project Administration, Supervision, Resources.

Use of AI*: During the preparation of this work, the author(s) used DeepL in order to translate the interview transcripts. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict Of Interest (COI): There is no conflict of interest

9 References

Abbott, A. (2004). Methods of discovery: Heuristics for the social sciences. Norton & Company.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2021a). Can I use TA? Should I use TA? Should I (not) use TA? Comparing reflexive thematic analysis and other pattern-based qualitative analytic approaches. Counselling and Psychotherapy Research, 21(1), 37–47. https://doi.org/10.1002/capr.12360

Braun, V., & Clarke, V. (2021b). One size fits all? What counts as quality practice in (reflexive) thematic analysis? Qualitative Research in Psychology, 18(3), 328–352. https://doi.org/10.1080/14780887.2020.1769238

Braun, V., & Clarke, V. (2022). Thematic analysis: A practical guide. SAGE.

Brockhues, A., & Boeselager, F. (2024, June 17). Zero Day in Südwestfalen. Deutschlandfunk. https://www.deutschlandfunk.de/zero-day-in-suedwestfalen-folge-1-hackeralarm-bei- nacht-dlf-cab9c129-100.html

Bryman, A. (2012). Social research methods. (Fourth edition). Oxford university press.

Bundesamt für Sicherheit in der Informationstechnik. (2023, February 1). IT-Grundschutz- Kompendium. https://www.bsi.bund.de/SharedDocs/Downloads/DE/BSI/Grundschutz/IT-GS-Kompendium/IT_Grundschutz_Kompendium_Edition2023.pdf?__blob=publicationFile&v=4#download=1

Denzin, N. K. (2017). The Research Act: A Theoretical Introduction to Sociological Methods (1st ed.). Routledge. https://doi.org/10.4324/9781315134543

European Agency for Cybersecurity. (2024). ENISA THREAT LANDSCAPE 2024. https://www.enisa.europa.eu/sites/default/files/2024-11/ENISA%20Threat%20Landscape%202024_0.pdf

European Union. (2022, December 27). Consolidated text: Directive (EU) 2022/2555 of the European Parliament and of the Council of December 14 2022 on measures for a high common level of cybersecurity across the Union, amending Regulation (EU) No 910/2014 and Directive (EU) 2018/1972, and repealing Directive (EU) 2016/1148 (NIS 2 Directive) (Text with EEA relevance)Text with EEA relevance. https://eur-lex.europa.eu/eli/dir/2022/2555

Frandell, A., & Feeney, M. (2022). Cybersecurity Threats in Local Government: A Sociotechnical Perspective. The American Review of Public Administration, 52(8), 558–572. https://doi.org/10.1177/02750740221125432

Fusi, F., Jung, H., & Welch, E. (2023). Technological vulnerability and knowledge of cyber-incidents: threats to innovativeness in local governments? Public Management Review, 1–27. https://doi.org/10.1080/14719037.2023.2250362

Harry, C., Sivan-Sevilla, I., & McDermott, M. (2025). Measuring the size and severity of the integrated cyber attack surface across US county governments. Journal of Cybersecurity, 11(1). https://doi.org/10.1093/cybsec/tyae032

Hatcher, W., Meares, W. L., & Heslen, J. (2020). The cybersecurity of municipalities in the United States: an exploratory survey of policies and practices. Journal of Cyber Policy, 5(2), 302–325. https://doi.org/10.1080/23738871.2020.1792956

Hossain, S. T., Yigitcanlar, T., Nguyen, K., & Xu, Y. (2024a). Local Government Cybersecurity Landscape: A Systematic Review and Conceptual Framework. Applied Sciences, 14(13), 5501. https://doi.org/10.3390/app14135501

Hossain, S. T., Yigitcanlar, T., Nguyen, K., & Xu, Y. (2024b). Understanding Local Government Cybersecurity Policy: A Concept Map and Framework. Information, 15(6), 342. https://doi.org/10.3390/info15060342

Hossain, S. T., Yigitcanlar, T., Nguyen, K., & Xu, Y. (2025). Cybersecurity in Local Governments: A Systematic Review and Framework of Key challenges. Urban Governance. https://doi.org/10.1016/j.ugj.2024.12.010

Hunter, D. J., Marks, L., Brown, J., Scalabrini, S., Salway, S., Vale, L., Gray, J., & Payne, N. (2016). The potential value of priority-setting methods in public health investment decisions: Qualitative findings from three English local authorities. Critical Public Health, 26(5), 578–587. https://doi.org/10.1080/09581596.2016.1164299

Ibrahim, A., Valli, C., McAteer, I., & Chaudhry, J. (2018). A security review of local government using NIST CSF: a case study. The Journal of Supercomputing, 74(10), 5171–5186. https://doi.org/10.1007/s11227-018-2479-2

Krischer, H. (2023, December 29). Seit einem Hackerangriff ist in Südwestfalen nichts mehr, wie es einmal war. Welt. https://www.welt.de/regionales/nrw/article249275488/In-Suedwestfalen-hat-ein-Hackerangriff-mehr-als-70-Kommunen-getroffen-auch-zwei-Monate-danach-liegen-noch-Systeme-lahm.html

Magnusson, E., & Marecek, J. (2015). Doing Interview-based Qualitative Research: A Learner's Guide (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9781107449893

Masuku, M. M., Mlambo, V. H., & Ndlovu, C. (2022). Service Delivery, Governance and Citizen Satisfaction: Reflections from South Africa. Global Policy and Governance, 11(1), 96-. https://doi.org/10.14666/2194-7759-11-1-6

Meza, O. D. (2015). Local Governments, Democracy, and Inequality: Evidence on the Political Economy of Inequality-reducing Policies in Local Government in Mexico. State and Local Government Review, 47(4), 285–296. https://doi.org/10.1177/0160323X15627852

Möller, D. (2023). Guide to Cybersecurity in Digital Transformation: Trends, Methods, Technologies, Applications and Best Practices (1st ed. 2023.). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-031-26845-8

National Institute of Standards and Technology. (2024). The NIST Cybersecurity Framework (CSF) 2.0 (NIST CSWP 29; p. NIST CSWP 29). National Institute of Standards and Technology. https://doi.org/10.6028/NIST.CSWP.29

Ndumbe, S.I., Velikov, P. (2024). Government Strategies on Cybersecurity and How Artificial Intelligence Can Impact Cybersecurity in Healthcare with Special Reference to the UK. In: Jahankhani, H., Bowen, G., Sharif, M.S., Hussien, O. (eds) Cybersecurity and Artificial Intelligence. Advanced Sciences and Technologies for Security Applications. Springer, Cham. https://doi.org/10.1007/978-3-031-52272-7_9

Norris, D. F., & Mateczun, L. K. (2022). Cyberattacks on local governments 2020: findings from a key informant survey. Journal of Cyber Policy, 7(3), 294–317. https://doi.org/10.1080/23738871.2023.2178319

Norris, D. F., Mateczun, L., Joshi, A., & Finin, T. (2019). Cyberattacks at the grass roots: American local governments and the need for high levels of cybersecurity. Public Administration Review, 79(6), 895–904. https://doi.org/10.1111/puar.13028

Nowak, D., & Distel, B. (2024). Trust in Times of Cyber Crisis: Understanding Organizational Trust Repair in the Public Sector. In M. Janssen, J. Crompvoets, J. R. Gil-Garcia, H. Lee, I. Lindgren, A. Nikiforova, & G. Viale Pereira (Eds.), *Electronic Government* (pp. 134–149). Springer Nature Switzerland.

OECD. (2023). OECD Regional Outlook 2023: The Longstanding Geography of Inequalities. OECD. https://doi.org/10.1787/92cd40a0-en

Preis, B., & Susskind, L. (2022). Municipal Cybersecurity: More Work Needs to be Done. Urban Affairs Review (Thousand Oaks, Calif.), 58(2), 614–629. https://doi.org/10.1177/1078087420973760

Roumani, Y., & Alraee, M. (2025). Examining the factors that impact the severity of cyberattacks on critical infrastructures. Computers & Security, 148, 104074-. https://doi.org/10.1016/j.cose.2024.104074

r-tec. (2024, January 19). Abschlussbericht Security Incident Südwestfalen-IT. https://www.sit.nrw/fileadmin/user_upload/SIT_Incident_Response_v1.1.pdf

Sabbi, M., Osei, A., Wigmore-Shepherd, D., & Ahlin, E. (2024). Minding the local slot: municipalities as drivers of trust in public institutions. Canadian Journal of African Studies, 58(2), 301–325. https://doi.org/10.1080/00083968.2024.2339490

Savaş, S., Karataş, S. Cyber governance studies in ensuring cybersecurity: an overview of cybersecurity governance. Int. Cybersecur. Law Rev. 3, 7–34 (2022). https://doi.org/10.1365/s43439-021-00045-4

Shandler, R., & Gomez, M. A. (2022). The hidden threat of cyber-attacks – undermining public confidence in government. Journal of Information Technology & Politics, 20(4), 359–374. https://doi.org/10.1080/19331681.2022.2112796

Srinivas, J., Das, A. K., & Kumar, N. (2019). Government regulations in cyber security: Framework, standards and recommendations. Future Generation Computer Systems, 92, 178–188. https://doi.org/10.1016/j.future.2018.09.063

Südwestfalen IT. (2024a). Das ist die Südwestfalen-IT. https://www.sit.nrw/sit

Südwestfalen IT. (2024b). Leistungen. https://www.sit.nrw/leistungen

Südwestfalen IT. (2024c). Unsere Gremien. https://www.sit.nrw/sit/gremien

Südwestfalen IT. (2024d, October 30). Ein Jahr nach dem Hackerangriff: Südwestfalen-IT zieht Bilanz. https://www.sit.nrw/detailansicht/ein-jahr-nach-dem-hackerangriff-suedwestfalen-it-zieht-bilanz

Trautman, L. J., Shackelford, S., Elzweig, B., & Ormerod, P. (2024). Understanding Cyber Risk: Unpacking and Responding to Cyber Threats Facing the Public and Private Sectors. University of Miami Law Review, 78(3), 840.

Wirtz, B. W., & Weyerer, J. C. (2017). Cyberterrorism and Cyber Attacks in the Public Sector: How Public Administration Copes with Digital Threats. International Journal of Public Administration, 40(13), 1085–1100. https://doi.org/10.1080/01900692.2016.1242614

Practitioners' Perceptions on Human-Centered Design Techniques in Digital Government Development

Viviane de Oliveira Garcia Coutinho[a], *Cláudia* Hazan[b], *Maurício* Ronny de Almeida Souza[c], *André* Pimenta Freire[d*]

[a]Departamento de Ciência da Computação, Universidade Federal de Lavras, Lavras, Brazil, viviane.coutinho@estudante.ufla.br, ORCID 0009-0008-2664-2833.

[b]Serviço Federal de Processamento de Dados (SERPRO), Rio de Janeiro, Brazil, claudia.hazan@serpro.gov.br, ORCID 0009-0000-8030-0940

[c]Departamento de Ciência da Computação, Universidade Federal de Lavras, Lavras, Brazil, mauricio.ronny@ufla.br, ORCID 0000-0002-0182-8016

[d]Departamento de Ciência da Computação, Universidade Federal de Lavras, Lavras, Brazil, apfreire@ufla.br, ORCID 0000-0001-7894-9740

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. This paper focuses on the application of Human-Centered Design (HCD) techniques to enhance the agile requirements engineering process within the context of Brazilian Digital Government. Providing a public experience that prioritizes digital platforms represents a significant opportunity to improve citizens' quality of life by facilitating access to information and services. Our analysis is based on a case study conducted in a large Brazilian public company, where a survey was applied to assess the use of HCD techniques such as prototyping, usability testing, Design Thinking, personas, user journey mapping, UX Writing, and Plain Language. The survey results highlighted prototyping as the most widely used technique. There was a high perceived value for usability testing; however, barriers to its broader implementation may exist. Techniques such as persona creation, user journey mapping, and Design Thinking showed moderate usage, while UX Writing and Plain Language had low adoption rates. The adoption of these techniques may vary depending on team roles. Factors such as age group, role accumulation, and time within the company influence their application. The findings reinforce the need to expand HCD training, especially for underutilized techniques, to maximize their benefits within the agile requirements engineering process. This effort can contribute to improving project efficiency and enhancing the quality of digital services in the governmental context.

Keywords. Digital Government, Human-Centered Design, Agile Requirements Engineering, Prototyping, Usability Testing, Personas, User Journey, Plain Language, Design Thinking, UX Writing, Industry Case.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1027

1. Introduction

The digital revolution is profoundly transforming public administration, gradually redefining the services offered by the State. This process brings challenges and demands that evolve as technologies become more advanced. At the core of this transformation is a citizen-oriented and citizen-driven model, in which users are no longer mere passive recipients of services but become co-creators of these solutions. This is a comprehensive digitalization effort that goes beyond seeking operational efficiency to promote the collaborative development of public services (Viana, 2021).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This movement requires the alignment of institutions, organizations, people, technologies, data, and resources to achieve significant change in both the public sector and society. More than just technological innovation, it represents a true shift in mindset aimed at generating public value and building a more inclusive, participatory, and effective government (Viana, 2021).

The Organization for Economic Co-operation and Development (OECD) defines digital government as the use of digital technologies to modernize government operations, aiming to generate public value. Unlike e-government, which focuses on the use of Information and Communication Technologies (ICT) to enhance operational efficiency and governance methods, digital government proposes a broader evolution. It promotes a paradigm shift by transforming service delivery and governmental processes into "digital by design" practices (Gardenghi et al., 2020).

According to the Brazilian Government GOV.br (2023), user-centered services are those that: i) are easy to find and understand; ii) require the least number of steps possible; iii) are accessible to everyone who needs to use them; iv) function in a way that feels familiar to the user; v) are consistent throughout the entire digital journey (not just parts of it). Understanding users' needs and promoting service quality assessments are essential for public acceptance (GOV.br, 2023).

In this context, Requirements Engineering becomes crucial for the production of quality software, with Human-Centered Design (HCD) practices supporting the process by helping to understand users' needs (Carreira et al., 2022; Neto et al., 2020; Pedrosa et al., 2022; Pereira & Marczak, 2020; Santos et al., 2022). ISO 9241-210:2019 (International Organization for Standardization, 2019) defines HCD as an approach to system design and development that aims to make interactive systems more usable by focusing on system usage and applying knowledge and techniques from human factors, ergonomics, and usability. Although the term "human-centered design" emphasizes the impact on a wide range of stakeholders—not just direct users—the terms "user-centered" and "human-centered" are often used interchangeably.

Additionally, there is a growing emphasis on the use of agile methodologies, as established by Ordinance SGD/MGI 750 of the Secretariat of Digital Government of the Ministry of Management and Innovation in Public Services (PortariaSGD750, 2023). This ordinance recommends adopting a software development process segmented into short iterations, frequent deliveries, and well-defined scopes. In this agile context, Requirements Engineering can integrate HCD to address challenges such as the lack of formal documentation and ensure a proper understanding of customer needs (Keshk et al., 2022).

Although there is extensive research correlating Requirements Engineering with HCD techniques such as prototyping (Bjarnason et al., 2021), usability testing (Keshk et al., 2022), personas (Pinheiro et al., 2019), user journey mapping (Carlos Filho et al., 2021), and Design Thinking (Pereira & Marczak, 2020), there is a noticeable lack of studies focusing on government projects. This work aims to advance the understanding of the integration of Agile Requirements Engineering and HCD techniques through a case study in a Brazilian public company that develops systems used by citizens. The purpose of this case study is to encourage system development teams to adopt HCD techniques, promoting the improvement of the quality of digital services widely used by society.

The remainder of the paper is organized as follows: Section 2 presents the theoretical foundation; Section 3 discusses related work; Section 4 describes the methodology used; Section 5 presents the results obtained; and finally, Section 6 provides final considerations and suggestions for future work.

2. Theoretical Framework

This section provides an overview of Human-Centered Design (HCD) and Agile Requirements Engineering.

2.1. Human-Centered Design

According to Grilo (2019), HCD emerges as an approach in which product decisions are guided by the diverse characteristics of the target audience. Human-centered design involves understanding experiences and narratives related to the circumstances users face (Grilo, 2019).

User-centered thinking is a powerful tool for creating innovative products. To ensure that systems provide meaningful experiences, it is crucial to understand what people seek and what motivates them. A product should be a direct solution to users' problems.

According to International Organization for Standardization (2019), User Experience (UX) encompasses users' perceptions and responses resulting from the actual and/or anticipated use of a system, product, or service. These perceptions and responses include users' emotions, beliefs, preferences, perceptions, comfort, behaviors, and accomplishments before, during, and after use.

HCD shifts the focus to human aspects. Ignoring these principles may lead to consequences such as: (i) lack of product or service adoption; (ii) switching to competitors; (iii) increased training and support costs; (iv) inefficiency in usage; and (v) user dissatisfaction and operational errors (Venson et al., 2022). The following sections describe some techniques associated with HCD.

2.1.1. Prototyping

A prototype is a sample, model, or initial release that simulates one or more aspects of the final product (Olsen, 2015). Prototyping is a requirements engineering practice that allows obtaining feedback on requirements directly from the client. According to Warfel (2011), the requirements process with prototyping significantly contributes to reducing inefficiencies and waste, standing out for the following benefits: (i) reduction of misinterpretation; (ii) tangible experience; (iii) resource savings; (iv) interdisciplinary engagement; (v) exploration of alternatives; (vi) product focus; and (vii) early identification of errors.

Applying prototyping in the early stages of product development offers several benefits, such as testing ideas, avoiding misunderstandings, encouraging constructive criticism, and involving professionals from all sectors related to the product's lifecycle. It is essential to conduct early testing, without waiting for the software to be fully completed. On the contrary, the earlier these tests are conducted, the greater the chances of identifying and correcting issues before investing unnecessary time and resources. Including wireframes alongside a requirements document can increase the accuracy of a written requirement by up to 80% (Warfel, 2011).

However, there is a misconception that using prototypes delays the process by consuming time with simulations. In practice, prototyping accelerates results by enabling learning through trial and error, while facilitating decision-making about which direction to follow (Olsen, 2015).

2.1.2. Usability Testing

Usability testing is one of the most widely used and well-known research techniques in the context of Human-Centered Design (HCD) (Nielsen, 2012). According to ISO9241-11 (2018), usability is defined as the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction.

Usability testing is a valuable tool for evaluating products by involving real users interacting with the designed solution. It analyzes user behavior, actions, and movements, linking their verbal expressions to their reactions regarding the product (Grilo, 2019). The use of prototypes and usability testing is recommended in the literature as an effective strategy to mitigate failures in software projects (Lauesen, 2020).

2.1.3. Design Thinking

Design Thinking (DT) has stood out as an effective approach to help developers better understand users' real needs by leveraging empathy, creativity, and rationality. DT is user-centered and aims to solve complex problems through innovation and iteration (Parizi et al., 2022).

Research conducted by Pereira et al. (2021) indicates that DT improves requirements gathering and specifi-

cation, promoting greater collaboration, communication, and understanding of user needs. Rapid prototyping and a human-centered focus present a promising approach to dealing with ambiguous and volatile requirements from various project stakeholders (Hehn et al., 2019).

However, challenges persist, including a lack of appreciation for the approach, insufficient time to explore user needs, a shortage of experienced professionals in DT, and low stakeholder engagement. Research by Canedo et al. (2022) has shown that developers' lack of knowledge limits the adoption of DT in industrial practice.

2.1.4. Personas

The personas technique is a user-centered approach used to explore and organize data about end-users (Pinheiro et al., 2019). Personas are fictional, specific, and detailed representations of target users. They provide a clear identity for the user, creating a memorable, engaging, and actionable image that serves as a focal point for the design process (Pruitt & Adlin, 2010). Furthermore, personas communicate information more effectively than other artifacts, helping the product team and organization stay focused on users' needs and expectations.

According to Pruitt and Adlin (2010), the application of personas provides the following benefits: (i) exploration of assumptions and knowledge; (ii) user focus; and (iii) generation of empathy.

Although personas offer a wealth of qualitative data, their traditional creation requires significant time and effort in data collection, making it a costly technique. As an alternative, (Pinheiro et al., 2019) propose the use of proto-personas. This agile approach allows designers and developers to quickly create personas based on prior knowledge of the target audience.

2.1.5. User Journey Mapping

According to Melo and Abelheira (2015), User Journey Mapping is used to deepen the understanding of an experience by analyzing its positive and negative aspects along a timeline. A user journey map should illustrate a specific journey for a persona, incorporating elements such as feelings or emotions, needs, barriers, and other relevant metrics aligned with the organization's goals (Carlos Filho et al., 2021).

This technique enables the identification of requirements from the user's perspective, which differentiates it from other approaches. Insights derived from user observations or statements can reveal valuable opportunities (Carlos Filho et al., 2021).

2.1.6. UX Writing

UX Writing is the process of creating text that shapes user interactions with an interface. This includes elements such as titles, buttons, labels, instructions, descriptions, notifications, alerts, and controls visible to the user. The process begins by identifying the project's purposes, opportunities, and constraints. Before writing, the professional must understand both the users' and the organization's goals (Podmajersky, 2019).

To define these goals, the writer collaborates with experts who understand them and with the users themselves, always in a co-creation process. From the early stages of ideation and development, the writer should actively participate in team meetings, contributing to the discovery, design, and refinement of the experience. UX Writing is thus an iterative process involving creation, evaluation, and continuous improvements.

Besides being a key component in product design and development, UX Writing aims to create content that guides users throughout their interactions, providing a more fluid and satisfying experience. According to Lentez and Mager (2023), this work not only improves navigation but also increases user engagement and satisfaction, enhancing the product's success. However, it requires a deep understanding of the target audience, the product or service, and the context in which they will be used (Lentez & Mager, 2023). UX Writers must balance clarity, conciseness, and personality to meet user expectations and organizational goals.

2.1.7. Plain Language

The Plain Language technique aims to make information more understandable to everyone, reducing barriers to inclusion (Oliveira et al., 2023). Clear comprehension is essential, especially when presenting information intended for citizens. Complex texts can pose a significant barrier to interacting with e-government systems, particularly in contexts with low literacy levels and limited access to support resources. The writing style commonly associated with the public sector often uses dense and complex linguistic constructions, making reading and comprehension difficult (Fischer et al., 2019).

Plain Language seeks to promote universal accessibility by creating clear texts that can be easily understood by people with different literacy levels (Fischer et al., 2019). When applied to Requirements Engineering, it can improve communication among developers, stakeholders, and end-users. Its application spans various areas, including technical documentation, user interfaces, and user stories.

2.2. Agile Requirements Engineering

The study by Lauesen (2020) revealed that the main cause of failures in projects is related to requirements. Missing, ambiguous, or incomplete requirements can result in errors in the final system, rework, customer dissatisfaction, and schedule delays. Gralha et al. (2018) highlighted that the requirements process has significant impacts on the product, the team, and the organization. Agile requirements engineering faces challenges such as: Insufficient user stories to adequately communicate the requirements, Interpretation errors and lack of understanding of the requirements and Requirement changes during development.

2.3. Related Work

This section provides a review of previous research related to the theme of this work. Various approaches integrating agile requirements engineering and Human-Centered Design (HCD) have been discussed in the literature, describing their relationships, challenges, and difficulties.

The study by Kusuma et al. (2024) proposes the Emotion Map to capture emotions during requirements elicitation, contributing to more adequate specifications. Another study by the same authors highlights methods such as interviews and usability testing to integrate UX into requirements engineering, emphasizing the benefits of reducing errors and improving software quality (Kusuma et al., 2023).

Techniques like lean persona, addressed by Teixeira and Zaina (2022), help document requirements in both startups and established companies. (Martinelli et al., 2022) show the importance of clear and measurable acceptance criteria to ensure user satisfaction. A. B. Marques et al. (2022) analyze the incorporation of usability into user stories in remote agile environments, highlighting communication and collaboration challenges.

Approaches such as those by Keshk et al. (2022) integrate prototypes and user stories into the agile flow to improve the clarity of requirements. Parizi et al. (2022) explore the application of Design Thinking (DT) in defining requirements, facing challenges in integrating with agile methods. Studies by Zorzetti et al. (2022), Zorzetti et al. (2020), and Machado et al. (2020) discuss the combination of HCD and Lean Startup with agile methodologies, promoting rapid adaptation and continuous feedback.

Other works, such as those by Bjarnason et al. (2021) and Pereira et al. (2021), propose frameworks and standards to guide teams in incorporating UX into agile requirements. Souza et al. (2020) present a recommendation tool to support the teaching of DT in requirements elicitation. Almeyda et al. (2021) analyze the integration of UX with agile methods, highlighting benefits such as more intuitive products and challenges such as resistance to change.

Parizi et al. (2021) and Carlos Filho et al. (2021) propose tools to recommend DT techniques and improve the specification of requirement scenarios. L. Marques et al. (2020) explores the post-interaction journey to map the user experience and identify improvements. Cleto Filho and Zaina (2020) discuss the integration of UX into user stories in remote agile environments. Studies also address how clients can contribute to defining requirements through proto-personas, enriching communication between stakeholders (Pinheiro et al., 2019). The studies presented explore how Human-Centered Design (HCD) practices can mitigate challenges

found in agile requirements engineering. This work distinguishes itself by analyzing the context of government projects, which bring specific challenges and scenarios.

The previously mentioned works do not consider the environment of a large public enterprise. In the case of agile process models, organizational culture influences the effectiveness of applying agile practices (Looks et al., 2024). Moreover, in the public sector, software development often occurs through external contracts (Looks et al., 2024).

3. Methodology

This work was conducted in 2024 at an information technology company within the Brazilian Federal Public Administration. The company has national presence, a robust technological infrastructure, and extensive experience with large systems. For over 50 years, it has developed solutions that enable control, transparency, and simplify the relationship between society and the government. Information was collected to assess the company's current scenario regarding the use of HCD techniques in the requirements engineering (RE) process, through the application of a questionnaire.

The questionnaire was developed based on the perceptions collected by the author in the daily work environment. The main objective was to assess the application of the studied techniques and the value perceived by participants in relation to them. To achieve this, questions were formulated to capture both the frequency of use of the techniques and the perception of their usefulness and impact. The questions are driven by the goal of understanding the adoption of the investigated practices within the participants' context.

To ensure that the questionnaire items adequately cover the construct we aim to measure, it was reviewed by two expert professors who are co-authors of this study. Additionally, it underwent a preliminary validation with a colleague from the company, who assessed the clarity and comprehensibility of the questions. The questionnaire was approved by the Research Ethics Committee with Human Beings. The academic research was authorized by the company.

3.1. Questionnaire design

The instrument used for data collection was a structured questionnaire with both closed and open-ended questions, divided into two sections: demographic information and participants' perception of the use of Human-Centered Design techniques. Below are the main questions:

- Demographics (Years in the company, Gender, Age)
- What role do you perform in your team?
- How much experience do you have with Requirements Engineering activities?
- How much experience do you have with User Experience activities?
- Have you applied or used the results of any of the following techniques: Persona Creation, User Journey, Design Thinking, Prototyping, User Testing, UX Writing, or Plain Language?
- Which of these techniques have you applied or used the results of?
- To what extent do you find these techniques valuable when used in the requirements engineering process?
- What benefits did you observe from applying these approaches?
- What limitations/drawbacks did you observe in these approaches?

The data analysis scope for this article focuses exclusively on the closed-ended questions. We invited software engineering practitioners to participate. The target population comprised 200 employees, with invitations sent via email. The research received 166 responses.

3.2. Data analysis

The data description utilized frequency tables displaying absolute values, percentages, and response rates by category for variables allowing multiple selections. To verify the relationship between team roles and the use or non-use of the studied techniques, a logistic model was constructed due to the possibility of multiple roles

within the team. The goodness of fit was checked using the Hosmer and Lemeshow Test, and the explanatory power was assessed using the Nagelkerke coefficient.

To check the association between categorical variables, the Chi-square Test was used, followed by a post hoc multiple comparisons test with Bonferroni adjustment to identify differences in variables with more than two levels. To verify the relationship between the values assigned to the techniques and other variables, the Cochran-Armitage Test (linear trend test) was used, as both the response and explanatory variables are ordinal. In cases of statistically significant differences, the Kendall Tau Correlation Coefficient was also calculated to identify possible monotonic trends in the levels of the explanatory variable. IBM SPSS Statistics 20 was used for the analysis. Due to the exploratory nature of the study in the field, where the effects may be subtler, the significance level adopted throughout the analysis was 10%.

3.3. Participants and sampling

In order to characterize the sample and examine the behavior of categorical variables, Table 1 presents the absolute and relative frequencies. Table 1 describes the participants' profile, highlighting that the majority have been with the company for more than 10 years (61.45%). The predominance of men (75.90%) is evident. Regarding age, the most represented range is between 36 and 45 years (34.34%). Nearly half of the respondents (47.59%) hold more than one role in the team. The "Implementer" role is the most common, practiced by 61.45% of individuals, followed by "Requirements Analyst" with 40.96%.

Tab. 1 – Data description.

Variables	Freq. Absolute	Freq. Percentage	Respondents (%)
How many years have you been with the company?			
Less than 1 year	63	37.95	-
From 1 to 2 years	1	0.60	-
More than 10 years	102	61.45	-
Gender			
Man	126	75.90	-
Woman	38	22.89	-
I prefer not to say	2	1.20	-
Age			
18-25	12	7.23	-
26-35	30	18.07	-
36-45	57	34.34	-
46-55	39	23.49	-
Over 55	28	16.87	-
Do you take on more than one role on the team?			
Yes	79	47.59	
No	87	52.41	
Role in the team			
Requirements Analyst	68	21.05	40.96
Function Point Estimator	38	11.76	22.89
Manager	27	8.36	16.27
Implementer	102	31.58	61.45
UX Designer	25	7.74	15.06
Tester	52	16.10	31.33
Other	11	3.41	6.63

4. Results

Table 2 presents the description of the variables related to the design capabilities studied. Based on the analysis of Table 2, it is highlighted that 63.25% of participants have applied or used the results of design techniques, with "Prototyping" (59.64%) being the most used, followed by "User Testing" (34.34%). Regarding experience, 43.37% have no experience in UX activities. For Requirements Engineering, 30.72% have more than 10 years of experience.

Tab. 2 – Description of data related to the design capabilities studied.

Variables	Freq. Absolute	Freq. Percentage	Respondents (%)
Time of experience with Requirements Engineering activities			
None	54	32.53	-
Up to 2 years	32	19.28	-
3 to 5 years	16	9.64	-
6 a 10 years	13	7.83	-
More than 10 years	51	30.72	-
Time of experience with User Experience (UX) activities			
None	72	43.37	-
Up to 2 years	55	33.13	-
3 a 5 years	32	19.28	-
6 a 10 years	5	03.01	-
More than 10 years	2	1.20	-
Which techniques below have you already applied or used the results?			
Personas	54	17.03	32.53
User Journey	48	15.14	28.92
Design Thinking	27	8.52	16.27
Prototyping	99	31.23	59.64
User Testing	57	17.98	34.34
UX Writing	11	3.47	6.63
Plain Language	21	6.62	12.65
Value Personas			
Very low	4	4.21	-
Low	25	26.32	-
High	41	43.16	-
Very high	25	26.32	-
Value User Journey			
Very low	3	3.23	-
Low	4	4.30	-
High	40	43.01	-
Very high	46	49.46	-
Value Design Thinking			
Very low	2	2.38	-
Low	8	9.52	-
High	38	45.24	-
Very high	36	42.86	-
Value Prototyping			
Very low	1	0.97	-
Low	0	0.00	-
High	23	22.33	-
Very high	79	76.70	-
Value Testing with Users			
Very low	2	2.20	-
Low	4	4.40	-
High	23	25.27	-
Very high	62	68.13	-
Value UX Writing			
Very low	4	5.71	-
Low	17	24.29	-
High	34	48.57	-
Very high	15	21.43	-
Value Plain Language			
Very low	2	2.70	-
Low	14	18.92	-
High	36	48.65	-
Very high	22	29.73	-

To identify which roles within the company might be linked to a higher use of the discussed methods, Table 3 was developed. The logistic model displayed below models the variable "Uses any of the mentioned techniques?" based on variables related to the roles held within the company. Table 3 shows that the majority of individuals, regardless of the role assumed, have used or applied the results of some HCD technique. It can also be observed that some roles significantly alter the likelihood of being classified as a user of the mentioned techniques. Individuals who are Requirements Analysts are twice as likely to be users of these techniques (compared to those who do not hold this role). Similarly, Function Point Estimators are 3.239 times more likely, and Managers are 2.987 times more likely to be users of some of the techniques. On the other hand, Implementers are 61.4% less likely to use the aforementioned techniques. The model shows a good fit (p-value = 0.922) and explains 38.7% of the variability in the response variable.

Tab. 3 – Logistic Model with explanatory dummies defined based on the variable "Role in the team".

Role in the team	Use techniques		( )	DP	P-value	Exp( )
	Yes	No				
Requirements Analyst	54	14	0.693	0.411	0.092	2.000
Function Point Estimator	34	4	1.175	0.633	0.064	3.239
Manager	22	5	1.094	0.519	0.035	2.987
Implementer	54	48	-0.488	0.246	0.047	614
UX Designer	25	0	20.326	7327.391	998	> 100
Tester	39	13	0.206	0.440	0.640	1.228
Percentage of correct predictions	76.2	62.3	Média = 71.1			
Nagelkerke = 0.387						
P-value = 0.922 (Hosmer test and Lemeshow)						

To verify the relationship between the use or non-use of the studied techniques and other categorical variables, Table 4 was developed. It is important to note that one individual was excluded from the analysis when crossing "How many years have you been with the company?" with "Uses any of the mentioned techniques?", as they were the only representative of their level in the table, which did not provide useful information, violated the test assumptions, and inflated the p-value.

We observed that individuals with more than 10 years in the company are more likely not to use the techniques (71 out of 102). Individuals in the age range of 26 to 35 years are more likely to adopt the techniques. Those who perform more than one role in the team significantly use the techniques more ($p < 0.0001$). In this context, potential relationships between the assigned values and other variables of interest were analyzed. No relevant associations were identified between team roles and the value assigned to the techniques of Design Thinking, User Journey, User Testing, UX Writing, Plain Language, and Persona Creation.

However, Table 4 reveals a significant association for the Implementer role with the Prototyping value ($p = 0.026$; Tau = -0.216). This suggests that implementers are less likely to value this technique. On the other hand, Requirements Analysts show a positive trend, although marginally significant ($p = 0.084$; Tau = 0.237), indicating a higher valuation of this technique.

5. Discussion

5.1. Demographic Data

The respondent profile is predominantly male, in the age range of 36 to 45 years. The male predominance may reflect a historical pattern in the Information Technology field, where men have traditionally occupied most positions. Despite efforts to increase diversity, female representation is still lower in many parts of the world. The age range of 36 to 45 years may indicate a significant presence of professionals with established experience. This result could lead to discussions about workplace diversity, as well as gender and age.

The high frequency of the "Implementer" role may indicate that the organization is focused on technical execution and software development. This suggests that the organization places emphasis on the technical delivery

Tab. 4 – Relationship between use of techniques and other variables of interest.

Variable	Use techniques Yes	No	P-value	Groups**
How many years have you been with the company?				
Less than 1 year	30	33	0.0393*	-
More than 10 years	31	71		-
Age range				
18-25	5	7	0.0132*	ab
26-35	18	12		b
36-45	18	39		ab
46-55	8	31		a
Over 55	12	16		ab
Has more than one role in the company?				
Yes	63	16	<0.0001*	-
No	42	45		-

of solutions, with a workforce concentrated on "making things happen."

The high incidence of Requirements Analysts may point to a concern with the elicitation and definition of requirements. This is a positive sign of maturity in software development processes, as it indicates attention to the early stages of the system life cycle, when requirements are gathered, analyzed, and validated. The relevance of requirements analysts may signify that the organization recognizes the importance of understanding the client's problem.

5.2. Use of HCD Techniques

Table 2 shows the design techniques adopted by the participants. The analysis of some aspects is as follows:

High adoption of design techniques (63.25%). An adoption rate above 60% indicates that the techniques are relevant and applicable to the participants' work.

Prototyping as a highlight (59.64%). The use of prototyping as the most applied technique is a positive indicator, as it allows for the quick visualization and testing of solutions, reducing risks in development and improving the quality of deliveries as pointed out by Bjarnason et al. (2021).

User Testing (34.34%). Although less used by participants than other techniques, user testing is a relevant technique for validating designed solutions based on real feedback. Its adoption demonstrates that participants are also concerned with the end-user experience. These findings are consistent with the studies by Kusuma et al. (2023). However, the significant difference between the use of prototyping (59.64%) and user testing (34.34%) may indicate barriers to implementing user testing. Possible reasons could include: (i) difficulty in accessing representative users; (ii) additional costs and resources required to organize tests; (iii) lack of familiarity or confidence in the technique as listed in the challenges of the work by Kusuma et al. (2023).

Moderately used techniques. Results placing Persona Creation (32.53%), User Journey (28.92%), and Design Thinking (16.27%) at a moderate level suggest some reflections on their application. Some participants are applying the Persona Creation and User Journey techniques, indicating recognition of their value, but the percentages suggest that not all projects or teams see them as essential. Their application might be viewed as relevant only in specific contexts. The even lower adoption of Design Thinking suggests difficulties in its incorporation into daily work. These techniques may be seen as time-consuming or complex, especially in contexts with tight deadlines and lean teams. There may be a misalignment with the reality of the projects, which requires adaptations to make them more relevant, as proposed by Pereira and Marczak (2020).

Less used techniques. The fact that the least used techniques are UX Writing (6.63%) and Plain Language (12.65%) may indicate challenges in their application. These techniques have a qualitative impact (improved communication, greater clarity for users), which may make it harder to prioritize them compared to techniques with a more direct impact, such as prototyping. Below is the analysis of some of these challenges:

- **Limited familiarity with the techniques.** These techniques may be less known to the participants, making their application in daily work more difficult.
- **Perception of relevance.** Participants may not perceive the relevance of these techniques for their activities and may be unaware of the results they can yield.
- **Lack of resources.** Implementing these practices may require cultural or organizational changes, such as greater collaboration between teams or process adaptations.

5.3. Perception of Value of HCD Techniques

The percentages presented for the value attributed to the techniques reflect the different impressions participants have about their importance. The main points are as follows:

High Perception of Value for Prototyping and User Testing. Prototyping (76.70%) is the technique with the highest perceived value, indicating that participants recognize the effectiveness of visualizing and testing solutions before implementation as addressed by Keshk et al. (2022). This result aligns with its high adoption rate (59.64%), reinforcing the connection between perceived value and actual use. The perception of value is also high for User Testing (68.13%), suggesting that participants recognize its impact. Despite this, its practical adoption (34.34%) is lower, implying that there may be barriers to its implementation.

Intermediate Perception of Value for Persona Creation and User Journey. The perception of value for Persona Creation (26.32%) may indicate that participants struggle to directly link personas to project outcomes. Some may view it as a theoretical exercise. The User Journey (49.46%) is rated higher than Persona Creation. This could be because mapping the journey provides more visible insights into touchpoints and opportunities for improvement.

Low Perception of Value for UX Writing and Plain Language. The values attributed to UX Writing (21.43%) and Plain Language (29.73%) suggest that participants may not fully understand the importance of these techniques in creating clear and effective communication.

5.4. Use of HCD Techniques According to the Role in the Team

Regarding the use of HCD techniques based on the role within the team, there is high adoption among Requirements Analysts, Function Point Estimators, and Managers. However, there is low adoption among Implementers. Below is an analysis of the results:

High Adoption Among Requirements Analysts, Function Point Estimators, and Managers

- Requirements Analysts (2x more likely). Since these professionals are directly involved in the elicitation, definition, and documentation of requirements, it is natural for them to see more value and applicability in design techniques, especially those focused on the user, such as prototyping, persona creation, and user journey. This suggests that the techniques align well with the responsibilities of those in this role.
- Function Point Estimators (3.239x more likely). This group is often involved in measurements that assess complexity and development effort. Design techniques can be seen as useful tools for refining requirements, making estimates more accurate. The high adoption rate may indicate that these professionals recognize the impact of these techniques on scope definition and reducing ambiguity.
- Managers (2.987x more likely). Managers tend to value tools that help align expectations with stakeholders, reduce risks, and improve value delivery.

Low Adoption Among Implementers (61.4% less likely)

- Distance from the design process. Implementers may feel less connected to the design process or view these techniques as outside their main responsibilities. This could reflect a traditional division between design and implementation, where implementers are more focused on technical execution.
- Lack of visibility of the impact. These professionals may not perceive how design techniques can directly benefit their work.
- The data highlights that design techniques are more widely used by those directly involved in defining requirements or managing projects, while those focused on implementation tend to underuse them.

5.5. Factors Influencing the Application or Use of Technique Results

Table 4 provides insights into the factors influencing the adoption of design techniques. The analysis is divided into three main perspectives: age group, role accumulation, and years with the company.

1. Greater Adoption in the 26 to 35 Age Group

- Possible correlation with experience and flexibility. Individuals in this age group may be at the beginning or peak of their careers, where: (i) they are more exposed to new trends, practices, and work methodologies, and (ii) they demonstrate a greater willingness to experiment and apply innovative techniques.
- Recent academic training. This generation may have had more exposure to design techniques during their education, making them more familiar with them.

2. Greater Use of Techniques by Those Playing Multiple Roles

- Holistic view of the project. Individuals with multiple roles have a broader understanding of the processes and needs of the project, which facilitates the adoption of techniques that connect different areas.
- Need for adaptation. The multiplicity of functions requires these professionals to seek more efficient solutions.
- Autonomy and decision-making. These professionals likely have more responsibilities within the project, motivating them to adopt tools that can generate better results.

3. Lower Use of Techniques Among Individuals with More Than 10 Years in the Company This presents an interesting contrast with the previous results. We suggest some possibilities for this difference:

- Resistance to change. Professionals with more years in the company may be more accustomed to established practices, showing resistance to adopting new approaches. This may include the perception that the proposed changes are unnecessary in relation to what already works well.
- Less exposure to recent training. Individuals with more time in the organization may have had less access to recent training that emphasizes these techniques.

5.6. Factors Influencing the Perception of Value of the Techniques

The result that implementers are less likely to value the technique and that requirements analysts show a positive trend may indicate:

Differences in Responsibilities and Focus of Roles. Implementers are more focused on the technical execution of solutions and code implementation rather than delving into user-centered design practices or early planning stages. Since these techniques are applied during the initial phases of the development cycle, implementers may view them as less relevant to their work.

Role of Requirements Analysts. Requirements analysts play a key role in translating user needs into technical requirements. This makes design techniques directly applicable to their work. Design techniques help better understand user requirements, aligning well with their responsibilities. This alignment tends to promote the appreciation of these techniques. The "marginally significant" trend may suggest that, while they recognize the benefits, the adoption of these techniques might not be as robust. Other more traditional approaches may still be perceived as sufficient or more practical.

These results indicate that, while requirements analysts recognize the utility of design techniques, implementers may need more convincing regarding the importance of these techniques in the development cycle. Thus, the findings of this research are consistent with the related works previously discussed, reaffirming the relevance of HCD techniques in supporting Agile Requirements Engineering. However, this study advances the field by deepening the analysis of how these techniques are used and perceived, specifically considering the role taken by each team member within the projects. Furthermore, it contributes by discussing the factors that influence this usage and the perceived value attributed to the techniques, framing these analyses within the specific context of governmental projects. It is therefore expected that the results presented here can support both theoretical reflection and practical application in similar environments, broadening the understanding of HCD implementation in complex and challenging organizational contexts.

6. Conclusion

The research revealed significant adoption of Human-Centered Design (HCD) techniques in the organization analyzed, demonstrating that these methods are considered relevant and applicable to the participants' work and can bring substantial improvements to digital government initiatives. Among the techniques, prototyping emerged as the most widely used, reinforcing its effectiveness. User testing also shows good usage, although there may be barriers to its broader implementation.

Techniques such as Persona Creation, User Journey Mapping, and Design Thinking showed moderate usage, while techniques like UX Writing and Plain Language had low application, indicating opportunities for greater dissemination and training in these areas. The perception of the techniques' value was aligned with their frequency of use, highlighting a direct relationship between practical application and recognition of benefits.

The analysis also revealed that the adoption of techniques varies depending on the roles played within the team. Requirements Analysts, Function Point Estimators, and Managers demonstrated high adoption, while Implementers showed lower application, likely due to differences in responsibilities and focus. In addition, factors such as age, role accumulation, and time in the company influence the application of the techniques.

In summary, the results reinforce the importance of expanding HCD training, particularly for groups with lower adoption and promoting underutilized techniques to maximize benefits in the Agile Requirements Engineering process. Aligning responsibilities, demonstrating how each role within the team can benefit from HCD techniques, fostering a collaborative environment, and reinforcing how these practices contribute to the entire development cycle can encourage broader adoption.

In future work, we propose to conduct focus groups to deepen the discussions based on the responses obtained from the questionnaire, allowing for a more comprehensive understanding of the investigated aspects. The composition of these groups should consider the diversity of participants—in terms of roles, experiences, and organizational contexts—to ensure multiple perspectives on the topics addressed. Additionally, we intend to further explore the specificities of agile methodology adoption, emphasizing the analysis of the integration between HCD practices and agile principles in governmental projects.

Acknowledgement

We thank Serviço Federal de Processamento de Dados (SERPRO) for funding part of this research. Author André Pimenta Freire thanks the National Council for Scientific and Technological Development (CNPq) for a research fellowship that supported his work. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001

References

Almeyda, S., Río, C. Z. D., & Cohn, D. (2021). Integration of user experience and agile techniques for requirements analysis: A systematic review. *Proceedings of the International Conference on Human-Computer Interaction (HCII)*, 187–203. DOI: https://doi.org/10.1007/978-3-030-78221-4_13.

Bjarnason, E., Lang, F., & Mjöberg, A. (2021). A model of software prototyping based on a systematic map. *Proceedings of the 15th ACM / IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM)*, 1–11. DOI: https://doi.org/10.1145/3475716.3475772.

Canedo, E. D., Calazans, A. T. S., Silva, G. R. S., Costa, P. H. T., de Mesquita, R. P., & Masson, E. T. S. (2022). Creativity and design thinking as facilitators in requirements elicitation. *International Journal of Software Engineering and Knowledge Engineering*, *32*(10), 1527–1558.

Carlos Filho, J., Damian, A., Parizi, R., dos Santos Marczak, S., & Conte, T. (2021). Aplicando técnicas de design thinking para a especificação de cenários na elicitação de requisitos. *Anais do XXIV Workshop em Engenharia de Requisitos (WER 2021), 2021, Brasil.*

Carreira, I. P., Guerino, G. C., Teixeira, H. M. P., & Valle, P. H. D. (2022). Práticas de ihc como apoio à engenharia de requisitos: Um relato de experiência. *Anais da VI Escola Regional de Engenharia de Software (ERES 2022)*, 1–10. DOI: https://doi.org/10.5753/eres.2022.226999.

Cleto Filho, A., & Zaina, L. A. (2020). Navigational distances between ux information and user stories in agile virtual environments. *ICEIS (2)*, 185–192.

Fischer, H., Mont'Alvão, C., & dos Santos Rodrigues, E. (2019). O papel do texto na compreensibilidade de e-serviços. *Ergodesign & HCI*, *7*(Especial), 207–219.

Gardenghi, J. L., Pereira, L. G., Alcantara, S. M., Figueiredo, R. M., Ramos, C. S., & Ribeiro Jr, L. C. (2020). Digitalization by means of a prototyping process: The case of a brazilian public service. *Information*, *11*(9), 413.

GOV.br. (2023). Governodigital. https://www.gov.br/governodigital/pt-br

Gralha, C., Damian, D., Wasserman, A. I. (, Goulão, M., & Araújo, J. (2018). The evolution of requirements practices in software startups. *Proceedings of the 40th International Conference on Software Engineering*, 823–833. DOI: https://doi.org/10.1145/3180155.3180158.

Grilo, A. (2019). *Experiência do usuário em interfaces digitais* (1st ed.).

Hehn, J., Mendez, D., Uebernickel, F., Brenner, W., & Broy, M. (2019). On integrating design thinking for human-centered requirements engineering. *IEEE Software*, *37*(2), 25–31.

International Organization for Standardization. (2019, March). Ergonomia da interação homem-sistema — parte 210: Design centrado no ser humano para sistemas interativos. iso 9241-210:2019(pt). DOI: https://doi.org/N/A.

ISO9241-11. (2018). Iso 9241-11:2018(en) ergonomics of human-system interaction, disponível em https://www.iso.org/obp/ui/iso:std:iso:9241:-11:ed-2:v1:en, acesso em 11/12/23.

Keshk, N., El-Ramly, M., & Salah, A. (2022). A proposal for enhancing agile requirements engineering with prototyping and enriched user stories. *Federated Africa and Middle East Conference on Software Engineering*, 59–63. DOI: https://doi.org/10.1145/3531056.3542773.

Kusuma, W. A., Jantan, A. H., Admodisastro, N. I., & Norowi, N. M. (2023). Capturing user experience of customer-centric software process through requirement process: Systematic review. *JOIV : International Journal on Informatics Visualization*, *7*, 760. DOI: https://doi.org/10.30630/joiv.7.3.1499.

Kusuma, W. A., Jantan, A. H. b., Abdullah, R. b., Admodisastro, N., et al. (2024). Capturing emotion in user requirement through emotion map for solo software developer. *AIP Conference Proceedings*, *2927*(1).

Lauesen, S. (2020). It project failures, causes and cures. *IEEE Access*, *8*, 72059–72067. DOI: https://doi.org/10.1109/ACCESS.2020.2986545.

Lentez, A., & Mager, G. (2023). Exploring the potential of chatgpt in enhancing user experience (ux) writing. *Human Interaction & Emerging Technologies (IHIET 2023)*, *111*(111).

Looks, H., Fangmann, J., Thomaschewski, J., Escalona, M.-J., & Schön, E.-M. (2024). Towards improving agility in public administration. *Software Quality Journal*, *32*(1), 283–311.

Machado, M., Salerno, L., Marczak, S., & Bastos, R. (2020). Assessment models for evaluating the combined use of agile, user-centered design and lean startup in the context of software development: A grey literature review. *Proceedings of the XIX Brazilian Symposium on Software Quality*, 1–10.

Marques, A. B., Costa, A. F., Santos, I., & Andrade, R. (2022). Enriching user stories with usability features in a remote agile project: A case study. *Proceedings of the XXI Brazilian Symposium on Software Quality*, 1–10. DOI: https://doi.org/10.1145/3571473.3571496.

Marques, L., Amazonas, M., Castro, T., Assuncao, W., Zaina, L., Gadelha, B., & Conte, T. (2020). Ux trek: A post-interaction journey from immersive experience logs. *Proceedings of the 19th Brazilian Symposium on Human Factors in Computing Systems*, 1–6.

Martinelli, S., Nascimento, N., Souza, J., Sales, A., & Zaina, L. (2022). Ux requirements matters: Guidelines to support software teams on the writing of acceptance criteria. *Proceedings of the XXXVI Brazilian Symposium on Software Engineering*, 398–408.

Melo, A., & Abelheira, R. (2015). *Design thinking & thinking design: Metodologia, ferramentas e uma reflexão sobre o tema*. Novatec Editora.

Neto, M., Abich, D., Correa, C., & Parizi, R. (2020). Abordagem metodológica de integração das disciplinas de engenharia de requisitos e interação humano-computador: Um estudo de caso. *Anais do Encontro Nacional de Computação dos Institutos Federais (EnCompIF 2020)*, 85–92. DOI: https://doi.org/10.5753/encompif.2020.11072.

Nielsen, J. (2012, January). Usability 101: Introduction to usability, disponível em https://www.nngroup.com/articles/usability-101-introduction-to-usability/, acesso em 11/12/23.

Oliveira, R., Cappelli, C., & Oliveira, J. (2023). Assessment of public information understanding using plain language and data visualization. *Proceedings of the 16th International Conference on Theory and Practice of Electronic Governance*, 228–234.

Olsen, D. (2015). *The lean product playbook*. Wiley.

Parizi, R., da Silva, M. M., Couto, I., dos Santos Marczak, S., & Conte, T. (2021). A tool proposal for recommending design thinking techniques in software development. *Journal of Software Engineering Research and Development*.

Parizi, R., Prestes, M., Marczak, S., & Conte, T. (2022). How has design thinking being used and integrated into software development activities? a systematic mapping. *Journal of Systems and Software*, *187*, 111217.

Pedrosa, G. V., Judice, A., Judice, M., Araújo, L., Fleury, F., & Figueiredo, R. (2022). Applying user-centered design on digital transformation of public services: A case study in brazil. *DG. O 2022: The 23rd Annual International Conference on Digital Government Research*, 372–379.

Pereira, L., & Marczak, S. (2020). Propondo um processo para mensurar a efetividade do design thinking na engenharia de requisitos. *Anais Estendidos do XIX Simpósio Brasileiro de Qualidade de Software*, 39–46. https://sol.sbc.org.br/index.php/sbqs_estendido/article/view/14191

Pereira, L., Parizi, R., Prestes, M., Marczak, S., & Conte, T. (2021). Towards an understanding of benefits and challenges in the use of design thinking in requirements engineering. *Proceedings of the 36th Annual ACM Symposium on Applied Computing*, 1338–1345.

Pinheiro, E. G., Lopes, L. A., Conte, T. U., & Zaina, L. A. (2019). On the contributions of non-technical stakeholders to describing ux requirements by applying proto-persona. *Journal of Software Engineering Research and Development*, *7*, 8–1.

Podmajersky, T. (2019). *Redação estratégica para ux: Aumente engajamento, conversão e retenção com cada palavra*. Novatec Editora.

PortariaSGD750. (2023, March). Portaria sgd 750/mgi nº 750, disponível em https://www.gov.br/governodigital/pt-br/contratacoes/portaria-sgd-mgi-no-750-de-20-de-marco-de-2023. acesso em 07/12/23.

Pruitt, J., & Adlin, T. (2010). *The persona lifecycle: Keeping people in mind throughout product design*. Elsevier.

Santos, A. A., Mendes, M. E., & Marques, A. B. (2022). Inserindo um olhar de ihc no ensino de engenharia de requisitos: Um relato de experiência. *Anais do XIII Workshop sobre Educação em IHC (WEIHC 2022)*, 13–18. DOI: https://doi.org/10.5753/weihc.2022.227508.

Souza, A., Ferreira, B., Valentim, N., Correa, L., Marczak, S., & Conte, T. (2020). Supporting the teaching of design thinking techniques for requirements elicitation through a recommendation tool. *IET Software*, *14*(6), 693–701.

Teixeira, G. V., & Zaina, L. A. (2022). Using lean personas to the description of ux-related requirements: A study with software startup professionals. *ICEIS (2)*, 211–222.

Venson, E., Correa, G. M., Judice, A. C. B., Judice, M. O., da Silva, W. C. M. P., Costa, F. F., & da Costa Figueiredo, R. M. (2022, April). Experiência do usuário e engenharia de software : Interações, atividades e produtos : Relatório técnico. http://repositorio2.unb.br/jspui/handle/10482/43289

Viana, A. C. A. (2021). Transformação digital na administração pública: Do governo eletrônico ao governo digital. *Revista Eurolatinoamericana de Derecho Administrativo*, *8*(1), 115–136.

Warfel, T. Z. (2011). *Prototyping: A practitioner's guide*. Rosenfeld Media.

Zorzetti, M., Signoretti, I., Pereira, E., Salerno, L., Moralles, C., Machado, M., Bastos, R., & Marczak, S. (2020). An empirical-informed work process model for a combined approach of agile, user-centered design, and lean startup. *Proceedings of the XIX Brazilian Symposium on Software Quality*, 1–10.

Zorzetti, M., Signoretti, I., Salerno, L., Marczak, S., & Bastos, R. (2022). Improving agile software development using user-centered design and lean startup. *Information and Software Technology*, *141*, 106718.

Virtual Visions: An Exploratory Comparative Analysis of EU and US Metaverse Governance Approaches

Summer Boucher-Robinson [a*], *Stanislav* Mahula [b], *Joep* Crompvoets [c]

[a] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, summer.boucher-robinson@student.kuleuven.be, 0009-0000-1666-1936

[b] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, 0000-0003-0568-9604

[c] Faculty of Social Sciences, Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium, 0000-0003-1077-597X

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Metaverse technologies are rapidly emerging and providing innovative opportunities to both the public and private sectors. Despite technological progress, governments worldwide face challenges in keeping pace, resulting in a misalignment of technological capability and governance mechanisms. This research aims to assess the differences in European Union and United States metaverse governance approaches, focusing on how broader digital governance models are being extended into immersive technology domains. This assessment utilizes a qualitative exploratory document analysis and two expert interviews to identify the key governance mechanisms and thematic orientations shaping early policy responses. Despite actions that both the EU and the US are taking to establish metaverse governance models, explicit regulation of immersive technologies remains limited. However, both have existing strategies, regulations, and legislation on related technology topics, such as AI and data privacy, which are expected to directly and indirectly impact the development and management of the metaverse. Drawing on an existing geopolitical technology governance assessment model as a framework, this research upholds existing assertions that the European Union values risk management and user protections in its digital governance and regulation. In contrast, the United States takes two other approaches: the Silicon Valley techno-solutionist approach and the Washington D.C. business-focused laissez-faire approach. These broader digital governance cultures are reflected in how each actor is beginning to position itself with regard to immersive technologies.

Keywords. Metaverse, virtual worlds, tech governance, digital governance, regulation
Research paper, DOI: https://doi.org/10.59490/dgo.2025.995

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1 Introduction

The development of metaverse technology by the private sector for entertainment purposes is featured frequently in the news. As Uzun (2023, p. 231) asserts, the metaverse is "*the next step in the evolution of the Internet,*" transitioning the Internet into a robust, three-dimensional immersive experience. Nonetheless, through public-private partnerships, the public sector is increasingly using metaverse and hybrid technologies for the public good in new ways that experts could not have fathomed.

However, technological solutions are not a silver bullet to public issues. Also described as "*the next internet battleground*" (Anderson & Rainie, 2022, p. 5), the metaverse offers an unprecedented opportunity for both the public and private sectors, but major risks threaten to introduce or perpetuate a whole host of ethical concerns if not governed appropriately. Threats found in both the physical and digital realms also extend to the metaverse (Qamar et al., 2023), and users have reported experiencing hate crimes, sexual assault, cyber and financial crime, and privacy abuse (Gómez-Quintero et al., 2024). Because of often ambiguous and insubstantial governance measures on both micro (platform) and macro (government) scales, offending users may perceive a positive cost-benefit, with risk and effort needed relatively low and potential rewards high (Gómez-Quintero et al., 2024). INTERPOL (2024) has also highlighted that the agile and digital nature of the metaverse provides perpetrators with the ability to leave the crime scene seamlessly and without leaving evidence behind, as they would in the analog world. The metaverse also raises questions and concerns around the collection and use of personal identifiable information and data privacy issues (Congressional Research Service, 2022), increased surveillance under the guise of accountability (Di Porto & Foà, 2023), ambiguity around data ownership and intellectual property, disparities in implementation across regions and demographics (Congressional Research Service, 2022), and rising levels of crime in general.

Thus, the rise of the metaverse as a converged digital-physical environment invites new questions about governance across virtual spaces that are technically interconnected, but socially and legally diverse. While the developments are often driven by the private sector, governments (even as potential eventual users) experience difficulty in acting promptly enough to address evolving opportunities and threats. For example, with jurisdictions across the world diverging in their treatment of data protection, platform accountability, and virtual assets, the metaverse may risk becoming a fragmented legal landscape unless universal principles or interoperable standards are established. As is true with other emerging innovations, the technology behind the metaverse is developing more rapidly than governments can regulate (Uzun, 2023).

Overall, understanding how different governments approach metaverse governance is crucial, as legal and regulatory frameworks will shape the rights, risks, and responsibilities of users, developers, and platforms in these virtual spaces. Admittedly, the present-day global metaverse governance landscape varies. For example, South Korea has enacted the world's first metaverse-specific law while simultaneously introducing non-binding ethical guidelines to guide industry development (Ministry of Science and ICT, 2024). The United Arab Emirates promotes a principle-based, innovation-friendly approach through its Dubai Metaverse Strategy and Responsible Metaverse Self-Governance Framework (United Arab Emirates, 2023), while China integrates metaverse identity into its broader surveillance and digital governance infrastructure (Hung, 2022).

Furthermore, regulation may often overcorrect in other regards, as seen in the European Union's (EU) risk aversion and the United States' (US) overemphasis on techno-solutionism and private sector prioritization. Despite the EU and US' shared democratic values and structure, and close historic and strategic partnership, the two governments take opposite-side-of-the-spectrum approaches, which makes them prime for comparative analysis.

Given the relatively nascent state of research on the metaverse and its usage in the public sector, this paper explores emerging metaverse technologies and potential use cases and opportunities for the public sector, thus establishing incentives for government regulation. Exploring these governance models not only reveals regulatory gaps, but also deeper tensions in the interplay between innovation, control, and fundamental rights in a rapidly evolving digital world.

The study will then build on these assessments to answer the following research question:

How do the EU's risk-averse regulatory orientation and the US's techno-solutionist and industry-friendly stance shape their respective approaches to metaverse governance?

In the research that follows, we present overviews of the related research, introducing metaverse technologies and their associated characteristics. The article then outlines areas of opportunity for public sector use of the metaverse and identifies the values present in EU and US digital governance models. Following this, we explain our research design by providing a description of our qualitative analysis approach and then offer a landscape of metaverse and related governance mechanisms. Finally, we present the findings of our comparative analysis, rooted in the predetermined values and geopolitical governance framework.

2 An Overview of Metaverse Governance

2.1 Interpreting the metaverse and virtual worlds

The metaverse is a multifaceted and evolving socio-technical system (Dwivedi et al., 2022). There are no uniform definitions of the terms *metaverse* and *virtual world,* and while some experts use them interchangeably, others argue for a differentiation between the terms. Generally, *virtual worlds* are nascent and developing, while the *metaverse* is used to describe virtual worlds that have fully matured (Di Porto & Foà, 2023). The European Union also favors the term *virtual world* in its strategy documents (European Parliamentary Research Service, 2023), although language on the topic is subject to change by source.

Broadly, the metaverse can be examined through a lens of four dimensions: as an environment, an interface, an interaction space, and as a social value holder (Dwivedi et al., 2022). These dimensions might range from highly immersive, realistic simulations to abstract, rule-defying virtual worlds, and from more basic sensory interfaces to identity-rich spaces for collaboration (Dwivedi et al., 2022). Overall, despite the varying terminology used, the technical characteristics that define metaverses and virtual worlds tend to stay consistent among experts. Research conducted by Gómez-Quintero et al. (2024) consulted 27 specialists with knowledge in metaverse and other digital crime. Consistent attributes proposed by the stakeholders included *"multiuser, multipurpose, user-generated, spatial, immersive, persistent, multiplatform, interoperable, and involve ownership and avatars"* (Gómez-Quintero et al., 2024, p. 3). Other experts from this group consulted have put forward the following attributes—scalable, synchronicity, open, decentralized, heterogenous, virtual-physical hybridity live, and hyper spatiotemporal—although these are more subject to vary. In 2023, the World Economic Forum built onto pre-established definitions by introducing the concept of interoperability as a requisite for the metaverse. However, this idea is not supported without exception, as the United States government views interoperability as an eventual characteristic of more mature, future metaverse technologies (Di Porto & Foà, 2023). For clarity's sake, this research will exclusively use the term *metaverse* to refer to metaverse and virtual world technologies, as appropriate.

The metaverse is further supported by a combination of extended reality (ER), augmented reality (AR), and virtual reality (VR) technologies (Uzun, 2023), and an amalgamation of other technologies such as artificial intelligence (AI), Internet of Things (IoT), 5G, and distributed ledger (e.g., blockchain, non-fungible tokens (NFT), and decentralized autonomous organizations (DAOs)) to facilitate actions such as commerce and interpersonal communication within the metaverse (European Parliamentary Research Service, 2023). As technology capabilities advance, experts anticipate that the use of the metaverse will become more ubiquitous in the coming years, shifting from users primarily accessing the metaverse using specialty virtual reality and augmented reality devices to using daily personal devices like laptops and smartphones (Gómez-Quintero et al., 2024).

2.2 Opportunities for the public sector

Digital transformation is an ongoing process for many public sector organizations across the world, with common objectives such as increasing public value through improved efficiency, transparency, and security of public services and internal administration.

Public sector interest in the metaverse accelerated during the COVID-19 pandemic and has sustained since (Mailangkay, 2024). For example, some early speculations of VR-based public services have been captured in the United Nation's 2022 biannual e-government survey (Lnenicka, 2024).

Furthermore, public organizations are discussing leveraging the metaverse technologies to enrich digital service delivery in areas where immersive, interactive, or spatial experiences can add value (Lnenicka, 2024), such as the fields of healthcare, education, manufacturing, and defense (European Parliamentary Research Service, 2023). For example, in a healthcare-oriented metaverse, doctors can virtually train for medical procedures and patients can obtain care from medical professionals remotely. Students can learn virtually and engage in a more "traditional" academic setting, such as a virtual classroom, rather than over a video call platform as popularized during the COVID-19 pandemic. In addition, businesses and militaries can create tools like digital twins within the metaverse to enhance and streamline design and manufacturing practices (European Commission, 2023a).

Additionally, governments worldwide have a vested interest in leveraging these opportunities to deliver services more efficiently and equally to residents and citizens who may not have had access to or interest in traditional, analog methods. For instance, Tuvalu—a small island nation facing significant threats from climate change and rising sea levels—uses the metaverse to address real-world challenges to serve its people. Experts predict that Tuvalu could be submerged by 2050, leaving the country uninhabitable (Yeo, 2024). To respond to this threat, the Tuvaluan government announced the Future Now Project, which aims to create the world's first digital completely digital nation. The project will feature digital twins of the islands that citizens can navigate, digitized administrative

documents and data, and virtual archives where citizens can interact with culturally meaningful traditions such as family stories and traditional dances (Yeo, 2024). Tuvalu's government is also seeking digital statehood recognition from other governments, which would establish a path to sovereignty (Accenture, n.d.). Current international law requires a clearly defined territory and permanent population for state sovereignty, but Tuvalu may lose both in the coming decades. Due to the slow-moving and reactionary nature of international law, Tuvalu is not able to rely on existing legal standards alone and instead is using metaverse technology to imagine a new version of statehood, when traditional options fall short (Yeo, 2024).

In addition, the Maldives, Sweden, Estonia, and other countries have embraced metaverse technologies, at one point maintaining embassies with limited functions in Second Life, a popular online virtual world platform from the mid-2000s. Moreover, the micronations of Principality of Sealand and the Dominion of Melchizedek have both been built on blockchain technology (Rothe et al., 2024). Furthermore, in 2021, the city of Seoul pledged to invest 3.9 billion won (approximately 2.5 million euros) to develop a new metaverse platform called "Metaverse Seoul." This platform would allow citizens to file civil complaints, receive consultation from civil servants, and take part in Korean cultural experiences such as festivals and memorials (Seoul Metropolitan Government, 2021), all innovative channels for increased citizen engagement and civic participation.

On the one hand, the metaverse can support new forms of interaction between citizens and public authorities, offering opportunities for more engaging, human-centered interfaces within digital government systems (Lnenicka 2024). On the other, to ensure that metaverse technologies are being governed appropriately to serve the public, a number of factors must be deliberated. These include the role and responsibility of platform moderators and managers (Gómez-Quintero et al., 2024); the future of digital identity and personhood, especially in the context of online accountability (Gómez-Quintero et al., 2024); ethical considerations (Lnenicka, 2024); user privacy, choice, and autonomy (Arbanas et al., 2023); and "protection by default" and "trust by design" principles (Arbanas et al., 2023).

2.3 Governance value interplay

Governance in the metaverse unfolds across multiple, layered dimensions that reflect both its technological architecture and social complexity (Dwivedi et al., 2022). As such, any successful metaverse governance will need to strike an appropriate balance between protecting user rights and encouraging innovation. The metaverse brings together diverse virtual spaces with varying rules, users, and values. As such, issues of interoperability, privacy, accountability, and cross-border regulation emerge with urgency (Dwivedi et al., 2022).

Furthermore, early research suggests that governance in the metaverse is not only about regulating a new technology (governance-of-metaverse) but also about reimagining how societies might operate when rules are embedded in code, space is borderless, and identities are fluid (governance-by-metaverse) (Dwivedi et al., 2022).

The governance landscape is further complicated by the presence of decentralized technologies such as non-fungible tokens (NFTs) and decentralized autonomous organizations (DAOs), which offer new models of ownership and collective rulemaking, yet also challenge traditional legal and institutional frameworks (Dwivedi et al., 2022).

One theory that defines the interplay between values, priorities, geopolitics, and state autonomy is the Four Internets model by researchers O'Hara and Hall (2018). This model uses the lenses of digital sovereignty and fragmentation to identify and assess rationales behind the digital governance models of the European Union and the United States. O'Hara and Hall's Four Internets include Brussels' Bourgeois Internet, Silicon Valley's Open Internet, DC's Commercial Internet, and Beijing's Authoritarian Internet, each with their own set of defining goals and approaches. Brussels' internet is characterized by its user-centric focus aimed at defending *"civilized bourgeois public space[s] against incivility, taking action, for example, against disruptors"* (O'Hara and Hall, 2018, p. 6). Silicon Valley's internet, in contrast, is innovation-focused, identifying technology as a potential (and often likely) solution to any problem users may face. Washington, DC follows a model that prioritizes the financial and commercial benefits of technological development, rewarding close relationships between Big Tech and politics. Finally, the Chinese model prioritizes state ownership and assertive growth into international digital spaces.

The EU and US models will be further expanded on in the discussion section, but in the meantime, they provide helpful framing on the interconnected relationship between a model's history (such as the creation of the EU or the birth of the Internet), government values (including risk mitigation, innovation, commercialization, and state autonomy), and regulatory mechanisms (a centralized versus fragmented approach).

3 Research Methods

3.1 Data collection

To conduct this research on metaverse governance, we used a combination of primary and secondary data content analysis.

Primary data came from the industry stakeholders with extensive experience in digital policy—particularly through Transatlantic and larger geopolitical lenses—and proven expertise on metaverse emerging technologies. A purposive sampling technique was applied to identify relevant interview partners. Potential participants were selected through web searches and personal networks, based on their engagement with metaverse-related topics and governance issues. Where contact information was available, individuals were invited to participate via email, with an explanation of the research objectives and interview purpose. Two positive responses were received, and interviews were conducted with participants actively involved in the field.

The overview of interview partners is presented below:

Tab. 1 – Experts overview

Expert	Role	Industry	Expertise	Application to metaverse
A	Data and privacy policy manager	Tech	AI policy and regulation European politics and technology	Data privacy, content moderation, and platform accountability
B	Senior policy analyst	Research	Geopolitics and governance of emerging technologies, e g. digital public infrastructure	AI governance, international digital policy, strategic regulation

The semi-structured interviews followed an interview guide, focusing on the state of digital regulation in the EU and US, as well as the opportunities and threats of each government's approach. The aim was to elicit detailed, expert-level insights into the contextual factors influencing how metaverse governance develops in the two contexts. The interviews helped inform larger thinking about the characteristic differences between broad digital governance approaches of the European Union and the United States, using artificial intelligence and digital public infrastructure (DPI) as grounding points. Both AI and DPI are two key emerging technologies that are fundamentally integrated into the metaverse, so the speakers' insights were valuable in reinforcing broader learnings from the literature review. The purpose the interviews served was general framing of the geopolitical and political aspects of each government's approach.

Secondary sources—such as academic articles, government reports and policy papers, and consulting reports—were reviewed to establish a general idea of the current state of regulation and governance. The type of sources available did vary. They were identified through purposive browsing of relevant institutional websites (e.g., European Commission, US federal agencies), professional platforms, and keyword searches using terms such as metaverse regulation, immersive technology governance, and digital policy. This engagement with secondary materials helped identify dominant framings, gaps, and conceptual tensions in current public discourse.

Because the United States does not currently have federal regulation explicitly addressing the metaverse (nor a streamlined digital policy framework comparable to the European Union), academic literature on the US approach to metaverse governance remains limited. As a result, we leaned heavily on gray literature for this part of the research, using sources from well-established international consulting firms and articles and reports from the US and EU governments.

3.2 Data analysis

Relevant and related metaverse governance mechanisms (including strategies, regulations, legislation, consultations and convenings, and initiatives) were identified during interviews and documents analysis as part of a data collection mapping exercise and were then grouped by the type of governance lever. These mechanisms covered a wide range of policy areas, from data privacy and user protection to artificial intelligence funding and virtual reality development, all of which are likely to shape the inner workings of the metaverse.

Because of the complex nature of the metaverse, the regulatory ecosystem will likely consist of interconnecting mechanisms and tools to sufficiently address new challenges, necessitating a broad look at specific and related levers. This approach enabled a flexible analysis of how existing digital governance measures, often not explicitly labelled as "metaverse governance," may nonetheless inform the emerging policy landscape in this domain.

4 Findings

European and American concepts of the metaverse share similar qualities, such as those featured first in 2022 policy papers in the European Union and the United States. Collectively, these definitions focus less on the characteristics and qualities of digital worlds and more on the differentiation between digital and physical worlds (Di Porto & Foà, 2023). The European Parliamentary Research Service described them as "*an immersive and constant virtual 3D world where people interact by means of an avatar to carry out a wide range of activities. Such activities can range from leisure and gaming to professional and commercial interactions, financial transactions or even health interventions such as surgery"* (European Parliamentary Research Service, 2022, p. 1). The US Congressional Research Center introduced the metaverse as "*an immersive and persistent virtual world where users can communicate and interact with other users and the surrounding environment and engage in social activities, similar to interactions in the physical world"* (Congressional Research Service, 2022, p. 3). Despite the similarities in conceptualization, each government takes a distinctly unique approach to addressing the metaverse and related emerging technologies.

4.1 European Union landscape

The European Union is relatively advanced in its metaverse governance approach—as demonstrated by its Strategy on Web 4.0 and Virtual Worlds framework released in 2023—and invests significant funding into developing associated technologies. In fact, more than half of European organizations working on metaverse-related projects receive funding from the EU (Joint Research Centre, 2023). In addition to the framework and funding opportunities, the EU has enacted a number of well-established regulations—such as the General Data Protection Regulation, Digital Services Act, and Digital Markets Act—that guide the development and management of digital spaces in the European Union and beyond.

One significant challenge the EU is expected to face in its regulatory efforts is the complicated dynamic introduced by its multi-state government model. *"For European policymakers, one challenge is of jurisdiction – of how to regulate a new infrastructure of global computing. This reflects broader concerns with regulation, where many countries are now considering the efficacy of domestic regulations in dealing with multi-national firms"* (Egliston et al., 2024, p. 14).

An overview of the metaverse governance landscape in the European Union is presented below. Organized and grouped by type of mechanism, the list includes metaverse and related strategies, regulations, legislation, consultations and convenings, and initiatives. Despite the actions the European Union is taking (to be outlined momentarily) to establish a framework strategy of governance for metaverse technologies, neither the EU nor the US have fully developed and executed a governance plan. However, both governments have existing regulations and legislation on related topics, which are expected to have a significant impact on the development and management of the metaverse. The following section will outline US governance mechanisms in the same format.

Strategy

- **Strategy on Web 4.0 and Virtual worlds** addresses the rapid development of digital and hybrid technologies—including metaverse technologies—and ensures they promote real-world European values and principles (European Commission, 2023b).

- **2030 Digital Decade Plan** provides a comprehensive framework for EU digital action on the following: "*a digitally skilled population and highly skilled digital professionals, secure and sustainable digital infrastructures, digital transformation of businesses, digitalization of public services*" (European Commission, 2024b).

Regulation

- **General Data Protection Regulation** imposes data privacy and security requirements on digital entities and platforms that collect data from Europeans. This is considered the most robust and strict data protection law in the world (Wolford, n.d.), but may not cover invasive forms of future data collection in the metaverse (Garcia, 2023).

- **Digital Services Act** & **Digital Markets Act** establish a comprehensive accountability system for internet

providers that protects the fundamental rights of users and enforces accountability for online platforms in Europe and ultimately abroad (European Commission, 2023b). However, experts are currently unclear how the protections will transfer to the metaverse (Di Porto & Foà, 2023).

- **Digital Identity Framework** sets out to provide Europeans with a digital wallet feature that facilitates digital payments and identity verification (European Commission, 2024b), both of which are key functions in the metaverse.

Legislation

- **Artificial Intelligence Act** addresses the risk that AI poses, sets guidelines on specific use for developers and deployers, and reduces financial and management burdens for smaller businesses (European Commission, 2024a).

- **Data Act** delegates the Commission to encourage interoperability of data spaces and data processing services and supports horizontal interoperability between companies of all sizes (Di Porto & Foà, 2023).

Consultation and convening

- **Citizens' Panel on Virtual Months** discusses recommendations for the Commission on implementing virtual world work based on citizens' values and expectations on topics such as work and job markets, digital identity in virtual worlds, and connectivity and access (European Commission, n.d.).

- **European Virtual and Augmented Reality (VR/AR) Industrial Coalition** convenes policymakers and industry experts to identify opportunities and challenges, inform policymaking, and encourage investment (European Parliamentary Research Service, 2023).

Initiative

- **Digital twin programs,** including **CitiVerse, Destination Earth (DestinE), Local Digital Twins for Smart Communities,** and **European Digital Twin of the Ocean,** create immersive, accurate environments to facilitate scientific research and medicine, urban planning and management, and policymaking (European Commission, 2023c).

4.2 United States landscape

In comparison to the EU, the US takes a lax regulatory approach to digital policy (Expert A). In general, federal frameworks are industry-specific, regulating the finance and healthcare sectors, while state jurisdictions are responsible for upholding broader consumer protection rules (Arbanas et al., 2023). Because the United States lacks mechanisms such as a federal data protection agency or a federal metaverse privacy law (Deloitte, n.d.), states are left to fill in the regulatory gaps with jurisdictional action, as demonstrated with California's legislation below. This jurisdictional approach creates a piecemeal and fragmented data regulation and enforcement ecosystem (Deloitte, n.d.) and few governance levers to pull. Misaligned actions also exist at the federal level; it is possible (and common) for the administration, Senate, and House of Representatives to have differing and opposing goals. Given the deeply integrated nature of metaverse technologies, platforms, and issues, the US' traditional fragmented approach limits which, and how many, governance levers the country can pull. Policies that are in place encourage innovation, limit private sector liability, and allocate funding for metaverse-related technology projects.

Strategy

- **Executive Order on Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence** establishes standards for AI safety, security, and privacy—while outlining user civil rights and commercial protections—and promotes innovation and domestic and international competition (White House, 2023). This, however, may not create lasting change because it is not binding, and priorities will change with the Trump administration (Expert A).

Legislation

- **Section 230 of the Communications Decency Act** grants online platforms the ability to moderate user content without being held legally liable, which contributed to the growth of the internet during its infancy (Deloitte, n.d.), although Section 230 is currently contested in the US and platform immunity may change

(Arbanas et al., 2023).

- **California's AB 587** requires social networks to publish content moderation policies and provide descriptions of their processes for flagging and reporting problematic content like hate speech, racism, extremism, dis- and misinformation, harassment, and political interference (Arbanas et al., 2023).

- **CHIPS and Science Act** authorizes funding to support research and development of key advanced communications technology and immersive technology (Congressional Research Service, 2022).

Consultation and convening

- **Congressional Caucus on Virtual, Augmented, and Mixed Reality Technologies** leads Congress' action on metaverse-related technologies. Established in 2017, the Caucus appears to be currently inactive (Garcia, 2023).

Initiative

- **Declaration for the Future of the Internet** asserts and recommits to international goals for the future of the internet, including openness, digital freedom, interoperability, and decentralization (Congressional Research Service, 2022).

5 Discussion

This study examined how two influential actors—the European Union and the United States—are beginning to govern the metaverse through broader digital policy mechanisms. While explicit metaverse regulation remains scarce, early signals in both jurisdictions reveal key differences in institutional logic, regulatory style, and governance priorities. These differences stem not only from legal structures (e.g., centralized vs. decentralized governance) but also from contrasting views on risk, innovation, and the role of the state in shaping emerging digital environments.

To meaningfully compare the two approaches, we focus on two dimensions observed across interview and document data: (1) whose interests are prioritized, and (2) how risk and innovation are framed in relation to immersive technologies. While both regions acknowledge the metaverse as a potential growth area, their governance trajectories reflect deeper normative and structural differences. In what follows, we discuss how these orientations influence emerging governance mechanisms, such as strategic positioning, regulatory design, and stakeholder engagement, and consider what they might mean for future public sector involvement in immersive technology governance.

5.1 Risk aversion

By outlining the EU's focus on long-term risk management and mitigation—ultimately for better user outcomes—Expert A reinforced the arguments O'Hara and Hall (2018) made in their Four Internets model assessment of the European Union's digital regulation approach. Again, the Brussels Bourgeois Internet values virtue, prudence, and civility. Because these objectives are long-term and not dependent on the whims of whichever major company is developing metaverse technology, the EU benefits from stronger political stability than the United States does. As Expert A explained, "*the fundamentals of that are almost similar in every situation: you look at privacy, you look at platform accountability. The EU is ahead, not necessarily because they're better at it, it's just because their processes matter more. The politics of it can at most postpone things, but it's done within a process of 'this is the policy that matters and we're going to push it through.'*" As demonstrated in the findings above, the European Union has a relatively robust and stable metaverse governance approach, including metaverse- and virtual world-specific strategies and other adjacent strategies and regulations.

5.2 Techno-solutionism

In direct contrast to the EU's approach of prioritizing policy over politics, the US takes a politics-first approach to governance. Rather than placing users at the center of governance decisions, the dominance of technology firms (specifically Big Tech) is emphasized above all else (Expert B). This view of techno-solutionism aligns with O'Hara and Hall's (2018) vision of the Silicon Valley Open Internet governance model. This digital model encourages technology providers to innovate fervently in a move fast and break things style, with the end goal of achieving public good through technology. Such emphasis leaves risk management conversations to develop organically, often as a second thought and to the detriment of users' wellbeing. In comparison, the United States' governance landscape is more limited, with existing related legislation and levers focused on private sector innovation and financial success.

5.3 Private sector focus

Additionally, Expert B argued that business culture in the United States—coupled with the country's standard light touch and laissez-faire regulatory approach—has greatly influenced innovation, as seen during the inception and growth of the early internet. Big Tech wields immense influence in the US through its lobbying efforts and close political relationships in Washington, DC, and O'Hara and Hall (2018) further advance this idea in their DC Commercial Internet model, which discusses the mutually beneficial (financial and political) relationship between Big Tech and Republican politicians. This focus on private good—rather than public good as in the Silicon Valley model—is likely to intensify as Republicans take control of the Presidency, Senate, and House of Representatives in early 2025. However, as Expert A pointed out, discussions around values and goals may have a limited impact in reality. "*Fundamentally, that [values and goals] doesn't matter, because there are limited levers that can be pulled in the United States within a very fragmented and very unresponsive set of actions."*

6 Conclusions

This research focused on exploring the landscape of metaverse opportunity and regulation in the US and EU—two strong players in the global technology arena—to establish the necessity for robust governance. This research has found inherent and fundamental differences between each government's digital models and priorities, which impact their metaverse governance perspectives. The United States values innovation and business opportunity, often overlooking user rights and protections, while the European Union prioritizes the user, often at the expense of stifling innovation. In short, the distinction can be summed up as "freedom to" versus "freedom from" (O'Hara & Hall, 2018). The EU also takes a centralized approach to governance and regulation, as compared to the US' decentralized and fragmented regulatory approach, resulting from the country's focus on state autonomy and ultimately reducing the number of regulatory mechanisms the federal government can use.

Both the European Union and the United States have new administrations and key legislation that will shape priorities over the next several years, with the European Union welcoming a new Commission in 2024, and a new party in the White House in 2025. Moreover, the European Union's Artificial Intelligence Act came into effect in 2024, and its impact will be felt across the artificial intelligence and related technology sectors. Given this evolving landscape and the rapid pace of technological development and the potential for public sector use of the metaverse for the public good, further research into the topic of metaverse governance is welcomed. For example, future studies can extend the findings of this paper onto broader geopolitical contexts for a more holistic overview of various approaches to metaverse governance. It is also relevant for future research in exploring how national governance frameworks shape the experience and agency of users in the metaverse.

6.1 Limitations

It is worth noting some of the limitations of this research, particularly the uncertainty surrounding the risks and benefits of the metaverse and related technologies, such as artificial intelligence. Experts worldwide are divided on the future of the metaverse (Anderson & Rainie, 2022, p. 6). Two main predictions on potential popularity and maturity emerge: one faction foresees a rise in the use of augmented- and mixed-reality technologies, though not to the immersive extent of full-scale metaverse technologies. The other argues that *"these new worlds could dramatically magnify every human trait and tendency – both the bad and the good."* Because of this ambiguity, existing research is limited and the future is unclear.

Another limitation of this research is potential bias, as both experts interviewed have professional experience at liberal institutions. This may color their perspectives on the political and geopolitical aspects of this conversation, as liberals generally tend to favor regulation, while conservatives often favor a laissez-faire and business-driven approach.

Ultimately, our findings are intended to provide preliminary insights, rather than broad generalizations. They provide an insightful lens on how metaverse regulation is addressed differently across the world and would only benefit from additional research in other regulatory contexts, like China, India, or middle-power governments, in the future.

7 Acknowledgements

Funding: The work leading to this paper was funded by the European Commission in its Horizon Europe (Grant agreement no. 101177536) framework. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting authority can be held responsible for them.

Conflict of interest: There is no conflict of interest.

Use of AI: During the preparation of this work, the authors used Grammarly to identify and correct grammatical errors. After using this tool, the authors reviewed, edited, made the content their own, validated the outcome as needed, and took full responsibility for the content of the publication.

References

Accenture. (n.d.). *Climate change gets real in the metaverse*. https://www.accenture.com/us-en/case-studies/technology/tuvalu

Anderson, J. & Rainie, L. (2022, June 30). *The Metaverse in 2040*. Pew Research Center. https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2022/06/PI_2022.06.30_Metaverse-Predictions_FINAL.pdf

Arbanas, J., McMillan, J., Arkenberg, C., Steinhart, M., & Dhameja, A. (2023, September 14). *Considerations for regulating the metaverse: New models for content, commerce, and data*. Deloitte Insights. https://www2.deloitte.com/us/en/insights/industry/technology/emerging-regulations-in-the-metaverse.html

Congressional Research Service. (2022, August 26). *The Metaverse: Concepts and Issues for Congress* (Report No. R47224). https://crsreports.congress.gov/product/pdf/R/R47224

Deloitte. (n.d.). *Regulating the metaverse: Implications for businesses and policymakers*. Deloitte. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/consulting/us-regulating-the-metaverse.pdf

Di Porto, F. & Foà, D. (2023, July). *Defining Virtual Worlds: Main Features and Regulatory Challenges*. Centre on Regulation in Europe. https://cerre.eu/wp-content/uploads/2023/07/CERRE-Virtual-Worlds-Issue-Paper-0723.pdf

Dwivedi, Y. K., Hughes, L., Baabdullah, A. M., Ribeiro-Navarrete, S., Giannakis, M., Al-Debei, M. M., Dennehy, D., Metri, B., Buhalis, D., Cheung, C. M. K., Conboy, K., Doyle, R., Dubey, R., Dutot, V., Felix, R., Goyal, D. P., Gustafsson, A., Hinsch, C., Jebabli, I., … Wamba, S. F. (2022). Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management, 66*, 102542. https://doi.org/10.1016/j.ijinfomgt.2022.102542

Egliston, B., Carter, M., and Clark, K. E. (2024, January 29). Who will govern the metaverse? Examining governance initiatives for extended reality (XR) technologies. *New Media & Society OnlineFirst*, 1-21. https://doi.org/10.1177/14614448231226172

European Commission. (2024a, October 14). *AI Act*. https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai

European Commission. (2024b, November 28). *European Digital Identity (EUDI) Regulation*. https://digital-strategy.ec.europa.eu/en/policies/eudi-regulation

European Commission. (2024c, November 29). *Europe's Digital Decade*. https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade

European Commission. (2023a, July 11). *Questions and Answers: EU initiative on Web 4.0 and virtual worlds: A head start in the next technological transition* [Press release]. https://ec.europa.eu/commission/presscorner/detail/en/qanda_23_3719

European Commission. (2023b, July 11). *Towards the next technological transition: Commission presents EU strategy to lead on Web 4.0 and virtual worlds* [Press release]. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3718

European Commission. (n.d.). *European Citizens' Panel on Virtual Worlds: Panel Output*. https://citizens.ec.europa.eu/document/download/772aa787-4038-48d7-9f42-878661b955f2_en?filename=Recommendations_Citizen%20Panel%20Virtual%20Worlds_0.pdf

European Parliamentary Research Service. (2022, June 24). *Metaverse: Opportunities, risks, and policy implications* (Briefing No. 733.557). European Parliament. https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733557

European Parliamentary Research Service. (2023, July). *Virtual worlds (metaverse)* (Briefing No. 751.408).

European Parliament.
https://www.europarl.europa.eu/RegData/etudes/ATAG/2023/751408/EPRS_ATA(2023)751408_EN.pdf

Garcia, M. (2023, September). *The Forgotten "Emerging" Technology*. New America.
https://d1y8sb8igg2f8e.cloudfront.net/documents/The_Forgotten_Emerging_Technology_2023.pdf

Gómez-Quintero, J., Johnson, S. D., Borrion, H., & Lundrigan, S. (2024, February 20). A scoping study of crime facilitated by the metaverse. *Futures, Volume 157*. https://doi.org/10.1016/j.futures.2024.103338

Hayne, H. (2023, May 17). Regulation of the Metaverse. *Boston University Review of Banking & Financial Law.*
https://www.bu.edu/rbfl/2023/05/17/regulation-of-the-metaverse/

Hung, H. T. (Bosco). (2022). Keep Your Eyes on China's Metaverse: Another Tool for Maintaining its National Security. *The Journal of Intelligence, Conflict, and Warefare, 5*(2), 1-31. https://doi.org/10.21810/jicw.v5i2.4340

INTERPOL. (2024, January 18). *Grooming, radicalization and cyber-attacks: INTERPOL warns of 'Metacrime'.*
https://www.interpol.int/en/News-and-Events/News/2024/Grooming-radicalization-and-cyber-attacks-INTERPOL-warns-of-Metacrime

Joint Research Centre. (2023, July 3). *Next-generation virtual worlds: opportunities, challenges, and policy implications*. European Commission. https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/next-generation-virtual-worlds-opportunities-challenges-and-policy-implications-2023-07-03_en

Library of Congress. (n.d.). *H.R.1668 – Internet of Things Cybersecurity Improvement Act of 2020, 116th Congress (2019-2020)*. https://www.congress.gov/bill/116th-congress/house-bill/1668

Lnenicka, M., Rizun, N., Alexopoulos, C., & Janssen, M. (2024, June). Government in the metaverse: Requirements and suitability for providing digital public services. *Technological Forecasting and Social Change, 203*, 123346.
https://doi.org/10.1016/j.techfore.2024.123346

Mailangkay, A., & Napitupulu, D. (2024). Metaverse Adoption in Public Sector: A Bibliometric Analysis. *Kenetik: Game Technology, Information System, Computer Network, Computing, Electronics, and Control, 9*(3), 221-330.
https://doi.org/10.22219/kinetik.v9i3.1891

Ministry of Science and ICT. (2024, August 19). *MSIT releases "Metaverse Ethics Principles"* [Press release].
https://www.msit.go.kr/eng/bbs/view.do?sCode=eng&mId=4&bbsSeqNo=42&nttSeqNo=1032

O'Hara, K. & Hall, W. (2018, December). *Four Internets: The Geopolitics of Digital Governance*. Centre for International Governance Innovation.
https://www.cigionline.org/static/documents/documents/Paper%20no.206web.pdf

Rothe, D., Boas, I., Farbotko, C., & Kitara, T. (2024, July 10). Digital Tuvalu: state sovereignty in a world of climate loss. *International Affairs, Volume 100*(4), 1491–1509, https://doi.org/10.1093/ia/iiae060

Seoul Metropolitan Government. (2021, November 5). *Seoul to provide public services through its own metaverse platform*. https://english.seoul.go.kr/seoul-to-provide-public-services-through-its-own-metaverse-platform/

Stevens, R. (2024, March 9). *Securities vs. Commodities: Why It Matters For Crypto*. CoinDesk.
https://www.coindesk.com/learn/securities-vs-commodities-why-it-matters-for-crypto

United Arab Emirates Government (2023, November 7). *Dubai Metaverse Strategy*. https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/government-services-and-digital-transformation/dubai-metaverse-strategy

Uzun, M. M. (2023, October 13). Metaverse Governance. In F. S. Esen, H. Tinmaz, & M. Singh (Eds.), *Metaverse: Technologies, Opportunities, and Threats* (pp. 231-244). Springer. https://doi.org/10.1007/978-981-99-4641-9_16

White House. (2023, October 23). FACT SHEET: President Biden Issues Executive Order on Safe, Secure, and Trustworthy Artificial Intelligence [Press release]. https://www.whitehouse.gov/briefing-room/statements-releases/2023/10/30/fact-sheet-president-biden-issues-executive-order-on-safe-secure-and-trustworthy-artificial-intelligence

Wolford, B. (n.d.). *What is GDPR, the EU's new data protection law?* GDPR.EU. https://gdpr.eu/what-is-gdpr/

Yeo, S. (2024, November 21). *Tuvalu: The disappearing island nation recreating itself in the metaverse*. BBC. https://www.bbc.com/future/article/20241121-tuvalu-the-pacific-islands-creating-a-digital-nation-in-the-metaverse-due-to-climate-change

Track 21: Dialogues about Latin America (Portuguese, Spanish and English track)

Track Description

The track aimed to explore the rich and complex context of the Latin American Digital Government. Latin America has a significant cultural and linguistic diversity, ranging from densely populated urban centers to rural areas. Some of the region's characteristics include urban populations, developing economies, and deep inequalities in access to services, including digital technologies. Digital infrastructure is a challenge from big cities' peripheries to remote areas, which affects the region's digital economy and public service delivery. However, Latin America has experienced rapid growth in digital government, a promising market for tech and govtech startups, presenting opportunities for digitalization. Many Latin American countries have invested in digital government strategies and adopted emerging technologies like AI and 5G. These initiatives aim to increase transparency, facilitate citizen engagement, and drive economic development while facing diverse and complex challenges, such as addressing digital exclusion, ensuring personal data privacy, and improving government interoperability and cybersecurity.

Track Chairs

E. Estevez, Universidad Nacional del Sur, Argentina
M. A. Cunha, Fundação Getúlio Vargas, Brazil
R. Sandoval-Almazan, Universidad Autónoma del Estado de México, México

Contents

Caminhos rumo a uma Região de Fronteira inteligente Brasil-Argentina: iniciativas e resultados 1324
R. A. Palacios

Cidadania no contexto da transformação digital na América Latina: uma proposta de framework analítico 1338
J. P. dos S. da Silva and D. C. Rodrigues

Futuros possíveis de processos de inovação para o Poder Judiciário a partir de experiências formativas 1351
J. G. de M. Peixoto and A. S. Gomes

Impacto social, econômico e ambiental da implantação de soluções de governo digital 1358
B. Campolina, A. P. Silva, L. M. dos Santos, L. R. Carvalho, E. L. de Aguiar, W. S. de Araújo, A. M. H. C. de Oliveira, and F. G. Jayme Jr.

Inteligência artificial como apoio à tomada de decisão no setor público 1371
C. T. Sandrini, T. R. Coelho, M. C. Adrião, and E. Razzolini Filho

Plataforma Pública de Conteúdos Audiovisuais Brasileiros Sob Demanda: Tecnologia social para formação de públicos, difusão e descentralização dos espaços de exibição 1385
L. Santa Rita, T. Cordeiro, A. Barbosa, N. Santos Júnior, C. Cabral, J. Rosa, A. Rego, V. Braga, A. Gomes, L. Távora, and D. Fernandes

Serviços eletrônicos de governo, *datafication* e *data justice*: o caso do Auxílio Emergencial no Brasil 1397
L. C. M. Vargas and M. A. Macadar

Smart Communities in Climate Disasters: A Case of Porto Alegre, Brazil 1412
C. T. Lopes, E. Luciano, and L. Roldan

Uso de DAG e IA para inovação na gestão pública e privada 1426
C. O. da Motta, G. C. Wiedenhöft, and M. Fitz-Oliveira

Caminhos rumo a uma Região de Fronteira inteligente Brasil-Argentina: iniciativas e resultados

Rosiane Alves Palacios [a*]

[a] Programa de Pós-graduação em Administração, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brasil, rosiane.palacios@edu.pucrs.br, ORCID 0000-0002-7588-6358

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Resumo. Cada vez mais as iniciativas de cidades e regiões inteligentes vem sendo pensadas a fim de conferir mais qualidade de vida para os cidadãos. A governança do espaço urbano é um elemento primordial ao desenvolvimento e gestão de cidades e regiões que almejam se tornarem inteligentes. Nas regiões de fronteira, que apresentam dinâmicas distintas das demais regiões dos países, desenvolver cidades e tornar regiões de fronteira inteligentes pode ser possível através da atuação conjunta dos governos subnacionais e da comunidade por meio da composição de uma governança binacional. Esse estudo de caso único teve por objetivo entender a motivação e o processo de criação de uma região de fronteira inteligente (RFI) no contexto latino-americano através da análise das iniciativas e resultados de uma rede formal de governança binacional localizada na fronteira Brasil-Argentina. Foram entrevistados 23 atores da governança e analisados diversos documentos. A motivação para criar uma governança binacional está relacionada a articulação e instrumentalização das ações de desenvolvimento planejadas em conjunto para a região de fronteira. As ações e iniciativas envolvem infraestrutura, inovação, segurança, tecnologia, educação, empreendedorismo e turismo. Com um considerável histórico de ações de desenvolvimento, a região estudada teve avanços em alguns projetos e ações, porém, foi só com a presença de uma governança binacional que muitas das ações planejadas puderam começar, de fato, a sair do papel. As ações de articulação se mostram indispensáveis para operacionalizar as iniciativas planejadas. O capital social e as redes que a governança movimenta são motrizes para a realização das ações e projetos inteligentes.

Palavras-chave. Região de fronteira inteligente, Governança, Desenvolvimento regional, América Latina, Iniciativas, Resultados
Research paper, DOI: https://doi.org/10.59490/dgo.2025.998

1. Introdução

As iniciativas de cidades inteligentes (CI) podem conter diferentes características e serem desenvolvidos por meio de diferentes dinâmicas quais sejam de colaboração, tecnologia e governança (Lousada & Valentim, 2011). As decisões sobre as iniciativas de CI, seja em cidades ou territórios, também estão sujeitas às questões legais, institucionais, político-geográficas e econômicas. Nos países da América Latina e em muitos dos países em desenvolvimento, as cidades localizadas em regiões de fronteira, por exemplo, são comumente desamparadas por políticas públicas concisas por parte de ambos os países (Oddone, Vázquez, & Oro, 2018). Não raro, os territórios de fronteira são planificados conforme as agendas e anseios do Estado central sem considerar as necessidades e especificidades de uma região de fronteira. Contudo, de alguns anos para cá, a fronteira passou a receber um olhar mais sensivel a ser também pensada e transformada pelos povos que a habitam (gestões subnacionais e ações de paradiplomacia) (Sant'Anna, 2013). Porém, ainda existem uma tendências à centralização; o diálogo sobre desenvolvimento regional e integração entre países limítrofes ainda acaba acontecendo, de maneira institucional, somente em capitais e em órgãos vinculados às relações internacionais como embaixadas e organizações intergovernamentais.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Mais recentemente, no campo da geopolítica e das fronteiras, surgiram linhas de pesquisa que investigam infraestruturas e projetos de integração entre os países (Rascovan, 2020). Estes estudos se baseiam em uma vasta história de integração regional, facilitação de fronteiras, comércio internacional e infraestruturas. Algumas iniciativas têm pensado as regiões de fronteira para além de campos referentes à segurança e à defesa. Na América Latina, geralmente os governos de localidades de faixa de fronteira vivenciam dificuldades com questões técnico-científicas e escassez de recursos porém, estes têm excelentes oportunidades de aprimorar várias questões em virtude de sua proximidade com os cidadãos e melhor conhecimento do território (Oddone *et al*., 2018). Mesmo na ausência de tratados, acordos e regramentos internacionais, a realidade das cidades fronteiriças, principalmente as conurbadas, é marcada pela integração econômica e cultural. As cidades conurbadas são aquelas cidades de fronteira cujo limite territorial geralmente é marcado somente por uma rua (Sandes, 2020). As regiões fronteiriças são espaços de propagação e de reunião de distintas identidades (Albuquerque, 2020). Nessas localidades, muitas vezes as pessoas residem em um país, mas trabalham em outro, por exemplo e, a população realiza compras conforme a cotação das moedas, optando por comprar em seu país ou no país vizinho. Existem relações sociais, afetivas e familiares, caracterizadas como binacionais e, se convive simultaneamente com duas moedas, dois idiomas e por vezes dois fusos horários (quando um país adota horário de verão e o outro não).

A governança é vista como uma das mais importantes dimensões das cidades inteligentes (Pereira, *et al*. 2017). A existência de governanças urbanas que estabeleçam objetivos comuns em favor da comunidade a partir das necessidades locais (Peters & Pierre, 2012) e governanças binacionais ou transfronteiriças (Oddone et al., 2018) onde instituições e governos subnacionais de dois ou mais países podem atuar de forma integrada pode ser a forma de fazer com que o desenvolvimento aconteça. Neste sentido, este estudo teve como objetivo entender a motivação e o processo de criação de uma região de fronteira inteligente (RFI) no contexto latino-americano através da análise das iniciativas e resultados de uma rede formal de governança binacional localizada na fronteira Brasil-Argentina.

Reconhecendo que o atual modelo de urbanização é insustentável (UN HABITAT, 2016), as principais respostas para esse problema estão na melhor gestão de recursos, na redução de resíduos e no melhor acesso às tecnologias digitais (ITU & UNECE, 2016). Nesta linha, o conceito de CIs desempenha um papel de destaque (Albino, Berardi, & Dangelico, 2015) por estar associado a inciativas mais enxutas em governos (Angelidou, 2014) porém, os arranjos de regiões inteligentes e regiões de fronteira inteligentes ainda não são muito explorados, por essa razão, é importante que sejam estudados. Observar as CI e as RFIs e seus processos é necessário pois, muitas das motivações para a adoção das iniciativas de CI objetivam a melhoria da qualidade de vida dos cidadãos e a redução das desigualdades(Caragliu & Del Bo, 2019).

Entre os países signatários do Mercado Comum do Sul (Mercosul), as fronteiras entre Argentina, Brasil e Uruguai são percebidas como as mais dinâmicas da América do Sul (Campos, 2017) o que traz oportunidades significativas de desenvolvimento de regiões de fronteira inteligentes. Os estudos que tratam sobre a governança em CI e que vão além do uso da tecnologia para soluções de governo, ainda são pouco expressivos uma vez que ainda são poucas as pesquisas que olham para o entendimento das relações políticas e estratégias desse novo modo de governar a cidade (Ruhlandt, 2018). Também, na América do Sul, ainda são poucas as iniciativas de governança transfronteiriça (Oddone & Vázquez, Oro, 2018).

2. Cidades e Regiões de Fronteira Inteligentes

As CI também são definidas como territórios com alta capacidade de aprendizagem e inovação, onde incorpora-se a criatividade de sua população, as instituições geradoras de conhecimento e infraestrutura digital de comunicação e gestão do conhecimento (Komninos, 2011). Algumas das publicações sobre o tema defendem fortemente o uso de tecnologias da informação e comunicação (TIC) no planejamento de CIs e definem o conceito de cidade inteligente com base nesse aspecto (Angelidou, 2014). O conceito de CI também é empregado abrangendo a gestão do conhecimento e as comunidades e regiões inteligentes (Batty *et al*., 2012; Deakin & Al Waer, 2011).

Conforme os estudos de Kourtit e Nijkamp (2012) as dimensões de CI estão vinculadas ao Capital humano (com a força de trabalho qualificada da cidade); ao Capital de infraestrutura (com as facilidades da alta tecnologia); ao Capital social (com intensas e abertas ligações de *network)* e, *ao* Capital empreendedor (envolvendo criatividade e atividades comerciais de alto risco). Ao estudar as conexões entre os *stakeholders* envolvidos nos projetos de CI, bem como suas orientações, objetivos e tendências, Giffinger *et al.* (2007) listaram e descreveram os elementos que compõem as dimensões.Cada uma das dimensões de CI são compostas por características e fatores que juntos norteiam as cidades sobre que temas e ações devem priorizar para as desenvolver. A Tabela 1 apresenta os principais elementos de cada dimensão de CI.

Tab. 1 – Características e Fatores de uma Cidade Inteligente

ECONOMIA INTELIGENTE (Competitividade)	**CIDADÃO INTELIGENTE (Capital Social e Humano)**
Espírito inovador	Nível de qualificação
Empreendedorismo	Afinidade com a aprendizagem ao longo da vida

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Imagem económica e marcas	Pluralidade social e étnica
Produtividade	Flexibilidade
Flexibilidade do mercado de trabalho	Criatividade
Integração internacional	Cosmopolitismo/Mente Aberta
Capacidade de transformar	Participação na vida pública
GOVERNANÇA INTELIGENTE (Participação)	**MOBILIDADE INTELIGENTE (Transporte e TIC)**
Participação na tomada de decisões	Acessibilidade local
Serviços públicos e sociais	Acessibilidade Internacional
Governança transparente	Disponibilidade da infraestrutura de TIC
Estratégias e perspectivas políticas	Sistemas de transporte sustentáveis, inovadores e seguros
AMBIENTE INTELIGENTE (Recursos Naturais)	**VIVER INTELIGENTE (Qualidade de Vida)**
Atratividade das condições naturais	Equipamentos culturais
Poluição	Condições sanitárias
Proteção ambiental	Segurança individual
Gestão sustentável dos recursos	Qualidade da habitação
	Instalações educativas
	Atratividade turística
	Coesão social

Fonte: Traduzido e elaborado com base em Giffinger *et al.* (2007)

As iniciativas de CI são consideradas um dos caminhos para dar melhores respostas às questões urbanas, ampliar a oferta de políticas públicas e fortalecer a democracia (Echebarria, Barrutia, & Aguado-Moralejo, 2020; Moolngearn & Kraiwanit, 2024; Vanolo, 2018). Neste sentido, as estratégias de CI geralmente focam em bairros e conglomerados geográficos escolhidos pelos decisores (Komninos, 2011). Entretanto, o campo das iniciativas de CI pode transpor os limites das cidades e da iniciativa pública. As iniciativas de CI podem envolver regiões e, contextos "multi-jurisdicionais" (Nam & Pardo, p.190, 2011). Muitos projetos de CI podem ser "intergovernamentais, interorganizacionais ou intraorganizacionais" onde as atividades de interação "podem ser de partilha, comunicação ou integração" (Nam & Pardo, p.190, 2011). Já existem territórios e ou regiões que adotam soluções de CI em várias de suas cidades de forma simultânea e estratégica.

A lógica das regiões inteligentes e das regiões de fronteira inteligentes (RFI) deve ser basicamente mesma das CI: promover desenvolvimento e gerar qualidade de vida para as pessoas que vivem no território indo além do conceito de limite geográfico do país. Cidades localizadas em regiões de fronteira que adotam soluções de CI o fazem de maneira a realizar cooperação internacional e gerar mais inteligência para ambos os países (Soe, 2018). A tecnologia vem sendo usada como ferramenta para oensar a inteligencia das regiões (Krimmer, et al., 2021). Já existem alguns exemplos de regiões de fronteira inteligentes como as cidades de Helsinki e Tallin que trabalham de forma conjunta são cidades do norte da Europa com alta frequência de deslocamento e que agora têm um novo modelo para serviços digitais conjuntos pensando-as como cidades transfronteiriças, o chamado Sistema Operacional Urbano (Soe, 2018).

Além de projetos individuais de CI e das regiões inteligentes, algumas cidades também participam de redes de CI onde, em diferentes aspectos, as melhores práticas são compartilhadas entre seus membros (Palomo-Navarro & Navío-Marco, 2018). Neste sentido, amplia-se o alcance dos objetivos das iniciativas de CI por meio do intercâmbio de experiências. Os governos locais podem obter diferentes benefícios pela participação na rede, adquirindo sinergia e eficiência nas operações além de poder replicar casos de sucesso, conseguir financiamento de projetos internacionais ou mesmo criar planos a nível nacional para as CIs (Palomo-Navarro & Navío-Marco, 2018).

Há, porém, que se levar com cautela algumas questões relacionadas às fronteiras inteligentes. Ao pensar somente em alta eficácia e eficiência usando TICs na forma de sistemas de monitoramento, por exemplo, sem pensar em questões culturais do território de fronteira, corre-se o risco de reforçar uma dinâmica de exclusão de algumas populações (Delgado, 2020). Pois, através de tecnologia se pode monitorar ilegalidades, o que é positivo, mas também diferenciar fluxos de pessoas e bens considerados inapropriados ou indesejados, interferindo nas dinâmicas das regiões de fronteira, ricas em intercâmbios, expressões culturais e sociais (Benedetti, 2014; Sandes, 2020). Gerir as fronteiras é fazer a gestão de locais, circulação de pessoas, mercadorias, transportes, fluxos migratórios e comércio e entre outros (Benedetti, 2011). Porém, embora permita maior volume de informações, capital, melhora de processos e gestão (Delgado, 2020) é preciso trabalhar a paradiplomacia com critério a fim de que a RFI possa ser inovadora mas também, socialmente justa e inclusiva.

3. Procedimentos metodológicos

Essa pesquisa adotou caráter qualitativo e exploratório-descritivo e foi desenvolvida por meio de um estudo de caso único (Yin, 2014). O caso estudado foi a governança binacional de uma região rural de fronteira localizada

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

entre o Brasil e a Argentina e que tem aplicado iniciativas de CI. O caso se intitula La Frontera (LF) e está composto em uma região que busca se tornar uma RFI. A escolha pelo caso deu-se porque a região é uma fronteira seca, característica geopolítica que potencializa implementar ações de integração. As cidades da região já vinham trabalhando em prol do desenvolvimento do território a partir de iniciativas isoladas e passou a atuar em conjunto. Essa região tem a particularidade de que no lado brasileiro há cidades de dois estados (Santa Catarina-SC e Paraná-PR) que fazem divisa com as cidades argentinas da província de Missiones (MS).

A fim de realizar triangulação de dados (Gibbs, 2009), foram coletados dados primários e secundários. As técnicas de coleta de dados empregadas na pesquisa foram entrevistas narrativas (em profundidade) e análise de documentos. Os dados da pesquisa foram coletados no mesmo período, compreendido entre agosto e dezembro de 2020, de forma a contemplar o recorte temporal da ocasião do processo de formação da governança binacional assim como a atuação da governança na criação de iniciativas inteligentes.

Na ocasião da realização da pesquisa o LF contava com 34 membros entre brasileiros e argentinos. Nessa pesquisa, foram realizadas 23 entrevistas com os atores da governança do LF sendo 5 no idioma espanhol e 18 no idioma português. Cabe ressaltar que os cinco entrevistados argentinos totalizam todos os atores argentinos atuantes na governança no momento da coleta de dados. Foi elaborado e entregue um Termo de Consentimento Livre Esclarecido (TCLE) para cada um dos entrevistados bem como, um Termo de Autorização de Uso de Nome para a direção do LF. Foram entrevistados todos os atores que coordenam os eixos temáticos do LF (7) e outros 16 membros da governança que desempenham diferentes papéis (Tabela 2). Para preservar o anonimato dos entrevistados os mesmos estão relacioandos de E1 a E23.

Tab. 2 – Relação dos entrevistados

Entrevistado	Nacionalidade	Cidade	Setor	Atuação na governança	Tempo de entrevista
1	Brasileira	Dionísio Cerqueira-SC	Privado	Presidente	40 min
2	Argentina	Bernardo de Irigoyen-MS	Privado	Vice-presidente	1h43min
3	Brasileira	Barracão-PR	Público	Eixo Cultura e Integração	52 min
4	Brasileira	Sto. Antônio do Sudoeste-PR	Público	Coord. do Eixo Economia	59 min
5	Brasileira	Dionísio Cerqueira-SC	Privado	Vice Coord. do Eixo Economia	1h4min
6	Brasileira	Capanema-PR	Público	Coord. do Eixo Educação	1h15min
7	Argentina	Bernardo de Irigoyen-MS	Público	Vice Coord. do Eixo Educação	1h46min 106
8	Argentina	San António-MS	Público	Vice Coord. do Eixo Cult. e Integração	50 min
9	Brasileira	Capanema-PR	Público	Eixo Economia	1h21min
10	Brasileira	Pato Branco-PR	Privado	Programa Líder Sebrae	1h29min
11	Brasileira	Barracão-PR	Privado	Eixo Educação	1h25min
12	Brasileira	Dionísio Cerqueira-SC	Público	Eixo Economia	1h2min
13	Brasileira	Sto. Antônio do Sudoeste-PR	Público	Eixo Educação	1h20min
14	Argentina	San António - MS	Público	Eixo Economia e Aduanas	1h17min
15	Brasileira	Sto. Antônio do Sudoeste-PR	Privado	Eixo Educação	1h30min
16	Brasileira	Sto. Antônio do Sudoeste-PR	Público	Eixo Cultura e Integração	1h5min
17	Argentina	Possadas -MS	Privado	Eixo Educação	2h11min
18	Brasileira	Sto. Antônio do Sudoeste-PR	Privado	Eixo Economia	1h10min
19	Brasileira	Realeza-PR	Privado	Eixo Educação	1h14min
20	Brasileira	Bom Jesus do Sul-PR	Público	Eixo Cultura e Integração	1h4min
21	Brasileira	Dionísio Cerqueira-SC	Privado	Eixo Educação	1h55min
22	Brasileira	Barracão-PR	Privado	Eixo Economia	53 min
23	Brasileira	Barracão-PR	Privado	Eixo Economia	1h3min

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Total	Argentinos 5 Brasileiros18	SC 4 PR 14 MS 5	Setor público 11 Setor privado 12	Cargos da Governança 7 Eixos 16	29h13 min

Fonte: dados da pesquisa

Em seguida da execução das entrevistas, foi feita a transcrição das entrevistas e a tradução das entrevistas dos atores argentinos do LF que foram realizadas no idioma espanhol. A seleção dos atores entrevistados se deu à partir da análise de documentos do LF e por bola de neve (Patton, 1990) conforme as indicações dos entrevistados. A saturação foi observada a partir da 20ª entrevista. A Tabela 3 mostra a relação dos documentos analisados por essa pesquisa conforme data e motivação. Ao longo do texto os documentos são identificados de D1 a D8.

Tab. 3 – Relação dos documentos

	Documento	Motivação	Órgão Expedidor	Período
1	Notícia "Fronteiras Cooperativas" Leva Empresários e Lideranças em Missão na França, Alemanha e Suíça	Registro fotográfico e jornalístico de missões técnicas realizadas à países europeus por atores do atual La Frontera	ASCOAGRIN	Out de 2014
2	Apresentação do Programa Líder	Descrição de elementos do Programa Líder Sebrae	Sebrae	Maio de 2019
3	Histórico de Ações de Integração Local Bem-sucedidas	Registro do status das atividades e projetos do Fronteiras Cooperativas	Sebrae	Ago de 2019
4	Agenda de Desenvolvimento do Território da Fronteira – Projeto Líder	Caracterização da região, elementos do Programa Líder, Inventários Turísticos, histórico de iniciativas e atores	Sebrae; La Frontera	Nov de 2019
5	Ofício 01/2020 ao Excelentíssimo Sr. Carlos Moises, Governador de Santa Catarina	Apresenta a Governança Binacional ao governo de Santa Catarina e declara apoio ao pedido de privatização da aduana de cargas da região	La Frontera	Março de 2020
6	Carta de Motivação do Território da Fronteira	Documento que registra motivações, objetivos e estratégicos e metas	Sebrae	Maio de 2020
7	Decreto Provincial nº 330/2020 da Província de Misiones-ARG	Prorroga emergência Epidemiológica e Sanitária Provincial devido à Pandemia de COVID-19 e fechamento da fronteira	Governador da Província de Misiones - Argentina	Set de 2020
8	Protocolo Sanitário Binacional Brasil/Argentina Enfrentamento de Pandemia em Cidades de Fronteira e Cidades Gêmeas	Documento elaborado pela Governança Binacional com disposições sanitárias para sensibilizar a população e solicitar a abertura da fronteira	La Frontera; ACESAS; ASCOAGRIN; Sebrae; CIF; e cidades gêmeas	Set de 2020

Fonte: dados da pesquisa

Os dados coletados foram analisados por meio da técnica de Análise do Conteúdo Categorial. A análise do conteúdo foi feita conforme orientações de Bardin (2016), onde, inicialmente as entrevistas foram transcritas para que todos os dados estivessem em modo de texto, após, as falas dos atores entrevistados e os textos dos documentos foram associadas à significados, ou seja; codificados de uma forma sistemática. As categorias analisadas foram: motivação, histórico, resultados e iniciativas. As entrevistas e documentos foram codificados com a utilização do programa Nvivo12© versão pra Windows. A partir da transcrição das entrevistas, e, análise dos documentos selecionados, foi possível relacionar sistematicamente as falas das entrevistas com os documentos; os classificando em itens e fazendo a associação dos achados com a fundamentação teórica relacionada às CI e RFI.

4. Análises e discussões

O caso estudado chamado projeto La Frontera (LF) se trata de uma Governança Binacional instituída no ano de 2019. O LF funciona através da atuação de atores dos setores público e privado de três cidades da Província de MS na Argentina e nove cidades brasileiras sendo uma localizada no estado de SC e oito cidades do PR. A governança busca operacionalizar a integração e desenvolvimento da região através de ações voltadas para as áreas de economia, migração, educação, inovação e turismo. Com a escolha desse caso, percebe-se que as dimensões de CI quais sejam governança, economia e viver inteligente são contempladas pela iniciativa. Existe certa trajetória de ações de desenvolvimento e iniciativas de CI em cidades da região. Os entrevistados relataram quais são essas iniciativas e a Tabela 4 mostra a quantidade de vezes em que o tema foi abordado nas entrevistas.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab 4 - Cadeia de evidências

Categoria e número de evidências	Evidências (número de evidências, subcategoria, entrevistados e número de citações)
Iniciativas de RFI (235)	**(117) La Frontera** E1 (3), E2 (9), E3 (2), E4 (6), E5 (5), E6 (3), E7 (4), E8 (2), E9 (4), E11 (7), E12 (6), E13 (6), E14 (1), E15 (7), E17 (1), E18 (3), E19 (1), 21(11), 22(5), D2(1), D4 (16), D6 (10), D8 (4)
	(103) Pré-Existente E2 (5), E3 (6), E4 (7), E5 (4), E6 (1), E7 (2), E9 (6), E11 (7), E12 (3), E13 (1), E14 (4), E15 (3), E17 (4), E18 (3), E19 (4), E20 (14), E21 (6), E22 (15), E23 (2), D3 (10), D4 (6), D6 (5)

Fonte: Dados da pesquisa

Conforme os relatos dos entrevistados e os documentos analisados, os primeiros esforços para a integração binacional e desenvolvimento regional se deram através da realização de Fóruns Locais de Desenvolvimento e com trabalhos e projetos realizados em parceria com o Sebrae (agência brasileira de desenvolvimento econômico) (D3). Na década de 1990, um prefeito de um dos municípios criou a primeira incubadora empresarial da região (E23). Na mesma época, os atores locais fizeram contato com uma *trainee* do Sebrae (que atualmente está na gestão regional do Sebrae Paraná), que passou a acompanhar atividades voltadas para ao empreendedorismo e desenvolvimento regional (E23 e E10). Apesar de que, quando as ações de integração e desenvolvimento da região iniciaram, o Sebrae não tivesse escritórios na região (E10) foi feita uma parceria entre Sebrae , prefeituras e micro e pequenas empresas (MPE's) criando várias ações e programas ao longo dos anos. Com base nas análises dos documentos e das falas dos entrevistados foi possível mapear as as iniciativas de desenvolvimento que antecederam o LF (D3):

- **EMPREENDEDORISMO E GESTÃO**: iniciativa de 1997 e funciona na atualidade realizando atendimento nas cidades de Capanema-PR, Santo Antônio do Sudoeste-PR e Realeza-PR;
- **1º PROGRAMA LÍDER**: primeira edição do Programa Líder Sebrae na região, ocorrida no período compreendido entre 2008 e 2009 sendo um projeto de formação de líderes que objetivava mobilizar, integrar e capacitar lideranças para elaboração de planos conjuntos de desenvolvimento regional;
- **CONSÓRCIO INTERMUNICIPAL DA FRONTEIRA (CIF):** criado em 2009 e funcionando até os dias de hoje. Surge, entre outros esforços, da 1ª edição do Programa Líder. O Programa consiste em um consórcio criado no ano de 2009 e que atualmente funciona como associação pública, de direito público dos municípios de Barracão-PR, Bom Jesus do Sul-PR, Dionísio Cerqueira-SC e a cidade de Bernardo de Irigoyen-MS da Argentina como parceira informal pois a legislação brasileira não contempla a participação de cidades estrangeiras em consórcios intermunicipais. O CIF foi motivado pela revitalização da região cuja meta principal foi promover o desenvolvimento regional (D3);
- **PRÓ-FRONTEIRA**: projeto de mobilização desenvolvido de 2010 a 2012 para abertura das aduanas vocacionais entre o Brasil e a Argentina;
- **AMBIENTE DE NEGÓCIOS DO SEBRAE**: projeto cidade empreendedora criado em 2017 (e atual) que ocorre em oito dos quatorze municípios que compõem o território brasileiro (divisão do Sebrae) – foi implementando a partir de lei geral e com a criação de Salas do Empreendedor (D3);
- **FRONTEIRAS COOPERATIVAS**: projeto de desenvolvimento de ações conjuntas entre Brasil e Argentina que funcionou de 2013 a 2018. Intuía tornar a região de fronteira uma referência em desenvolvimento, através de ações de cooperação internacional, empreendedorismo, cidadania, integração produtiva e negócios. Focou o desenvolvimento de competências de relacionamento junto a lideranças que atuaram de forma integradas com iniciativas locais a fim de construir estratégias e planejar as cidades integradamente e sinergicamente. Seu objetivo principal era melhorar o ambiente transfronteiriço para as MPE's e o empreendedorismo, visando gerar e aproveitar oportunidades de cooperação para o desenvolvimento econômico integrado das cidades gêmeas;
- **COMITÊ DAS MICRO E PEQUENAS EMPRESAS:** criado em 2017 e ainda em funcionamento, implantando temas que contribuam para a melhoria do ambiente de negócios (compras, crédito, inovação, aduanas vocacionadas e educação) das MPE's;
- **ESCRITÓRIO DE ARTICULAÇÃO DO SEBRAE NA FRONTEIRA:** criado em 2019, um escritório que pretende concretizar a integração da fronteira, através de promoção, mobilização, qualificação, atendimento de lideranças e empresários, com ênfase no estabelecimento de ambiente favorável a atuação das MPE's;
- **PROGRAMA LÍDER FRONTEIRA:** realizado entre os anos de 2018/2019 foi a terceira edição de formação do Programa realizada pelo SEBRAE na região. Teve como objetivo a composição de uma governança para articular as ações de desenvolvimento do território. Nesta ocasião, o programa Fronteiras Cooperativas fez parceria com o SEBRAE para capacitação de lideranças locais, brasileiras e argentinas, que ao final do período do programa originou como entregável o LF e o Fronteiras Cooperativas foi descontinuado. A partir do final do ano de 2019 surge o LF.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Com esses processos de desenvolvimento regional em curso e com a questão geográfica a região tornou-se foco interessante para o desenvolvimento de uma agenda econômica e política. Neste sentido, o Programa Líder Sebrae voltado a reconhecer e desenvolver lideranças para o desenvolvimento regional foi realizado para identificar e treinar líderes locais para atuar com desenvolvimento regional. A nível nacional, nas palavras do Sebrae esse projeto foi criado para "responder a carência de uma atuação integrada entre as lideranças do poder público, entidades privadas e do terceiro setor para a promoção de desenvolvimento sustentável dos territórios brasileiros" (Sebrae, 2021). Através do programa, o Sebrae esperava sensibilizar lideranças e fomentar a organização e qualificação de atores para a construção e implementação de agendas de desenvolvimento econômico para todo o território. Neste sentido, a terceira edição do Programa Líder foi a primeira em que atores argentinos participaram. Destaca-se que para atuar no países vizinho, o Sebrae recebeu aval do Itamaraty e de embaixada argentina (E10). O Programa Líder vem sendo realizado em outras regiões brasileiras (Sebrae, 2021), mas até o momento o único projeto binacional foi o desenvolvido nessa região (E10, E15).

A articulação prévia da governança culminou em alguns ganhos políticos. E12 coloca: "nós conseguimos também transformar, ser reconhecido pelo Ministério da Fazenda, Dionísio Cerqueira, Barracão e Santo Antônio de Sudoeste, como cidades gêmeas" (E12). Este é visto como um passo importante no caminho rumo à constreução de uma RFI. As cidades apresentavam as características de cidades gêmeas (Benedetti, 2014) e o reconhecimento de Santo Antônio do Sudoeste-PR, Barracão-PR Dionísio Cerqueira-SC como cidades gêmeas com cidades argentinas se deu por meio da Portaria Nº 213, de 19 de Julho de 2016 do Ministério da Integração Nacional que estabeleceu no Brasil o conceito, os critérios e a listagem de todas as cidades brasileiras (Brasil, 2016).

Cada uma das edições do Programa Líder acabou originando uma iniciativa de desenvolvimento para a região e contribuindo para que o LF fosse criado. A E10 fala que já no ano de 2013 começava-se a ouvir falar do conceito de cidades inteligentes (Caragliu & Del Bo, 2019) e da integração em cidades gêmeas (Benedetti, 2014) porém ainda não se tinha uma visão da possibilidade de construir uma região de fronteira inteligente ainda mais em uma região rural. A visão de uma RFI foi sendo construída com o passar dos anos e com a constatação de que o desenvolvimento seria mais efetivo se ocorresse de forma binacional (Soe, 2018, Krimmer et al., 2021).

Em maio de 2019, antes da criação do LF ainda em formação do Líder, os atores elaboraram um documento intitulado Carta de Motivação Território de Fronteira. Abaixo, o trecho da Carta de Motivação apresenta informações sobre as expectativas da criação do LF:

> *"O Projeto Líder Fronteiras Cooperativas teve um papel fundamental na identificação dos atores desse processo, de forma a permitir ações, no sentido de suprir de informações referentes à transferência de tecnologias, investimentos financeiros e internacionalização dos negócios, permitindo fazer parte do processo de desenvolvimento da região na qual as organizações estão inseridas. Esse projeto de desenvolvimento estruturante está associado ao processo de acumulação da inovação e da formação do capital social. O território está cada vez mais sendo considerado como uma estrutura ativa (de desenvolvimento, de sustentabilidade e de capital social). Temos líderes que fazem acontecer o progresso através do pertencimento do território, protagonismo e orgulho de ser da Fronteira"* (D3).

Esse documento demonstra que elementos presentes no conceito de CI como inovação (Mills et al., 2024) e capital social (Fletcher, 2020) estão presentes na motivação para a criação do LF. Outro elemento percebido como motivador foi o de que não existia um sentimento de identidade fronteiriça. . Destaca-se o fato de que as cidades da faixa de fronteira são codependentes (Sandes, 2020) e portanto, precisam umas das outras para se desenvolverem, principalmente por questões de infraestrutura e de economia. Durante o programa Líder, os atores da atual governança perceberam que para viabilizar as iniciativas de CI e as ações planejadas a nível de território, precisavam constituir uma governança que fosse binacional. Constata-se que a composição da governança bonacional foi uma espécie de entregável da formação do Sebrae e que passou a atuar no ano de 2019. O LF então se associa às iniciativas anteriores e compõe a Governança Binacional com CIF e Fronteiras Corporativas.

Outra iniciativa que leva a região rumo a se desenvolver como RFI é o **Consórcio Intermunicipal da Fronteira** (CIF) que é uma associação de direito público, um consórcio formado por quatro cidades: Dionísio Cerqueira-SC, Barracão-PR, Bom Jesus do Sul-PR e Bernardo de Irigoyen-MS. Foi criado objetivando desenvolver propostas e projetos de desenvolvimento para a região de fronteira. Desenvolve parcerias principalmente nas áreas da saúde, economia, educação e assistência social. Essa iniciativa que trouxe várias outras iniciativas para os municípios integrantes como a reforma de um hospital que antes era particular e hoje atende os três municípios brasileiros do consórcio sendo atualmente 100% SUS (E3). Se caracteriza como uma iniciativa de governança inteligente e traz elementos de governança colaborativa (Giffinger et al., 2007; Pereira, Cunha, et al., 2017) altamente estratégicos para a consolidação de uma RFI.

À partir de ações de articulações, o LF conquistou a construção do **Parque Turístico Ambiental da Integração** (PTAI), conhecido popularmente por Lago Internacional da Tri Fronteira que tem uma extensão de 3 km. É um parque classificado como uma iniciativa de Viver intelogente (Giffinger et al., 2007), localizado na divisa entre Bernardo de Irigoyen-MS e Dionísio Cerqueira-SC cuja área que também compreende o rio Peperi-guaçú que antes era degradada, com pontos alagados, usada como depósito irregular de lixo e local de passagem ilegal e descaminho

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

foi recuperada de forma conjunta entre Brasil e Argentina e hoje é um espaço integração, prática de esportes, lazer, atividades recreativas, culturais, gastronômicas e comerciais para os cidadãos argentinos e brasileiros. O parque ambiental recebeu o investimento de mais de 10 milhões, recursos oriundos do Governo Federal do Brasil e da província de MS, do PR e de SC, além de recursos do município de Dionísio Cerqueira. A Figura 1 mostra o PTAI.

Fig. 1 – Parque Turístico Ambiental da Integração (PTAI)



Fonte: (D3) Dados da pesquisa (2021)

O **Gabinete de Gestão Integrada-Intermunicipal** – GGI-I é uma iniciativa que faz o monitoramento da fronteira e o tráfego de veículos por meio de câmeras de monitoramento na faixa de fronteira. Se caracteriza como outra iniciativa no escopo da Governança Inteligente e que contribui para a RFI (Pereira, et al., 2017; Pereira, Parycek, et al., 2018). Trabalha em parceria com as prefeituras e com o CIF e tem órgãos trabalhando de forma integrada na Argentina e no Brasil, como as polícias civil e militar, a Receita Federal e o exército dos dois países:

"O GGI, da segurança pública, trabalha a integração das forças policiais né, em um território, um local, um Estado e nós trabalhamos toda essa questão do GGI, da união, toda a força policial de Barracão, de Dionísio, de Bom Jesus e Bernardo de Irigoyen. Isso acaba envolvendo as polícias civis, militares, dos dois Estados, a polícia federal, de Dionísio, a Receita Federal e toda a força policial da Argentina, policial federal da Argentina, o exército. Então nós temos esse, esse gabinete, já há muito tempo que ele é fomentado pelo CIF, no consórcio, mas é a gente que organiza, dá toda estrutura, né, apoio inclusive a gente conseguiu muito acordo, a gente conseguiu equipamentos com a receita federal, com a polícia a gente conseguiu canil, para instalar na polícia de Dionísio pra atender toda nossa região, e conseguimos com a Itaipu, a Itaipu bancou, deu desde animais, foi adquirido ração, o equipamento tudo. Então tudo graças ao consorcio e ao GGI, então o consorcio ele é fundamental também, no fomento dessas, dessas outras ações" (E3)

Aspecto interesante é que a cidade de Realeza-PR detém o título de Cidade Amiga do Idoso conferido pela Organização Mundial da Saúde (OMS) a cidades que pensam o envelhecimento ativo a partir de infraestrutura e serviços públicos adaptados às necessidades dos idosos (Realeza, 2021). A fim de incluir essa população e promover qualidade de vida e o viver inteligente (Giffinger et al., 2007) o município tem iniciativas como o **Clube do Vovô**, o **Vôlei Adaptado** e o **Centro Dia** (Realeza, 2021) que promovem a saúde e a participação ao assumir que um envelhecimento ativo demanda que os idosos participem da vida da cidade, da política e que sejam ouvidos, tendo seus direitos assegurados. O **Fronteira Iguassu Circuito de Cicloturismo** é uma iniciativa de Viver Inteligente (Giffinger et al., 2007) realizada pelo Fronteiras Cooperativas nos municípios de Comandante Andesito-MS, Capanema-PR e Planalto-PR. Objetiva fortalecer a prática esportiva e turística e potencializar a economia e comércio dos mais diversos setores. Além da realização do circuito, o Fronteira Cooperativas fez o mapeamento de pontos turísticos localizados ao longo dos trajetos (Planalto, 2018) para desenvolver a região com turismo de aventura. A partir daí, algumas das iniciativas que aconteciam de forma isolada e estavam concentradas nas cidades de Barracão-PR, Dionísio Cerqueira-SC, Bom Jesus do Sul-PR e Bernardo de Irigoyen-MS começam a ser ampliadas. A partir da criação do LF como uma governança binacional com definição de planejamento estratégico em três eixos temáticos (educação, economia e integração e cutltura) do LF, foram estabelecidas ações a serem desenvolvidas em praticamente todo o território de fronteira da região a fim de torná-lo mais inteligente. Mapeou-se as iniciativas de CI e de RFI desenvolvidas e classificou-as conforme as dimensões de CI propostas no *framework* de (Giffinger et al., 2007) (Tabela 5).

Tab. 5 - Iniciativas da governança binacional quando às dimensões de cidade inteligente

Iniciativa	Descrição	Dimensão

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Formação de professores gestores nas escolas públicas	Cursos para formar professores da rede pública do BR e da ARG na área da gestão escolar	Cidadão Inteligente por Nível de qualificação dos gestores das escolas
Projeto Levantamento bibliográfico sobre a história da fronteira	Projeto para fazer Levantamento bibliográfico sobre a história da fronteira, organizar em material impresso	Dimensões Viver e Cidadão inteligente por facilidades culturais, desenvolvimento de uma educação pautada na história da região
JEPP (Jovens Empreendedores Primeiros Passos)	Disseminar a cultura empreendedora e orientar para o plano de negócios	Dimensões Economia e Cidadão Inteligente por espírito inovador, habilidade de transformar, empreendedorismo, nível de qualificação
Melhoria na eficiência do Polo Aduaneiro da fronteira	Tornar a região um Polo Aduaneiro - Trabalhar politicamente para acelerar a publicação da licitação junto a RFB para privatizar a ACI Cargas de Dionísio Cerqueira. Implantar lojas francas nos três municípios da fronteira, fortalecer os apoios políticos para a abertura do Porto Seco; criar uma revista: Polo Aduaneiro – La Fronteira	Dimensão Economia inteligente por integração internacional, fomento a turismo, e visão do território de forma abrangente
App La Frontera	Mapeamento e elaboração de App de pontos turísticos, informações sobre o território e comunicação com a governança	Dimensão Economia e viver inteligente por integração internacional, fomento a turismo e economia
La Frontera Inova	Trilha com metodologia criada e executada pelo SEBRAE com conteúdo de empreendedorismo e inovação para desenvolver Startups - Aplicação nos IFES da região e universidades	Dimensão Economia inteligente por empreendedorismo e inovação
Programa La Frontera Compra Aqui	Objetiva aumentar a participação de empresas do território nas compras públicas através de três iniciativas: Divulgação de editais, parceria com as associações comerciais e capacitação de empresários locais	Dimensão Economia Inteligente por inovação, estímulo da economia local
Projeto - Passeio Costaneiro da Integração	Parque binacional que irá revitalizar área pública respeitando rio que divide Santo Antônio do Sudoeste-PR e San Antônio e onde será construído um espaço verde e cultural com "anfiteatro natural"	Dimensões Viver, Mobilidade e Ambiente Inteligente: construção verde, proteção do meio ambiente, atratividade turística, mobilidade internacional e facilidades culturais
Projeto - Paisagem e espaços públicos para a integração transfronteiriça	Elaboração dos projetos de engenharia, levantamento topográfico planimétrico	Dimensões Ambiente Inteligente: acessibilidade, atratividade turística, mobilidade internacional
Escola de Robótica - Bernardo de Irigoyen-MS	Espaço projetado para o desenvolvimento, treinamento e expansão de vocações tecnológicas, através de modelo pedagógico inovador, projetada para crianças e jovens de 5 a 18 anos, onde são realizados treinamentos em robótica e/ou programação. É pautada na Lei de Educação Disruptiva da Província de Misiones-ARG.	Dimensões Viver e Economia Inteligente por Empreendedorismo, inovação e educação para o século XXI
POLOTIC – Misiones – Campus Bernardo de Irigoyen -MS	O ICT Misiones Polo é um projeto provincial de inovação industrial que desenvolve sua primeira experiência no Parque Industrial Posadas (SAPEM). Para mudar a matriz produtiva da província voltada para as novas tecnologias, foi planejado como um espaço-chave para pensar em Missões para o futuro. O polo é baseado em diferentes bases: como um local para treinamento em programação em diferentes idiomas e níveis, testes, modelagem 3D, impressão 3D, desenvolvimento de aplicativos móveis, linguagem audiovisual, gerenciamento e construção de drones e, em breve, robótica, eletrônica aplicada e automação industrial.	Dimensões Viver e Economia Inteligente por Empreendedorismo, inovação e educação para o século XXI
Internacionalização de Startups – SEBRAE/PR	A internacionalização das Startups, tem como objetivo a abertura de novos mercados e prospecção de negócios com outros países, para as iniciativas que participam do programa STARTUP-PR. Está prevista através da interação com a Rede Ibero Americana de Incubadoras (RETEI), que	Dimensão Economia inteligente por integração internacional, inovação e empreendedorismo

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

	conta com 20 incubadoras (México, Costa Rica, El Salvador, Peru, Colômbia, Chile, Paraguai e Argentina), além de Portugal, Bélgica e Israel.	
Centro de Empreendedorismo e Inovação Binacional	Será espaço compartilhado, localizado em Bernardo de Irigoyen-MIS, que utilizará o movimento de crianças, jovens, comunidade, empresas e startups, que buscam trabalhar e desenvolver projetos de forma colaborativa, para crescer e desenvolver-se de forma mais rápida e sustentável. Será formado por: Polotic, Escola de Robótica e Programa de Internacionalização de STARTUPS SEBRAE-PR. Será binacional, atendendo brasileiros e argentinos. Uma ferramenta de intercâmbio cultural, boas práticas de gestão e ampliação de mercado, promovendo o desenvolvimento local.	Dimensões Viver e Economia Inteligente por Empreendedorismo, inovação e educação para o século XXI

Fonte: Dados da pesquisa (2021)

Conforme os entrevistados, um dos resultados esperados quando da criação de espaços públicos de lazer como o Parque Turístico Ambiental da Integração e o *Paseo Costanero* é que estes: "ajudam na coesão social [...] o parque é um lugar de dispersão para abrir as mentes e levar à integração da sociedade, não há diferença entre ricos e pobres, ajuda a economia porque tem sempre algum lugar perto do parque [...]" (E2). A proposta do *Paseo Costanero* é ser construído respeitando o curso do rio e a arborização composta por vegetação nativa. Além das questões ambientais, e de atratividade turística, os parques podem ser uma oportunidade de fazer integração (Benedetti, 2011), de se conviver com a diversidade e de que se construa uma consciência coletiva (Coesão Social) contemplada pela dimensão Viver Inteligente (Giffinger et al., 2007). A Figura 12 mostra projeto do Projeto Paseo Costanero da Integração.

Fig. 2 – Projeto do Paseo Costanero da Integração (em construção)



Fonte: dados da pesquisa (2021)

Os recursos para essas iniciativas de CI foram, em sua maioria, recursos públicos oriundos dos governos municipais, da província de Misiones, do governo do estado do Paraná, do governo federal, do Sebrae e do FOCEM o que coincide com o proposto por Chourabi *et al.* (2012) que diz que a maioria dos projetos de CI é fomentado e financiado direta ou indiretamente pelos governos. O Sebrae é uma agência de desenvolvimento vinculada ao Estado e o FOCEM um fundo internacional financiado por governos de países do Mercosul. Muitas dessas iniciativas que estão em status de implementação ou de articulação já eram ideias de iniciativas e projetos anteriores, mas que sem uma governança binacional não achavam maneira de serrem realizadas.

Através dessas iniciativas se pode ver materializados os conceitos de CI e de RFI. A Governança Binacional tem o desafio de coordenar os esforços necessários para articular e integrar as iniciativas e de oportunizar o desenvolvimento. Percebe-se que as iniciativas planificadas ainda estão em sua maioria no escopo das ações do Sebrae. A médio prazo seria interessante que as ações do LF extrapolassem a dimensão econômica e se utilizassem de TICs, por exemplo, para trazer um olhar mais diverso e mais social a novas iniciativas de CI e RFI. Outro ponto que ainda não é muito explorado nas ações do LF é a livre circulação dos fronteiriços. Ao pensar novas estruturas aduaneiras, por exemplo, os atores precisam atuar a fim de que todos os cidadãos possam ter os mesmos direitos na RIF.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5. Considerações Finais

Objetivando entender a motivação e o processo de criação de uma região de fronteira inteligente (RFI) no contexto latino-americano através da análise das iniciativas e resultados de uma rede formal de governança binacional localizada na fronteira Brasil-Argentina foi possível perceber que regiões de fronteira inteligentes são passíveis de serem construídas a partir de uma abordagem colaborativa e *multistakeholder*. A governança colaborativa já é abordada em inúmeros estudos sobre CI mas os estudos sobre RFI focam mais em questões de migração e menos em governança e desenvolvimento regional, especialmente em espaços urbanos em regiões rurais. A partir do estudo deste caso percebe-se que na RFI a colaboração e a integração se fazem ainda mais importantes. Indo além do modelo de governança binacional, não basta que atores de ambos os países pensem o desenvolvimento e as ações para o território, é necessário que exista uma diversidade de atores participando das decisões e da implementação das iniciativas e atuando para articular ações com outros níveis como estados, governos federais e agências internacionais de desenvolvimento.

Gerir territórios de fronteira envolve certos níveis de complexidade pois engloba a circulação de pessoas, mercadorias, transportes, fluxos migratórios, comércio internacional e entre outros. Em localidades pequenas, é mais fácil promover o desenvolvimento quando os esforços são conjuntos. Mas comunidades rurais, via de regra, estão mais afastadas dos grandes centros e podem ter menos poder político. Os governos subnacionais, as instituições da região e os cidadãos encontram em uma governança bi ou trinacional, metodologia adequada para o desenvolvimento. Na governança binacional a formulação de políticas públicas e de promoção de desenvolvimento regional e iniciativas de desenvolvimento que carecem de articulação também podem ser praticadas por meio de capital social e redes de cooperação com outros países vizinhos uma vez que necessitam de planejamento, articulação e de captação de recursos.

A respeito da transformação da fronteira em uma RFI, assume-se que o conceito de RFI deva englobar questões de melhoria de condições de infraestrutura aduaneira, migratórias e de segurança, porém deve ir além. Considera-se que uma região de fronteira só se tornará inteligente quando, em nível institucional, puder trabalhar de forma conjunta para superar ou minimizar gargalos de questões relativas às diferenças culturais, legais e estruturais, através de participação ativa da sociedade e passar a proporcionar qualidade de vida aos cidadãos de ambos os países. Além da governança inteligente ser dimensão chave para o planejamento das ações executadas em outras áreas, no caso de uma RFI, uma governança participativa, colaborativa e plural apoiará as ações necessárias à região.

Acerca das limitações da pesuisa os resultados encontrados somente são analisados a partir da ótica dos atores da governança, que são gestores, empresários e atores de instituições, mas, a visão dos cidadãos fronteiriços não foi contemplada pela investigação. Como sugestão de pesquisas futuras aponta-se a realização de pesquisas analisando as nuances da presença de iniciativas de CI na efetiva mudança social para as pessoas que vivem no território de fronteira e sobre o direto à cidade em ambos os países. Investigar se altos níveis de centralização e hierarquização mais rígida das instituições dos países podem em certa medida interferir do desenvolvimento de CI e RFI. Verificar se existe relação entre a descontinuidade ou a sucessão de múltiplos projetos de CI em uma mesma cidade ou território e seus possíveis impactos para a comunidade. Estudos que investiguem processos de gentrificação ou globalismo fechado em regiões de fronteira na América Latina que utilizem soluções de TIC em questões migratórias e possível relação entre tais fatores.

Agradecimentos

O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Código de Financiamento 001.

Referencias

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

Albuquerque, J. L. C. (2020). Identidad. In *Palabras clave para el estudio de las fronteras Org. Benedetti, Alejandro Gabriel* (1º ed, p. 695). Ciudad Autónoma de Buenos Aires: Teseo Press.

Angelidou, M. (2014). Smart city policies: A spatial approach. *Cities*, *41*, S3–S11. https://doi.org/10.1016/j.cities.2014.06.007

Bardin, L. (2016). Análise de Conteúdo. São Paulo: Edições 70. *São Paulo: Edições 70*, p. 279.

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., … Portugali, Y. (2012). Smart

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

cities of the future. *European Physical Journal: Special Topics*, *214*(1), 481–518. https://doi.org/10.1140/epjst/e2012-01703-3

Benedetti, A. (2011). Lugares de frontera y movilidades comerciales en el sur sudamericano. Una aproximación multiescalar. *Fronteiras em foco*, 33–55.

Benedetti, A. (2014). Espacios fronterizos del sur sudamericano. Propuesta de un modelo conceptual para su estudio Bordering spaces in the South American south. Proposals for a conceptual model for their study. *Estudios Fronterizos, nueva época*, *15*, 11–47. Recuperado de https://dialnet.unirioja.es/descarga/articulo/5195986.pdf

Brasil. Portaria nº 213, de 19 de julho de 2016. Estabelece o conceito de "cidades-gêmeas" nacionais, os critérios adotados para essa definição e lista todas as cidades brasileiras por estado que se enquadram nesta condição. , Imprensa Nacional. Ministério da Integração Nacional - Diário Oficial § (2016).

Campos, H. Á. (2017). O papel estratégico de cidades gêmeas no controle de mercadorias em regiões de fronteira no contexto do MERCOSUL: Uruguaiana (BR) e Paso de los Libres (AR) / The strategic role of twin cities in controlling goods in border regions in the MERCOSUR context: *Redes*, *22*(1), 56. https://doi.org/10.17058/redes.v22i1.8667

Caragliu, A., & Del Bo, C. F. (2019). Smart innovative cities: The impact of Smart City policies on urban innovation. *Technological Forecasting and Social Change*, *142*(July 2018), 373–383. https://doi.org/10.1016/j.techfore.2018.07.022

Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., … Scholl, H. J. (2012). Understanding smart cities: An integrative framework. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2289–2297. https://doi.org/10.1109/HICSS.2012.615

Deakin, M., & Al Waer, H. (2011). From intelligent to smart cities. *Intelligent Buildings International*, *3*(3), 140–152. https://doi.org/10.1080/17508975.2011.586671

Delgado, M. C. (2020). Imaginario. In *Palabras clave para el estudio de las fronteras Org. Benedetti, Alejandro Gabriel* (1º ed, p. 383–391). Ciudad Autónoma de Buenos Aires: Teseo Press.

Echebarria, C., Barrutia, J. M., & Aguado-Moralejo, I. (2020). The Smart City journey: a systematic review and future research agenda. *Innovation: The European Journal of Social Science Research*, *34*(2), 159–201. https://doi.org/10.1080/13511610.2020.1785277

Fletcher, A. L. (2020). Smart city visions: pathways to participatory planning in two American cities. *Foresight*, *22*(5–6), 689–702. https://doi.org/10.1108/FS-04-2020-0036

Gibbs, G. (2009). *Analise de dados qualitativos*. Porto Alegre: Artmed.

Giffinger, R., Fertner, C., Milanovic, N., Kalasek, R., & Kramar, H. (2007). Smart cities: ranking of European mid-sized cities. In *Smart cities Ranking of European medium-sized cities*. https://doi.org/10.1016/S0264-2751(98)00050-X

ITU, & UNECE. (2016). *Unlocking Cities of the Future: The Road to Smart Sustainable Cities*. Recuperado de http://habitat3.org/

Komninos, N. (2011). Intelligent cities: Variable geometries of spatial intelligence. *Intelligent Buildings International*, *3*(3), 172–188. https://doi.org/10.1080/17508975.2011.579339

Kourtit, K., & Nijkamp, P. (2012). Smart cities in the innovation age. *Innovation*, *25*(2), 93–95. https://doi.org/10.1080/13511610.2012.660331

Krimmer, R., Dedovic, S., Schmidt, C., & Corici, A. A. (2021). Developing Cross-border E-Governance: Exploring Interoperability and Cross-border Integration. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *12849 LNCS*(November), 107–124. https://doi.org/10.1007/978-3-030-82824-0_9

Lousada, M., & Valentim, M. L. P. (2011). Modelos de tomada de decisão e sua relação com a informação orgânica. *Perspectivas em Ciencia da Informacao*, *16*(1), 147–164. https://doi.org/10.1590/s1413-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

99362011000100009

Mills, D. E., Pudney, S., Gomes, R. C., & Sarturi, G. (2024). Smart City Capacities: Extant Knowledge and Future Research for Sustainable Practical Applications. *Sustainability*, *16*(9). https://doi.org/10.3390/su16093719

Moolngearn, P., & Kraiwanit, T. (2024). Barriers To Development of Smart Cities: Lessons Learned From an Emerging Economy. *Corporate and Business Strategy Review*, *5*(2), 255–262. https://doi.org/10.22495/cbsrv5i2art22

Nam, T., & Pardo, T. A. (2011). Smart city as urban innovation: Focusing on management, policy, and context. *ICEGOV*, 185–194. https://doi.org/10.1145/2072069.2072100

Oddone, N., Vázquez, H. R., & Oro, M. J. Q. B. (2018). Paradiplomacia local y transfronteriza como un instrumento de gobernanza ambiental en el Mercosur y la Unión Europea: una descripción comparada. *Civitas - Revista de Ciências Sociais*, *18*(2), 332. https://doi.org/10.15448/1984-7289.2018.2.29690

Palomo-Navarro, Á., & Navío-Marco, J. (2018). Smart city networks' governance: The Spanish smart city network case study. *Telecommunications Policy*, *42*(10), 872–880. https://doi.org/10.1016/j.telpol.2017.10.002

Patton, M. (1990). Qualitative designs and data collection. In *Qualitative evaluation and research methods* (p. 169–186). https://doi.org/10.4135/9781473913882.n3

Pereira, G. V., Cunha, M. A., Lampoltshammer, T. J., Parycek, P., & Testa, M. G. (2017). Increasing collaboration and participation in smart city governance: a cross-case analysis of smart city initiatives. *Information Technology for Development*, *23*(3), 526–553. https://doi.org/10.1080/02681102.2017.1353946

Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017). Delivering public value through open government data initiatives in a Smart City context. *Information Systems Frontiers*, *19*(2), 213–229. https://doi.org/10.1007/s10796-016-9673-7

Pereira, G. V., Parycek, P., Falco, E., & Kleinhans, R. (2018). Smart Governance in the Context of Smart Cities : A Literature Review. *Information Polity*, (May). https://doi.org/10.3233/IP-170067

Peters, B. G., & Pierre, J. (2012). Urban Governance. In *The Oxford Handbook of Urban Politics* (p. 1–19). https://doi.org/10.1093/oxfordhb/9780195367867.013.0005

Planalto. (2018). CIRCUITO DE CICLOTURISMO FOI APRESENTADO EM PLANALTO.

Rascovan, A. (2020). Geopolítica. In *Palabras clave para el estudio de las fronteras Org. Benedetti, Alejandro Gabriel* (1º ed, p. 695). Ciudad Autónoma de Buenos Aires: Teseo Press.

Realeza. (2021). Prefeitura Municipal de Realeza-PR. Recuperado 4 de janeiro de 2021, de CIDADE AMIGA DO IDOSO website: http://realeza.pr.gov.br/cidade-amiga-da-pessoa-idosa/

Ruhlandt, R. W. S. (2018). The governance of smart cities: A systematic literature review. *Cities*, *81*(October 2017), 1–23. https://doi.org/10.1016/j.cities.2018.02.014

Sandes, E. S. (2020). Ciudad. In *Palabras clave para el estudio de las fronteras Org. Benedetti, Alejandro Gabriel* (p. 117–125). Ciudad Autónoma de Buenos Aires: Teseo Press.

Sant'Anna, F. M. (2013). O PAPEL DA INTEGRAÇÃO FRONTEIRIÇA PARA A INTEGRAÇÃO REGIONAL NA AMÉRICA LATINA. *Revista Geonorte*, *7*(1), 520–536.

SEBRAE. (2021). O LIDER fomenta. Recuperado 13 de janeiro de 2021, de O LIDER fomenta website: https://www.sebrae.com.br/sites/PortalSebrae/projetolider

Soe, R. M. (2018). Smart cities: From silos to cross-border approach. *International Journal of E-Planning Research*, *7*(2), 70–88. https://doi.org/10.4018/IJEPR.2018040105

UN Habitat. (2016). UN World Cities Report 2016: Abridged Edition. In *UN Habitat*. Recuperado de http://wcr.unhabitat.org/wp-content/uploads/2017/02/WCR-2016_-Abridged-version-1.pdf

Vanolo, A. (2018). Cities and the politics of gamification. *Cities*, *74*, 320–326.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://doi.org/10.1016/j.cities.2017.12.021

Yin, R. K. (2014). *Case study research design and methods* (5º ed). Thousand Oaks: Sage.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Cidadania no contexto da transformação digital na América Latina: uma proposta de framework analítico

João Paulo dos Santos da Silva [a*], *Diana Cruz* Rodrigues [b]

[a] Programa de Pós-graduação em Administração, Universidade da Amazônia, Belém, Brasil, joaopssilva803@gmail.com, 0000-0002-6096-4544

[b] Programa de Pós-graduação em Administração, Universidade da Amazônia, Belém, Brasil, dicruzrodrigues@gmail.com, 0000-0001-6670-8907

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Resumo. O artigo é um ensaio teórico que busca apresentar um framework de análise e um quadro analítico das dimensões de cidadania no contexto da transformação digital na América Latina a partir dos diferentes projetos políticos em disputa na região. Para a construção do framework e do quadro, são utilizadas as dimensões de cidadania de status legal/associação, direitos sociais e participação. O conceito de cidadania no contexto da transformação digital é apresentado em contraposição ao conceito de cidadania digital, a partir do entendimento de que a cidadania é um processo abrangente e em constante mudança através das práticas sociais dos agentes e das instituições. A transformação digital afeta este processo permanente da cidadania permitindo o uso das tecnologias da informação e comunicação (TIC) por parte das instituições e agentes na construção destas práticas sociais. No contexto latino-americano, os projetos políticos democrático-participativo e neoliberal estabelecem uma disputa de significados de dimensões chave como status legal/associação, direitos sociais e participação. Neste contexto, as práticas sociais são orientadas por estes projetos políticos em disputa. O framework e o quadro analítico propostos neste estudo buscam contribuir para a análise da complexidade do contexto latino-americano ao estabelecerem essa relação entre o impacto das práticas sociais com uso de TIC nas dimensões da cidadania e a orientação dessas práticas pelos projetos políticos em disputa.

Keywords. Cidadania, Transformação digital, Práticas sociais, Projetos políticos, América Latina
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1001

1. Introdução

Com o avanço da transformação digital nas relações sociais e entre Estado e sociedade, a cidadania cada vez mais vem sendo relacionada com a utilização de tecnologias da comunicação e informação (TIC), gerando o conceito de cidadania digital (Mossberger et al., 2008; Mossberger & Tolbert, 2021; Schou & Hjelholt, 2018). A perspectiva hegemônica deste conceito está baseada na relação entre Estado e sociedade intermediada através do uso de TIC (Moosberger et al., 2008; Ribble & Bailey, 2007; Robles, 2009). Nesta perspectiva, a centralidade está direcionada a observar se o cidadão possui o acesso necessário às TIC para se relacionar de forma efetiva com o Estado e acessar políticas e serviços digitais.

Este conceito hegemônico é criticado por não observar o cidadão como um sujeito político que pode estabelecer práticas de mudança da cidadania (Chen et al., 2021) e entender a cidadania como algo estático e não como um processo de participação e transformação ativa da sociedade (Benhabib, 2004; Isin, 2008). Nesta perspectiva crítica, as práticas sociais de cidadania digital são estabelecidas por um cidadão que se constitui através do uso das TIC para a reivindicação de direitos (Isin & Ruppert, 2020).

Porém, tanto a perspectiva hegemônica quanto a crítica propõem um conceito de cidadania digital e de cidadão digital que desfocam a importância do contexto histórico local e das instituições na construção da cidadania. Mesmo com a inclusão das TIC, a cidadania segue relacionada ao pertencimento a uma determinada comunidade

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

política com seu conjunto de direitos e organização legal (Rydén et al., 2024).

Neste sentido, propomos o conceito de cidadania no contexto da transformação digital como uma forma de retomar a centralidade do contexto histórico e da relação entre instituições e cidadão. Através deste conceito, a construção da cidadania é entendida a partir da relação dialética estabelecida entre as práticas sociais regulamentadas historicamente pelas instituições e influenciadas pelas ações dos agentes em um determinado contexto (Fairclough 2016; Fairclough & Fairclough, 2012).

Na América Latina, a cidadania possui uma trajetória histórica própria vinculada a confluência de múltiplos projetos políticos de disputas de significados (Dagnino, 2006). Estes múltiplos projetos afetam o significado das práticas sociais, com vieses convergentes devido à proximidade discursiva.

O contexto de transformação digital afeta diretamente essa disputa entre projetos políticos de construção de significados da cidadania, com as TIC sendo utilizadas nas práticas sociais de diferentes formas conforme o projeto. As dimensões de cidadania presentes no contexto latino-americano apresentam variação de significados dependendo do projeto político dominante e da forma como as TIC são utilizadas para estabelecer essa preponderância de poder.

Neste sentido, o objetivo deste estudo é apresentar um framework de análise das dimensões de cidadania no contexto da transformação digital na América Latina a partir dos diferentes projetos políticos em disputa na região. Partindo das dimensões de cidadania propostas por Stokke (2017) – status legal/associação, direitos sociais e participação –, o estudo busca contribuir com a discussão sobre o significado destas dimensões pelos diferentes projetos políticos e como as práticas sociais de desenvolvimento e uso de TIC são estabelecidas pelas relações dialéticas entre as instituições da estrutura social e os agentes baseados nesta disputa discursiva. A questão central que orienta essa pesquisa é: *Como a cidadania no contexto da transformação digital se constitui no cenário latino-americano?*

O artigo está estruturado na seguinte forma, além dessa introdução: na seção 02 é apresentado o conceito de cidadania no contexto da transformação digital em contraposição ao conceito de cidadania digital; na seção 03 é apresentado a cidadania no contexto latino-americano e como as TIC são utilizadas para as práticas sociais dos agentes e instituições através dos diferentes projetos políticos; a seção 04 apresenta a discussão do uso de TIC pelos diferentes projetos políticos e como eles influenciam as dimensões de cidadania e traz a proposta de framework de análise e de quadro analítico.

2. Crítica ao conceito de cidadania digital: a cidadania no contexto da transformação digital

2.1 A relação entre cidadão e Estado através da lente da cidadania digital

Cidadania digital é um tema de pesquisa que vem avançando no campo acadêmico em diversas áreas do conhecimento (Chen et al., 2021; Fernández-Prados et al., 2021). Apesar deste avanço, ainda há uma amplitude conceitual e de formas de mensuração da cidadania digital a partir de diferentes campos de estudo (Chen et al., 2021).

Podemos observar, em diferentes revisões de literatura sobre o tema (Chen et al., 2021; Fernández-Prados et al., 2021), que duas visões hegemônicas de cidadania digital se aproximam conceitualmente. Na área da ciência política, Moosberger et al. (2008) conceituam a cidadania digital enquanto a capacidade do indivíduo em participar da sociedade e se relacionar com o Estado através do uso da internet. Na educação, Ribble e Bailey (2007) definem cidadania digital enquanto o uso apropriado e responsável da internet por parte do indivíduo em sua interação em sociedade e com o Estado.

Ambas as perspectivas partem de uma centralidade das TIC na construção conceitual de cidadania digital. O acesso e as condições de uso da internet são observados como determinantes de alcance das diferentes dimensões da cidadania.

Esta construção conceitual aproxima a cidadania digital de categorias próprias de mensuração da inclusão digital, como as utilizadas no conceito de digital divide (Andreasson, 2015; van Deursen & Helsper, 2015; van Deursen & van Dijk, 2014). As desigualdades digitais entre indivíduos e comunidades, seja na disponibilidade de acesso à internet ou no conhecimento necessário para utilizar as TIC, afetam o engajamento do cidadão e a capacidade de participação social online (Mossberger & Tolbert, 2021).

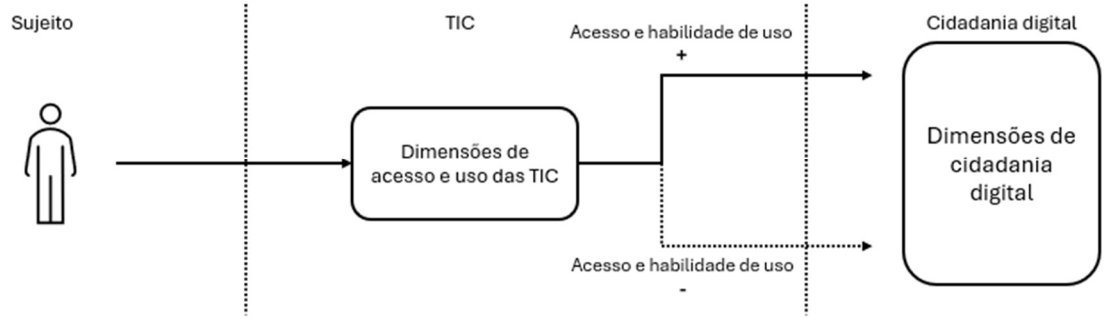
Partindo desta construção binária entre inclusão e exclusão digital, a proposta conceitual de cidadania digital de Mossberger et al. (2008) busca observar como o uso da internet afeta a capacidade do cidadão em acessar

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

diferentes dimensões de cidadania. Utilizando as dimensões de cidadania civil, política e social propostas por Marshall & Bottomore (2021), Mossberger et al. (2008) demonstram como a falta de utilização da internet afeta o cidadão em cada uma dessas dimensões no contexto estadunidense.

A proposta conceitual de Mossberger et. al (2008), relacionada com a de Ribble e Bailey (2007) e outras como a de Robles (2009), que entende o cidadão digital como o indivíduo que exercita seus direitos políticos e sociais através da internet, podem ser observadas a partir de um framework comum. Neste framework, a centralidade está nas TIC como forma de acesso à cidadania, como podemos observar na figura 01:

Fig. 1 - Framework comum do conceito de cidadania digital (elaborado pelos autores).



Porém, essa construção conceitual instrumental da cidadania digital não observa o cidadão como um sujeito político que age e pode estabelecer práticas sociais de mudança da realidade (Chen et al., 2021). Esta limitação acaba deixando o conceito aberto à crítica por não conseguir abarcar aspectos das modificações ocorridas através da transformação digital em dimensões da cidadania em determinado contexto histórico e geográfico.

Um destes aspectos passíveis de crítica no conceito de cidadania digital está na presunção da existência de um cidadão digital e de uma cidadania digital dada, o que levaria a existência de uma não cidadania formada por aqueles que estão excluídos da sociedade digital (Rydén et al., 2024). Apesar do impacto das TIC na cidadania devido à transformação digital, a cidadania ainda é fixada nas relações offline do cidadão (Rydén et al., 2024), que se relaciona com o ambiente online, mas não é definida por ele como pretende este conceito de cidadania digital.

Outro aspecto passível de crítica no conceito hegemônico de cidadania digital está no entendimento da cidadania como algo a ser alcançado através do uso das TIC. Este conceito se baseia na definição clássica da cidadania como um conjunto de direitos e deveres estáticos (Isin, 2008), e não como um processo de participação e transformação ativa da sociedade onde indivíduos e grupos lutam em busca de reconhecimento (Benhabib, 2004; Isin, 2008).

Neste conceito de cidadania digital, o cidadão se apresenta como um recipiente de direitos e obrigações a partir do uso da internet (Isin & Ruppert, 2020). O que falta nesta construção conceitual é a figura do cidadão enquanto um sujeito constituído historicamente que se utiliza da internet para reivindicar seus direitos (Isin & Ruppert, 2020).

Ao focalizar a capacidade de acesso do indivíduo à cidadania através da tecnologia, a perspectiva hegemônica de cidadania digital acaba por relegar a segundo plano a capacidade do indivíduo e de movimentos organizados em utilizar a tecnologia não para acessar uma determinada realidade, mas sim transformá-la. A cidadania é um processo em constante construção, sendo as TIC mais um fator que influencia esta construção em um contexto de transformação digital.

Uma perspectiva de contraposição a este conceito hegemônico de cidadania digital parte desta crítica para propor o foco no cidadão digital enquanto agente central no processo de construção da cidadania (Isin & Ruppert, 2020). As dimensões de cidadania deixam de ser algo estático a ser alcançado através das TIC para se tornarem processos dinâmicos influenciados pelo agir do cidadão.

2.2 O processo de construção da cidadania digital

Entender a cidadania e o cidadão digital não deve se resumir apenas à habilidade de se relacionar em sociedade ou com o Estado através da internet (Isin & Ruppert, 2020). A formação da cidadania e do cidadão é um processo histórico e geográfico complexo, em que as TIC se constituem em um novo elemento que possui o potencial de alterar esse processo, mas não de determiná-lo (Isin & Ruppert, 2020).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

A questão é que o acesso e participação em dimensões da cidadania baseada no uso de TIC não estabelece necessariamente uma nova forma de cidadania e um novo cidadão, mas afeta a já existente (Schou, 2018). As dimensões da cidadania são afetadas, mas não criadas, através da nova forma de participação política com o uso de TIC (Schou, 2018).

Se entendemos a construção da cidadania e do cidadão enquanto um processo político e social e não apenas como o uso da internet para acessar direitos já estabelecidos, a questão se torna qual perspectiva utilizar para observar este processo. Neste sentido, duas perspectivas podem ser utilizadas para esta análise: a primeira estabelece o foco na construção do cidadão enquanto sujeito que reivindica direitos através do uso de TIC (Asenbaum, 2019; Isin & Ruppert, 2020) e a segunda foca na relação de construção da cidadania enquanto um processo dialético estabelecidas entre agentes e instituições através de práticas sociais com o uso de TIC (Fairclough, 2016; Fairclough & Fairclough, 2012).

A perspectiva focada na construção do cidadão digital analisa como este se constitui em uma nova figura política (Isin & Ruppert, 2020; Schou, 2018). E esta constituição ocorre através das práticas adotadas pelo cidadão em uma interconexão entre o espaço offline e online (Isin & Ruppert, 2020).

As TIC influenciam na redefinição deste cidadão ao alterar suas interações políticas (Asenbaum, 2019). Nesta perspectiva, a cidadania digital é um processo que se conforma através da intersubjetividade do cidadão em espaços online e offline (Asenbaum, 2019).

No entanto, há aspectos que a perspectiva focada na construção do cidadão digital não contempla. O processo histórico de formação da cidadania conforma não apenas o cidadão, mas também instituições com capacidade de regulamentar práticas sociais e afetar a agência do cidadão. Estas instituições devem ser entendidas em seu contexto histórico e geográfico e as práticas sociais que elas regulam estão diretamente relacionadas a este contexto.

Neste sentido, adotamos uma perspectiva focada na relação entre o cidadão e as instituições e as práticas sociais que eles estabelecem entre si como o aspecto central na formação da cidadania (Fairclough, 2016; Fairclough & Fairclough, 2012). Tanto a formação do cidadão quanto da cidadania ocorre através deste processo em constante mudança entre instituições e agência. A transformação digital é um aspecto que se agrega a esta relação, em que as TIC podem ser utilizadas tanto pelo cidadão quanto pelas instituições em práticas sociais de modificação de diferentes dimensões da cidadania.

Para entender este impacto das TIC na construção da cidadania e do cidadão, propomos o conceito de cidadania no contexto da transformação digital em contraposição à cidadania digital e cidadão digital. Esse conceito é entendido como a construção de práticas sociais de cidadania através da regulação das instituições e da agência dos agentes com o uso de TIC em um determinado contexto histórico.

2.3 A cidadania contextualizada e o conceito de cidadania no contexto da transformação digital

Cidadania é um conceito multifacetado, onde diferentes dimensões e categorias se combinam em configurações múltiplas, dependendo do contexto histórico sob análise (Dagnino, 2006; Wappenstein, 2004). Neste sentido, não há um único conceito de cidadania, mas cidadanias que se conformam por parte de agentes sociais e estatais em práticas de demanda, reivindicações e lutas em determinados contextos locais ou nacionais (Wappenstein, 2010).

Apesar da complexificação conceitual devido a fenômenos como a globalização, migração populacional e a construção de espaços online de participação (Rydén et al., 2024; Stokke, 2017), a cidadania segue relacionada com o vínculo entre um território e os membros da comunidade (Rydén et al., 2024). Um dos principais aspectos de defesa do conceito de cidadania no contexto da transformação digital em contraposição à cidadania digital está no entendimento de que as práticas sociais seguem relacionadas a este contexto territorial offline, e não circunscritas a um universo digital (cyberespaço) construído através das TIC.

Isto significa afirmar que mesmo as práticas sociais realizadas pelos agentes através de TIC em ambientes online estão vinculadas a construção histórica da cidadania em um determinado território. A representação estabelecida no ambiente online é uma abstração do mundo físico com regras e regulação definidas pelos agentes e instituições responsáveis pela produção e implementação das TIC (Sørensen & Pica, 2005).

Os próprios desafios colocados pela transformação digital estão diretamente vinculados com o processo de construção da cidadania em determinado contexto. O movimento #BlackLivesMatter, que ganhou força nas redes sociais e plataformas digitais, está relacionado ao combate ao racismo estrutural existente na realidade estadunidense, ou seja, é uma luta histórica offline que foi redirecionada para as plataformas online (Francis & Wright-Rigueur, 2021).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

No âmbito dos estudos de cidadania digital e de cidadão digital, a questão do contexto histórico também é considerada, porém sem a centralidade que estamos propondo neste estudo. Mossberger et al. (2008) demonstra como as dimensões de cidadania digital no contexto estadunidense estão ligadas à princípios ideológicos como o liberalismo econômico, o republicanismo político e a hierarquia atributiva entre os cidadãos. No contexto dinamarquês, Schou e Hjelholt (2018) apresentam a digitalização vinculada ao processo de neoliberalismo afetando o Estado de bem-estar social no contexto dinamarquês.

É a partir deste processo contextualizado na transformação digital que podemos entender como a construção de práticas sociais pelos agentes políticos através do uso de TIC afeta a cidadania e o cidadão. Práticas sociais devem ser entendidas neste estudo enquanto entidades organizacionais estabelecidas entre instituições e agência, sendo moldadas pelas instituições, mas também influenciadas pelos indivíduos através de suas ações (Fairclough, 2003; Fairclough, 2005).

No conceito de cidadania no contexto da transformação digital, as instituições de cidadania são entendidas como estruturas sociais construídas historicamente em um determinado contexto que organizam e regulam as práticas sociais. As TIC podem ser utilizadas nas práticas sociais dos agentes para questionar estas estruturas históricas (Fairclough & Fairclough. 2012).

A mudança nas diferentes dimensões de cidadania e no cidadão ocorrem a partir desta relação entre instituições e agência interrelacionadas através das práticas sociais. No contexto da transformação digital, as TIC são utilizadas para fortalecer práticas sociais de transformação em determinado contexto.

Para entender como as práticas sociais estabelecidas através das TIC pelos agentes e instituições se interconectam, partimos do modelo baseado em dimensões da cidadania proposto por Stokke (2017). Neste estudo, as dimensões de status legal e associação são analisadas em conjunto. As dimensões de cidadania propostas podem ser resumidas da seguinte forma:

a) Status legal/associação: pertencimento a uma determinada comunidade política, sendo o conceito de comunidade política variável no tempo e espaço (Stokke, 2017). Relacionada também à condição contratual entre cidadão e Estado baseada em direitos e responsabilidades (Stokke, 2017).

b) Direitos sociais: relacionada a dimensão de cidadania social de Marshall e Bottomore (2021), se refere ao conjunto de direitos relacionados à associação e ao status formal de cidadão de uma determinada comunidade (Stokke, 2017).

c) Participação: a participação nos processos de decisão da comunidade é vista como uma dimensão central da cidadania ativa (Dagnino et al., 2006; Stokke, 2017). O direito à participação do cidadão é um aspecto central do aprofundamento democrático (Dagnino et al., 2006).

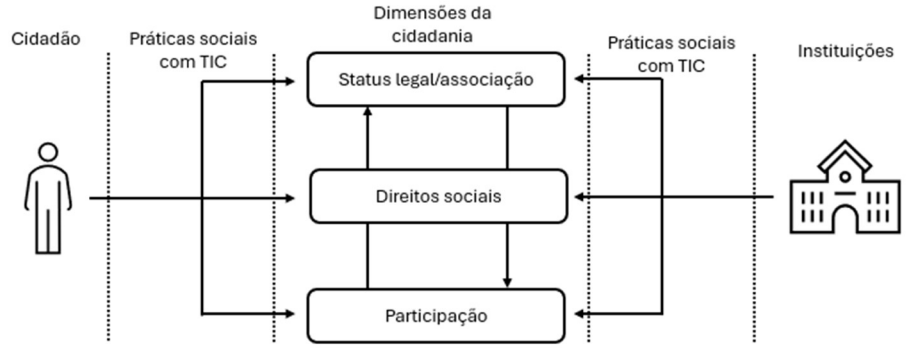
A partir deste modelo, pode-se entender a cidadania como uma construção onde a forma e a substância das diferentes dimensões são o resultado de disputas políticas (Clarke et al., 2014; Stokke, 2017). No contexto da transformação digital, estas disputas são influenciadas pelo uso de TIC por parte dos agentes e das instituições.

No conceito de cidadania no contexto da transformação digital proposto neste estudo, entendemos que o elo de conexão entre as diferentes dimensões está nas práticas sociais estabelecidas pelas instituições e pelos agentes. Neste sentido, práticas sociais de participação e luta podem ser voltadas para garantir direitos ou a associação do cidadão à determinada comunidade.

Esta relação entre as diferentes dimensões e as práticas sociais de instituições e agentes com o uso de TIC no contexto da transformação digital pode ser ilustrada da seguinte forma (figura 02):

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Fig. 2 - Framework de cidadania no contexto da transformação digital (elaborado pelos autores).



Ao analisar o contexto latino-americano, Dagnino et al. (2006) demonstram como a confluência entre projetos políticos antagônicos levam os agentes e as instituições a estabelecerem práticas sociais difusas. Este contexto difere do dinamarquês apresentado por Schou e Hjelholt (2018) onde a contraposição entre o projeto neoliberal e o Estado de bem-estar social está bem definida.

3. A cidadania no contexto da transformação digital na América Latina

3.1 Cidadania na América Latina e a disputa discursiva

No contexto latino-americano, o fenômeno da cidadania ganha força a partir dos anos 1970 e 1980 com a emergência de movimentos sociais de luta pela democratização e por avanços em direitos civis, em especial em países com regime autoritário (Dagnino, 2003). Com a redemocratização observada na América Latina a partir dos anos 1980, estes movimentos sociais adotaram o discurso da cidadania enquanto referência de luta por direitos sociais e como articulador comum entre as diferentes pautas de reivindicações (Alvarez et al., 1998; Dagnino, 2003).

O papel desempenhado pelos movimentos sociais questiona uma cidadania formada historicamente na administração das diferenças sociais a partir da reprodução legalizada das desigualdades (Holston, 2013). É construída uma cidadania insurgente no sentido da ruptura com essa legalização das desigualdades e alicerçada no "direito a ter direitos" (Dagnino, 2003; Holston, 2013).

Movimentos de diferentes matizes e demandas, como as associações comunitárias urbanas no Brasil (Holston, 2013), asambleas barriales na Argentina (Torres et al., 2021) e o Movimento Zapatista no México (Martínez Espinoza, 2024), se aglutinaram em um projeto político específico. Este projeto, multifacetado em suas diferenças nacionais, possui em comum o questionamento das definições políticas de poder na América Latina: seus participantes, instituições, processos, agenda e escopo (Alvarez et al., 1998). Este projeto comum é denominado por Dagnino (2006) como projeto democrático-participativo e tem como base o aprofundamento da democracia em contraposição aos limites de participação estabelecidos pela democracia liberal representativa.

Estabelecendo uma relação com as dimensões de cidadania propostas neste estudo, o projeto democrático-participativo propõe práticas voltadas ao reconhecimento das diferenças como status legal/associação à comunidade. Este entendimento reflete na dimensão de direitos sociais na lógica do "direito a ter direitos" proposta pelos movimentos sociais (Dagnino, 2003) e na de participação através da concepção de compartilhamento do poder do Estado pelo cidadão e por grupos sociais nas esferas decisórias.

No entanto, no mesmo período em que os movimentos sociais ascendiam na América Latina em questionamento aos regimes autoritários ou às limitações da democracia representativa, outro projeto político ganhava força devido à crise do estados de bem-estar social europeus e a necessidade de reorganização das relações de acumulação capitalista (Dagnino et al., 2006; Pollitt & Bouckaert, 2011): o projeto neoliberal. Ao contrário do foco estabelecido na ampliação da democracia do projeto democrático-participativo, o projeto neoliberal se estrutura na primazia do mercado e no enxugamento do Estado, com a transferência de responsabilidades para a sociedade civil e para o setor privado (Dagnino et al., 2006; Osborne & Gaebler, 1991).

Na América Latina o projeto neoliberal adquire características específicas devido ao contexto de avanço de conquistas democráticas encontrado na maioria dos países da região (Dagnino, 2004). Esta configuração leva o projeto neoliberal a estabelecer interlocução com a sociedade civil e com movimentos sociais em instâncias de participação estabelecidas pelo Estado. Esta relação estabelecida entre os diferentes projetos estabelece uma confluência onde as nuances de entendimentos sobre participação, representação e a própria cidadania se

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

confundem em discursos com retóricas próximas, mas com significados extremamente diferentes (Dagnino, 2004).

Isto não significa que este processo de confluência ocorra da mesma forma entre os diferentes Estados da América Latina. Enquanto no Chile o processo de democratização ocorreu de forma lenta após a queda de um regime autoritário que serviu de laboratório de experiências neoliberais (Budds, 2013), na Argentina as asembleas barriales ocuparam posição de poder durante a crise política de 2001com as quedas dos governos de la Rua e Saá (Torres et al., 2021). O que permanece enquanto característica comum entre os diferentes países é a confluência entre os dois projetos e a disputa de significados da cidadania.

Com relação às dimensões de cidadania, o discurso das políticas de status legal/associação do projeto neoliberal é voltado à inserção do indivíduo à comunidade e a manutenção do contrato social através de ações de entidades privadas e do terceiro setor, buscando reduzir a participação do Estado (Dagnino et al., 2006; Osborne & Gaebler, 1991). Além da redução das atribuições estatais, na visão conservadora do projeto, a expansão da cidadania reivindicada por grupos sociais é questionada.

Na dimensão de direitos sociais, o projeto neoliberal estabelece uma lógica de mercado, tendo o Estado enquanto provedor de serviços e o cidadão visto como um cliente (Dagnino, 2004; Dagnino et al., 2006). Na dimensão de participação, o projeto estabelece uma lógica política instrumental, voltada para o repasse de responsabilidades do Estado para outros setores, como organizações não governamentais (Dagnino, 2004; Dagnino et al., 2006).

Um dos aspectos centrais para o entendimento da confluência entre os dois projetos está em compreender que eles não ocorrem de forma homogênea. Ou seja, dependendo do contexto, as práticas sociais próprias de um determinado projeto podem estar combinadas com outro. Isto ocorre devido a heterogeneidade dos agentes estatais e da sociedade civil (Dagnino et al., 2006) e pelas relações de poder estabelecidas entre os agentes e as instituições, que não permite a hegemonia absoluta de um projeto político devido as variações contextuais de poder.

A transformação digital observada a partir dos anos 2000 afetou diretamente as relações dentro da sociedade e entre Estado e sociedade (Mossberger et al., 2008) devido ao uso das TIC. A utilização das TIC possui a capacidade de ressignificar as práticas sociais estabelecidas pelos diferentes projetos políticos na América Latina. A cidadania no contexto da transformação digital latino-americana é afetada diretamente por estas práticas sociais.

3.2 Transformação digital e a reconstrução das práticas sociais

Segundo dados do E-government Development Index 2024, a América Latina apresenta um índice relevante de governo digital (0.6553), acima da média mundial (0.6382) e que reflete a evolução das agendas digitais de governo eletrônico nos países latino-americanos (Nicolás et al., 2022). Em especial os países da América do Sul apresentam um índice bem acima da média mundial (0.7462).

No âmbito do acesso à internet, a região apresenta um crescimento exponencial a partir dos anos 2000. Apesar deste avanço, desafios de conectividade são observados principalmente em áreas rurais e entre a população de baixa renda (Galperin, 2017).

Este avanço da transformação digital na América Latina possui a capacidade de impactar em diferentes aspectos da cidadania na região. Na implantação de serviços públicos através das TIC (Filgueiras et al., 2019) e no uso de redes sociais e aplicativos para organização e divulgação de lutas por direitos (Blanco, 2019).

Com base no conceito de cidadania no contexto da transformação digital, podemos entender que as dimensões de cidadania são vinculadas ao contexto histórico nas quais são construídas. O uso de TIC na elaboração de práticas sociais de cidadania pelos diferentes agentes é diretamente influenciada por estas instituições construídas historicamente em um determinado contexto.

4. Dimensões de cidadania no contexto da transformação digital e proposta de framework analítico

Nesta seção, apresentaremos as dimensões de cidadania relacionando-as com o contexto latino-americano, as TIC e os projetos políticos. Através desta relação, propomos no final da seção um quadro analítico a ser utilizado em conjunto com o framework de análise de práticas sociais a partir do conceito de cidadania no contexto da transformação digital.

4.1 Status legal/associação à comunidade

Os Mapuches possuem um histórico de contestação territorial frente ao Estado chileno que remonta ao período da

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

colonização. Para auxiliar nesta luta histórica, comunicadores e ativistas mapuche tem utilizado as TIC para a construção de redes de comunicação e a mobilização entre as comunidades que quebram o bloqueio imposto pela mídia tradicional (Rivera & del Valle Rojas, 2021).

O uso das TIC por movimentos indígenas não se restringe apenas ao caso dos Mapuches. No sul global, as TIC vem sendo utilizadas por estes movimentos como forma de resistência e potencialização de lutas históricas por reconhecimento de reivindicações estabelecidas (Guntarik, 2022; McLean, 2020; Soriano, 2012).

Assim como ocorre com os movimentos indígenas, a apropriação de TIC por movimentos sociais na América Latina é uma constante nas lutas contra as desigualdades (Friedman, 2005; Treré & Magallanes-Blanco, 2015). O uso estratégico destas tecnologias, em especial para comunicação, contribuiu para o desenvolvimento de lutas por direitos de diversos movimentos, como o Zapatista no México (Treré & Magallanes-Blanco, 2015).

Nestes casos como dos Mapuches e do movimento Zapatista, as TIC são apropriadas para potencializar as reivindicações de "direito a ter direitos", construindo práticas sociais vinculadas ao projeto democrático-participativo. Esta forma de apropriação de tecnologias contrasta com as práticas sociais estabelecidas através do projeto neoliberal.

No discurso do projeto político neoliberal, a dimensão de statu legal/associação está vinculada à utilização das TIC por parte do cidadão para acessar o Estado e vantagens de mercado. "Ser digital" é um prerrequisito para o cidadão ser competitivo e estar incluso na vida em sociedade (Schou & Hjelholt, 2018).

Esta construção discursiva aproxima a visão do projeto neoliberal sobre o reconhecimento do cidadão da perspectiva hegemônica de cidadania digital, que observa como o cidadão possui a capacidade de se utilizar das TIC para acessar as diferentes dimensões de cidadania (Mossberger et al, 2008). As estratégias de governo digital na América Latina também refletem essa visão de inclusão a uma cidadania digital através do uso de TIC (OECD, 2023).

A principal diferença entre o projeto democrático-participativo e o projeto neoliberal na dimensão de status legal/associação não está vinculada a questão da importância das TIC para o cidadão. O diferencial está no uso das TIC para acessar a cidadania presente no discurso do projeto neoliberal contrastando com a apropriação das TIC como forma de reivindicação de direitos de acesso à comunidade e manutenção do contrato social.

No projeto democrático-participativo, a apropriação das TIC ocorre como forma de se contrapor as tecnologias da mídia tradicional e as implementadas por instituições estatais (Rivera & del Valle Rojas, 2021; Treré & Magallanes-Blanco, 2015). Enquanto no projeto neoliberal, o uso por parte do cidadão é uma necessidade, mas a ampliação de direitos é questionada através das mídias tradicionais.

4.2 Direitos sociais

A dimensão da cidadania enquanto direitos sociais é uma das mais afetadas por práticas sociais com o uso de TIC. Isto se deve ao avanço na implementação de serviços públicos digitais como uma das principais estratégias de governo digital (Distel & Lindgren, 2021; Filgueiras et al., 2019; Lindgren & Jansson, 2013).

Neste sentido, a implementação de serviços públicos digitais acaba afetando não apenas a discussão de quais direitos sociais o cidadão possui, mas também de como ele acessa estes direitos. Na lógica dos serviços públicos digitais, a interação entre cidadão e Estado é realizada diretamente através das TIC, com o próprio cidadão acessando as plataformas digitais sem a necessidade de mediação de um servidor público (Filgueiras et al., 2019).

Na América Latina, a implementação de serviços públicos digitais também é umas das estratégias centrais de governo digital da maior parte dos países (OECD, 2023). A necessidade do cidadão utilizar as TIC para acessar estes serviços e o papel das TIC nos direitos sociais estabelece uma disputa entre as práticas sociais do projeto neoliberal e do projeto democrático-participativo.

Para o projeto neoliberal, a digitalização de serviços públicos é uma estratégia que vai além da oferta de melhores serviços e a criação de valor para o cidadão. Ela está vinculada também com a redução de custos para a administração pública, sendo esta muitas vezes a prioridade institucional, como demonstra a fala do então ministro da economia do Brasil Paulo Guedes durante o Dia Nacional do Supermercado de 2020:

> A Reforma Administrativa tem um alcance estimado em R$ 300 milhões nos próximos anos. E acreditamos que o resultado será muito maior, pois assumimos que, para cada 100 brasileiros que se aposentem, 70 seriam contratados. O que acontece, na verdade, é que a cada 100 que aposentam, contratamos apenas 26, justamente por conta da digitalização que permite economizar alguns serviços. Então, é possível que a economia seja de até R$ 500 milhões nos próximos anos por conta do digital (Paulo Guedes, 2020).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Estas práticas de implementação de políticas públicas voltadas para a redução de custos na administração levam a um descompasso entre o avanço da digitalização e a situação fática de acesso às TIC por parte do cidadão. No caso de serviços públicos voltados às populações com menor acesso à internet por questões econômicas ou capacidade de uso, serviços implementados unicamente na modalidade digital podem restringir a capacidade de requerimento (Dos Santos Da Silva & Cruz Rodrigues, 2023).

Quando o projeto neoliberal busca estabelecer respostas para a inclusão digital, ele aposta em uma perspectiva de determinismo tecnológico, atribuindo às TIC a capacidade de resolver questões complexas de exclusão por si só (Rosa, 2013). O projeto democrático-participativo se contrapõe a esta visão instrumental estabelecendo o foco no papel que as TIC podem desempenhar na garantia e expansão de direitos (Rosa, 2013).

Na visão do projeto democrático-participativo, a questão deixa de ser o uso das TIC como instrumentos de acesso ao Estado para se tornar a possibilidade de autonomia para o cidadão. A apropriação tecnológica deve estar combinada com serviços públicos digitais para a garantia e avanço de direitos sociais (Silveira, 2008). A implementação de serviços públicos digitais não pode ser dissociada desta lógica de autonomia e avanço de direitos sociais.

4.3 Participação

A participação do cidadão e do outros agentes não governamentais na definição de políticas públicas digitais é entendida como um aspecto central para a construção de uma cidadania ativa (Bianchi, 2021). A construção de uma agenda de transformação digital no setor público mais inclusiva, sustentável e igualitária depende da participação destes agentes (OECD, 2023).

Apesar deste entendimento sobre a necessidade de participação do cidadão e de outros agentes, os órgãos de coordenação sobre governo digital nos países da América Latina ainda necessitam avançar nesta inclusão de agentes estratégicos não-governamentais. O Uruguai é um caso particular por possuir representação da academia e do setor privado no Consejo Asesor Honorario para la Sociedad de la Información (OECD, 2023).

No entanto, a pauta sobre participação e de agentes não-governamentais se torna uma discussão complexa quando questionamos sobre qual participação estamos falando. Participação é um dos principais conceitos no qual o significado está em disputa entre os diferentes projetos políticos.

Para o projeto neoliberal, o significado de participação está vinculado à transferência de responsabilidades do Estado para agentes não-governamentais e privados. Estes agentes ficam responsáveis pela execução de serviços públicos enquanto o poder decisório das políticas públicas segue nas mãos do Estado (Dagnino, 2004; Dagnino, 2006).

Parcerias-público privadas tem sido utilizadas por governos na América Latina como forma de vencer desafios relacionados ao governo digital (Palaco et al., 2019). Em países como o Brasil, estas parcerias são firmadas para repassar à agentes não-governamentais a operacionalização de plataformas de requerimentos de serviços digitais (Dos Santos Da Silva & Cruz Rodrigues, 2023).

A questão é que a participação no discurso do projeto neoliberal não avança para construção de espaços públicos de discussão e deliberação sobre a estratégia de transformação digital. No discurso do projeto democrático-participativo, este compartilhamento de poder decisório é central para uma participação efetiva do cidadão e de outros agentes não-governamentais (Dagnino et al., 2006).

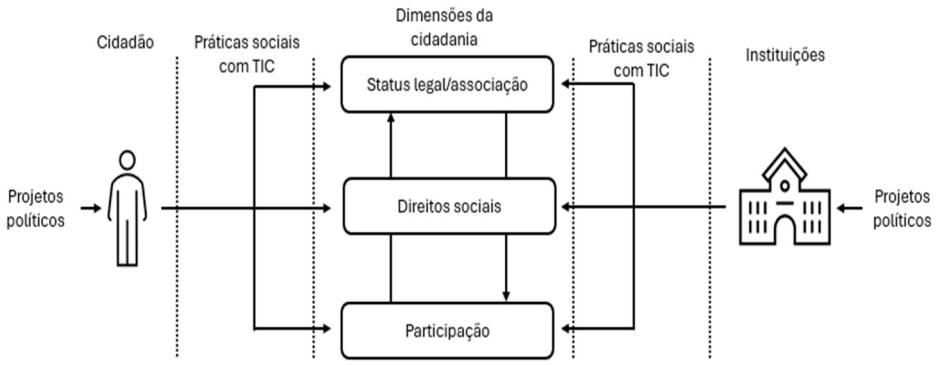
O caso do Consejo Asesor Honorario para la Sociedad de la Información do Uruguai (OECD, 2023), a instituição do Comitê Consultivo da Estratégia Nacional de Governo Digital (MGI, 2024) e as diversas experiências de orçamento participativo digital na América Latina (Cunha et al., 2014; Pineda & Iasulaitis, 2016) são casos em que a participação pode deixar de ser instrumental. Este significado de participação pode resultar em um poder decisório efetivo do cidadão e dos agentes não-governamentais através do uso de TIC.

4.4 Framework analítico a partir das dimensões propostas

A análise do contexto latino-americano e da disputa existente entre o projeto democrático-participativo e neoliberal permite a expansão do framework de cidadania no contexto da transformação digital. O framework analítico passa a incorporar os projetos políticos, entendidos como construção discursivas que orientam as práticas sociais com o uso de TIC (figura 03):

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Fig. 3 - Framework de cidadania no contexto da transformação digital a partir dos projetos em disputa (elaborado pelos autores).



O cidadão e os agentes não-governamentais não estabelecem apenas práticas sociais vinculadas ao projeto democrático-participativo e as instituições práticas sociais orientadas pelo projeto neoliberal. A pluralidade política, social e cultural do contexto latino-americano reforça essa heterogeneidade e a capacidade de diferentes agentes e instituições em estabelecerem suas práticas a partir dos diferentes projetos políticos em disputa (Dagnino et al., 2006).

Neste sentido, a análise do impacto das práticas sociais com uso de TIC nas diferentes dimensões de cidadania não deve estar focado em qual agente está agindo ou qual instituição está afetando as práticas sociais. A análise deve estar focada em qual projeto político está orientando as ações dos agentes e influenciando as instituições.

No contexto latino-americano, os projetos democrático-participativo e neoliberal disputam o significado de conceitos vinculados as dimensões de cidadania como status legal/associação, participação e direitos sociais. Propomos um quadro analítico (tabela 01) para entendimento destes diferentes significados e como eles podem ser utilizados para a análise de práticas sociais com uso de TIC nas diferentes dimensões de cidadania.

Tab. 01 – Significado das dimensões de cidadania a partir dos projetos políticos

	Status legal/associação	Direitos sociais	Participação
Projeto democrático participativo	Apropriação das TIC como forma de reivindicação de direitos de acesso à comunidade. As TIC se tornam instrumentos de potencialização de lutas por direitos.	TIC como forma de expansão de direitos sociais. Serviços públicos digitais vinculados com a autonomia e avanço de direitos para o cidadão.	Participação enquanto compartilhamento de poder entre agentes estatais, cidadão e agentes não-governamentais. As TIC são utilizadas pata construção de espaços deliberativos.
Projeto neoliberal	Uso das TIC para acessar dimensões de uma cidadania já estabelecida. Busca reduzir a capacidade de reivindicação do cidadão.	Direitos sociais acessados através do uso de TIC. A redução de custos é um objetivo a ser alcançado através das TIC. Inclusão digital entendida a partir de uma lente instrumental.	Participação instrumental vinculada com o repasse de responsabilidades estatais para agentes não-governamentais e privados. Poder decisório permanece exclusivo dos agentes estatais.

O framework e o quadro analítico proposto formam um conjunto a ser instrumentalizado para pesquisas empíricas de cidadania no contexto da transformação digital na América Latina. As dimensões e a construção conceitual dos projetos políticos em disputa permitem uma amplitude para abarcar as diferenças regionais, além da inclusão de questões próprias de contextos nacionais.

5. Conclusão

Podemos observar como o contexto latino-americano apresenta questões próprias no processo de construção da cidadania e como os diferentes projetos políticos em disputa na região afetam esta construção. Neste contexto, as

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

TIC são utilizadas para a construção de práticas sociais orientadas pelos projetos em disputa.

O conceito de cidadania no contexto da transformação digital busca abarcar essa complexidade contextual ao entender as dimensões da cidadania enquanto processos em disputa de significados. As práticas sociais dos agentes e das instituições, orientadas pelos projetos políticos em disputa, se constituem no fator central deste processo.

Significados de conceitos como status legal/associação, direitos sociais e participação não são únicos no contexto latino-americano e se modificam dependendo da visão de cada projeto político em disputa. Ao analisar processos como a implementação de serviços públicos digitais ou a utilização de TIC na construção de espaços virtuais de participação, os analistas devem levar em consideração estes múltiplos significados.

O framework de análise e o quadro analítico apresentados a partir da discussão da cidadania no contexto da transformação digital na América Latina são a contribuição teórica presente neste estudo. Entendemos que este framework e a análise dos diferentes projetos políticos em disputa no contexto latino-americano podem contribuir para estudos empíricos futuros que busquem entender as dinâmicas das práticas sociais com uso de TIC na América Latina.

Estes estudos empíricos de entendimentos das dinâmicas de práticas sociais com uso de TIC na América Latina são a sugestão para estudos futuros. A aplicação do framework e do quadro analítico proposto podem auxiliar no avanço da proposta e na inclusão ou modificação de entendimentos a partir de casos concretos.

6. Informações gerais

- **Financiamento:** Os autores agradecem à Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (código de financiamento 001) pelo suporte financeiro.

- **Contribuições dos autores:**

  Primeiro(a) autor(a): Conceptualisation, Writing – Original Draft.

  Segundo(a) autor(a): Supervision, Validation, Writing – Review & Editing.

- **Uso de IA:** Os autores não utilizaram IA em nenhuma etapa da execução deste estudo.

- **Conflitos de interesse:** Os autores informam que não há conflito de interesses.

Referências

Alvarez, S. E., Dagnino, E., & Escobar, A. (eds.) (1998). *Cultures of Politics/Politics of Cultures: Revisioning Latin American Social Movements.* Boulder: Westview Press

Andreasson, K. J. (2015). *Digital divides : the new challenges and opportunities of e-inclusion*. CRC Press, Taylor & Francis Group.

Asenbaum, H. (2019). Rethinking Digital Democracy: From the Disembodied Discursive Self to New Materialist Corporealities. *Communication Theory*. https://doi.org/10.1093/ct/qtz033

Benhabib, S. (2004). The Rights of Others: Aliens, Residents, and Citizens. In *The Seeley Lectures*. Cambridge University Press. https://doi.org/DOI: 10.1017/CBO9780511790799

Bianchi, C. (2021). Fostering sustainable community outcomes through policy networks: A dynamic performance governance approach. *Handbook of Collaborative Public Management*, *February*, 349–372. https://doi.org/10.4337/9781789901917.00036

Blanco, M. R. (2019). From "Ni una más" to #Niunamenos: Women's and feminism in Latin America | Del ¡Ni una más! al #NiUnaMenos: movimientos de mujeres y feminismos en América Latina. *Politica y Sociedad*, *56*(1), 47–67.

Budds, J. (2013). Water, power, and the production of neoliberalism in Chile, 1973-2005. *Environment and Planning D: Society and Space*, 31(2), 301–318. https://doi.org/10.1068/d9511

Chen, L. L., Mirpuri, S., Rao, N., & Law, N. (2021). Conceptualization and measurement of digital citizenship across disciplines. *Educational Research Review*. https://doi.org/10.1016/j.edurev.2021.100379

Clarke, J., Coll, K., Dagnino, E., & Neveu, C. (2014). Disputing citizenship. In *Disputing Citizenship*. https://doi.org/10.51952/9781447312543

Cunha, M. A. V. C. Da, Coelho, T. R., & Pozzebon, M. (2014). Internet and participation: The case of digital participatory budgeting in Belo Horizonte. *RAE Revista de Administracao de Empresas*, *54*(3), 296–308. https://doi.org/10.1590/S0034-759020140305

Dagnino, E. (2003). Citizenship in Latin America. *Latin American Perspectives*, *30*(2), 211–225. https://doi.org/10.1177/0094582x02250624

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Dagnino, E. (2004). ¿Sociedade civil, participação e cidadania: de que estamos falando? *MATO, D. (Org.). Políticas de Ciudadanía y Sociedad Civil En Tiempos de Globalización*, 95–110.
Dagnino, E. (2006). MEANINGS OF CITIZENSHIP IN LATIN AMERICA. *Canadian Journal of Latin American and Caribbean Studies / Revue Canadienne Des Études Latino-Américaines et Caraïbes*, 31(62), 15–51. http://www.jstor.org/stable/41800320
Dagnino, E., Olvera A., J., & Panfichi, A. (2006). Para uma outra leitura da disputa pela construção democrática na América Latina In Dagnino, E., Olvera A., J., & Panfichi, A. (Org). *A Disputa pela Construção Democrática na América Latina.* Paz e Terra
Distel, B., & Lindgren, I. (2023). A matter of perspective : Conceptualizing the role of citizens in E-government based on value positions. *Government Information Quarterly*, *February*, 101837. https://doi.org/10.1016/j.giq.2023.101837
Dos Santos Da Silva, J. P., & Cruz Rodrigues, D. (2023). DIGITAL PUBLIC SERVICES FOR ARTISANAL FISHERMEN: A case study under Bourdieu's theory of practice in communities of the Brazilian Amazon. *Proceedings of the 24th Annual International Conference on Digital Government Research*, 601–613. https://doi.org/10.1145/3598469.3598535
Fairclough, I, & Fairclough, N. (2012). *Political Discourse Analysis: a method for advanced students.* Routledge
Fairclough, N. (2003). *Analysing Discourse: textual analysis for social research*. Routledge
Fairclough, N. (2005). Discourse analysis in organization studies: The case for critical realism. *Organization Studies*, *26*(6), 915–939. https://doi.org/10.1177/0170840605054610
Fairclough., N. (2016). *Discurso e Mudança Social.* Editora UNB
Fernández-Prados, J. S., Lozano-Díaz, A., & Ainz-Galende, A. (2021). Measuring digital citizenship: A comparative analysis. *Informatics*, *8*(1), 1–13. https://doi.org/10.3390/informatics8010018
Filgueiras, F., Cireno, F., & Palotti, P. (2019). Digital Transformation and Public Service Delivery in Brazil. *Latin American Policy*, *10*(2), 195–219. https://doi.org/10.1111/lamp.12169
Francis, M. M., & Wright-Rigueur, L. (2021). Black Lives Matter in Historical Perspective. *Annual Review of Law and Social Science*, *17*, 441–458. https://doi.org/10.1146/annurev-lawsocsci-122120-100052
Friedman, E. J. (2005). The Reality of Virtual Reality: The Internet and Gender Equality Advocacy in Latin America. *Latin American Politics and Society*, 47(3), 1–34. doi:10.1111/j.1548-2456.2005.tb00317.x
Galperin, H. (2017). *Sociedade digital: hiatos e desafios da inclusão digital na América Latina e o Caribe.* UNESCO. Disponível em: https://unesdoc.unesco.org/ark:/48223/pf0000262860_por
Guntarik, O. (2022). Indigenous Resistance in the Digital Age. *Indigenous Resistance in the Digital Age*, *1*(2015), 1–8. https://doi.org/10.1007/978-3-031-17295-3
Holston, J. (2013). *Cidadania Insurgente: disjunções da democracia e da modernidade no Brasil.* Companhia das Letras.
Isin, E. (2008). Theorizing acts of citizenship. *Acts of Citizenship.*
Isin E, & Ruppert E (2020) *Being Digital Citizens*. 2nd ed. London/New York, NY: Rowman and Littlefield International
Lindgren, I., & Jansson, G. (2013). Electronic services in the public sector: A conceptual framework. *Government Information Quarterly*, *30*(2), 163–172. https://doi.org/10.1016/j.giq.2012.10.005
Marshall, T. H. & Bottomore, T. (2021). *Cidadania e Classe Social.* Editora Unesp
Martínez Espinoza, M.I. (2024). Democracia para la dignidad. Movimientos políticos sociales y ciudadanía como aportes a las reflexiones sobre la democracia en América Latina. El caso del Movimiento Zapatista. *Revista Española de Investigaciones Sociológicas.*
McLean, J. (2020). Decolonising Digital Technologies? Digital Geographies and Indigenous Peoples. In *Changing Digital Geographies: Technologies, Environments and People* (pp. 91–111). Springer International Publishing. https://doi.org/10.1007/978-3-030-28307-0_5
Mello, P. C. (2020). *A Máquina do Ódio: notas de uma repórter sobre fake news e violência digital.* Companhia das Letras
Ministério da Gestão e da Inovação em Serviços Públicos (MGI). (2024). *Portaria MGI Nº 9.682, de 23 de dezembro de 2024*. Diário Oficial da União.
Mossberger, K., & Tolbert, C. J. (2021). Digital citizenship and digital communities: How technology matters for individuals and communities. *International Journal of E-Planning Research*, *10*(3), 19–34. https://doi.org/10.4018/IJEPR.20210701.oa2
Mossberger, K., Tolbert, C. J., & McNeal, R. S. (2008). *Digital citizenship : the internet, society, and participation*. MIT Press.
OECD/CAF (2023), *Digital Government Review of Latin America and the Caribbean: Building Inclusive and Responsive Public Services*, OECD Digital Government Studies, OECD Publishing, Paris, https://doi.org/10.1787/29f32e64-en.
Osborne, D., & Gaebler, T. (1994) *Reinventando o governo: como o espírito empreendedor está transformando o setor público.* MH Comunicação
Palaco, I., Park, M. J., Kim, S. K., & Rho, J. J. (2019). Public private partnerships for e-government in developing countries: An early stage assessment framework. *Evaluation and Program Planning*, *72*, 205–218. https://doi.org/10.1016/j.evalprogplan.2018.10.015
Pineda, C., & Iasulaitis, S. (2016). Presupuesto participativo digital: los nuevos formatos de la participación en

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

red. In *VII Congreso Internacional en Gobierno, Administración y Políticas Públicas GIGAPP (Madrid España)* 3–5 de Octubre de 2016.
Pollitt, C. & Bouckaert, G. (2011). *Public Management Reform: A Comparative Analysis*. Oxford
Ribble, M., & Bailey, G. (2007). *Digital citizenship in schools (1st ed.)*. International Society for Technology in Education
Rivera, C. A. M., & del Valle Rojas, J. A. (2021). Technology appropriation and Mapuche self-communication: An interpretation of indigenous e-communication in Chile. *Ethnicities*, *21*(6), 1026–1045. https://doi.org/10.1177/1468796821998715
Robles, J., M. (2009). *Ciudadanía Digital: uma introducción a um nuevo concepto de ciudadano*. Editorial UOC
Rosa, F. R. (2013). Inclusão Digital Como Política Pública: Disputas No Campo Dos Direitos Humanos. *Sur: Revista Internacional de Direitos Humanos*, *10*(18), 32–55. https://search.ebscohost.com/login.aspx?direct=true&db=foh&AN=95035070&amp%0Alang=pt-br&site=eds-live&scope=site
Rydén, H. S. M. H., Melchiori, C. E., Braccini, A. M., Cunha, M. A., & Sæbø, Ø. (2024). Citizenship in a Digitalized Society: Exploring Administrative Evil in Digital Government. *CEUR Workshop Proceedings*, *3737*, 0–2.
Schou, J. (2018). *Remaking Citizenship: Welfare Reform and Public Sector Digitalization*, https://pure.itu.dk/en/publications/remaking-citizenship-welfare-reform-and- public-sector-digitalizat.
Schou, J., & Hjelholt, M. (2018). Digital citizenship and neoliberalization: governing digital citizens in Denmark. *Citizenship Studies*. https://doi.org/10.1080/13621025.2018.1477920
Silveira, S. A. (2008). A noção de exclusão digital diante das exigências de uma cibercidadania. In: Hetkowski, T. M. (Org). *Políticas públicas e inclusão digital.* EDUFBA, p. 20-41.
Sørensen, C., & Pica, D. (2005). Tales from the police: Rhythms of interaction with mobile technologies. *Information and Organization*, *15*(2), 125–149. https://doi.org/10.1016/j.infoandorg.2005.02.007
Soriano, C. R. (2012). The arts of indigenous online dissent: Negotiating technology, indigeneity, and activism in the Cordillera. *Telematics and Informatics*, *29*(1), 33–44. https://doi.org/10.1016/j.tele.2011.04.004
Stokke, K. (2017). Politics of citizenship: Towards an analytical framework. *Norsk Geografisk Tidsskrift*, *71*(4), 193–207. https://doi.org/10.1080/00291951.2017.1369454
Torres, F. V., Torres, F. V., Farías, M., & Farías, M. (2021). Construir la ciudadanía colectivamente: prácticas urbanas de una asamblea popular en Buenos Aires, Argentina. *Null*. https://doi.org/10.12795/habitatysociedad.2021.i14.02
Treré, E., & Magallanes-Blanco, C. (2015). Battlefields, experiences, debates: Latin American struggles and digital media resistance. *International Journal of Communication*, *9*(1), 3652–3661.
van Deursen, A. J. A. M., & Helsper, E. J. (2015). *The Third-Level Digital Divide: Who Benefits Most from Being Online? December*, 29–52. https://doi.org/10.1108/s2050-206020150000010002
van Deursen, A. J. A. M., & van Dijk, J. A. G. M. (2014). The digital divide shifts to differences in usage. *New Media and Society*, *16*(3), 507–526. https://doi.org/10.1177/1461444813487959
Wappenstein,S. (2004). *Re-Signifying Citizenship: lessons from the human rights movement in Argentina.* Paper presented at the annual meeting of the American Sociological Association. www.allacademic.com/meta/p109862_index.html
Wappenstein, S. (2010). Sobre ciudadanía(s). *Iconos. Revista De Ciencias Sociales*, No. 36

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Futuros possíveis de processos de inovação para o Poder Judiciário a partir de experiências formativas

João Guilherme de Melo Peixoto [a*], *Alex Sandro* Gomes [b*]

[a] School of Communication, Catholic University of Pernambuco, Recife, Brazil, email address: joao.peixoto@unicap.br, ORCID number 0000-0001-6628-3152.

[b] Computer Science Center, Federal University of Pernambuco, Recife, Brazil, , email address: asg@cin.ufpe.br, ORCID number 0000-0003-1499-8011

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. This work aims to analyze senses and meanings related to the construction of continuing education processes designed with the objective of transversalizing the culture of innovation, creativity and public entrepreneurship in the Judiciary. For this, narrative interviews were carried out with actors from the Judiciary who participated in the lato sensu Postgraduate course "Innovative Jurisdiction beyond 2030". Within the results obtained from the collected data, we found the presence of three macro themes, namely: a) meanings of the notion of innovation; b) dialogue between the field of law and the culture of innovation in the Judiciary; and c) perceptions about the effectiveness of the strategy for implementing innovation processes via training actions. Such aspects point to the need to structure training processes which point to the development of skills (whether individual, collective and/or organizational) which enable the actors of the Judiciary to reflect, produce and share knowledge, methodologies, approaches and other processes specific to current societies.

Keywords. Innovation, continuing education, Public sector, Justice

Policy paper, DOI: https://doi.org/10.59490/dgo.2025.926

1. Introdução

O futuro das instituições governamentais e os processos de modernização da administração pública são temas recorrentes nas sociedades contemporâneas (MAZZUCATO, 2014 FURTADO, 2009; FREEMAN, 1995). Ademais, ainda sobre o tema, no que diz respeito à incorporação de tais questões às dinâmicas estratégica, tática e operacional voltadas ao setor público (KOURY, 2011), mais especificamente àquelas associadas ao Poder Judiciário, protocolos concernentes à tríade gestão de dados, inovação e avanço tecnológico configuram-se como macro-temáticas essenciais para pensar a prática da Justiça no futuro.

Sobre aspectos associados à gestão de dados no sistema jurídico nacional, aponta-se que, desde os anos 90 do século XX, avanços podem ser percebidos acerca da utilização de sistemas digitais de captura e processamento de dados produzidos pelos atores que compõem o Judiciário nacional. Iniciativas nacionais, a exemplo do Justiça em Números (publicado desde 2004) demonstram que a incorporação de dinâmicas próprias ao uso de big data (ORSINI, 2017), como a criação de algoritmos voltados à análise de um grande volume de dados os quais auxiliem na compreensão de problemáticas reais e contemporâneas da Justiça brasileira, podem configurar-se como uma eficiente opção estratégica.

Já em relação à inovação, definida aqui como fruto do processo de aprendizagem, procura e exploração, de onde brotam novos produtos, novas técnicas, novas formas organizacionais, alterações institucionais, de mercado e de

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

serviços, que podem ser tecnológicas ou sociais (CASTRO; GUIMARÃES, 2019, p. 175), a criação de laboratórios de inovação (WERNECK, 2020) e demais espaços dedicados ao estímulo da criatividade e ao intraempreendedorismo já fazem parte da realidade de diversos tribunais no país.

Visto isso, e a partir de Roger (1995), fica claro que o conceito de inovação nos anos 90 do século XX direcionou o debate para questões relacionadas ao desenvolvimento de novas ideias, práticas ou objetos, apontando para uma visão excessivamente abrangente e voltada à originalidade desses. Essa conceituação converge em certa medida com o que a Comissão Europeia (2013) afirma ao classificar a inovação como o processo de geração e implementação de novas ideias com foco na geração de valor para a sociedade. Ainda com esse viés, Van de Vem et al. (2000) traz uma abordagem do conceito de inovação que incorpora a implementação de novas ideias por meio de aspectos associados à motivação e ao engajamento. Por fim, destaca-se Schwella (2005), apontando a necessidade de desenvolver competências relevantes para a inovação a partir de um intenso trabalho de educação continuada dos atores envolvidos no processo.

Diante disso, e com foco nas especificidades relacionadas ao setor público, também é necessário entender a inovação como um importante motor de mudança diante dos desafios que envolvem a administração pública. Muitos autores identificam o papel ativo do setor público na sociedade e suas particularidades (KIM; SUNG, 2021; AGUNE; CARLOS, 2017; BELMONTE DA SILVA; FERNANDEZ JARDÓN, 2021; EL-HADDADEH; IRANI; MILLARD; SCHRÖDER, 2014), bem como a necessidade de aprofundar estudos sobre as transformações da cultura de inovação relacionadas ao setor (ANDHIKA; NURASA; KARLINA; CANDRADEWINI; 2018; WIPULANUSAT; PANUWATWANICH; STEWART; SUNKPHO, 2019; DE OLIVEIRA; DOS SANTOS; 2019).

Em pesquisa realizada no Reino Unido, Holanda e República Checa, Baxten, Schoeman e Goffin (2015) apontam para a necessidade de criação de uma cultura sistêmica de inovação a qual estimule a geração de novas ideias e cooperação entre os atores envolvidos (CASTRO; GUIMARÃES, 2019). De acordo com Werneck et al. (2020), "os laboratórios surgem como uma das tentativas de lidar com as incertezas e complexidade dos problemas públicos" (p. 13).

Outrossim, questões alusivas ao desenvolvimento tecnológico devem ser encaradas como salutares para a compreensão dos desafios voltados à construção dos futuros possíveis da inovação no Poder Judiciário. Incorporação de temáticas, como o uso e a aplicação de inteligência artificial (FELIPE; PERROTA, 2018) e sua compreensão por parte dos servidores, magistrados e demais integrantes do Judiciário estadual e nacional, apontam para a necessidade de construção de políticas de "popularização" deste e de outros conceitos (programação de computadores, metodologias ágeis de projetos, etc.); os quais se constituem como essenciais para uma política eficaz de formação continuada.

Visto isso, surge aqui uma questão-chave: como oferecer aos atores do Poder Judiciário nacional subsídios teórico-metodológicos e práticos para a incorporação de saberes relacionados à inovação?

Dessa forma, e tendo em vista a necessidade de expansão e atualização de pesquisa relacionadas aos processos de formação voltados ao Poder Judiciário, este trabalho orienta-se à necessidade de uma investigação exploratória acerca do que faria sentido em processos de formação continuada desenhados visando difundir a cultura da inovação, da criatividade e do empreendedorismo público no Poder Judiciário. Que elementos podem ser destacados destas formações e de que forma os participantes atribuem sentido aos conteúdos e as práticas realizadas nestas experiências formativas?

2. Método

O presente trabalho visou analisar, a partir da realização de entrevistas narrativas (JOVCHELOVICH; BAUER, 2002) com atores do Poder Judiciário matriculados no curso de Pós-graduação lato sensu "Jurisdição inovadora para além de 2030" (iniciativa inédita da Escola Nacional de Formação e Aperfeiçoamento de Magistrados Ministro Sálvio de Figueiredo Teixeira – ENFAM), a construção de processos de formação continuada desenhados visando difundir a cultura da inovação, da criatividade e do empreendedorismo público no Poder Judiciário. Buscamos que sentidos e significados podem ser extraídos dos discursos e narrativas destes participantes no que se refere às vivências em inovação dentro de seus respectivos órgãos e unidades judiciais.

Para a realização da coleta de dados, foram selecionados, a partir de uma amostra não-probabilística (por conveniência), 4 participantes do curso em questão, os quais foram divididos em "servidores" (dois participantes) e "magistrados" (dois participantes). As entrevistas foram realizadas virtualmente entre os meses de abril e maio de 2023. Importante destacar os participantes foram informados que a entrevista não teria nenhuma validade para o processo de avaliação do curso, como também foram informados que poderiam interromper a realização a qualquer momento.

Já no que se refere ao curso de Pós-graduação lato sensu "Jurisdição inovadora para além de 2030", destacamos, entre os objetivos de aprendizagem elencados na proposta (ANDERSON, 2001; WIGGINS; MCTIGHE, 2005): "capacitar os

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

cursistas à cultura da inovação, colaborando para que o Poder Judiciário nacional se fortaleça na consecução de sua atividade-fim (prestação jurisdicional) e meio (questões extrajudiciais e de governança do sistema de justiça)"

Por fim, ressaltamos que, a partir dos elementos obtidos durante a coleta, realizamos um processo de sistematização dos dados em macro temáticas visando buscar elementos de conexão entre práticas elencadas por servidores e magistrados entrevistados e características relacionadas ao desenvolvimento de uma cultura de inovação no setor público.

3. Resultados

Após a realização das entrevistas narrativas com participantes do curso pós-graduação lato sensu "Jurisdição Inovadora – para além de 2030", constatamos a presença de macro-temáticas as quais articulam processos relacionados aos sentidos da implantação da cultura da inovação no Poder Judiciário.

A partir de aspectos conectados à: a) acepções da noção de inovação; b) interlocução entre a prática do direito e a cultura da inovação no Poder Judiciário; e c) percepções sobre a efetividade de estratégia de implantação de processos de inovação via ações de formação; visamos sistematizar insights apontados durante as entrevistas em macro-temáticas no sentido de especular futuros possíveis para apontar cenários possíveis para a implantação de processos de inovação focados nas realidades plurais do Poder Judiciário brasileiro.

3.1 Macro-temática 01: acepções da noção de inovação

Para os servidores e magistrados entrevistados, a própria ideia de inovar no Poder Judiciário se apresenta como uma perspectiva muitas vezes evitada pelos representantes da alta administração dos tribunais. Tal posicionamento está associado, em alguns casos, a falta de protocolos e práticas de gestão difundidas de maneira clara e objetiva entre tais representantes. Para o "Servidor A": "Há um afastamento das necessidades, sendo completamente distintas e também dos processos, que deveriam ser descentralizados, o que não acontece, né? Quando acontece algo inovador, normalmente é algo imposto e vem de cima para baixo. E isso prejudica a análise concreta do que acaba sendo efetivamente implementado nas varas, entendeu? A gente vê muito isso. !

Também vale destacar que as transições entre equipes gestoras, que no judiciário brasileiro dura dois anos, figurou como um dos fatores que impactam a absorção da cultura da inovação pelos gestores, como também para os demais integrantes dos tribunais. Para o "Magistrado B": "Eu preciso registrar uma certa dificuldade, alguns empecilhos estruturais… por exemplo, poderia citar a mudança de gestão de presidência de tribunais, isso é um empecilho à inovação porque há uma mudança às vezes de política institucional por parte do gestor e acaba ou atrasando, ou mudando o foco. E nessas transições se perde muito tempo num momento que não tem como perder, né? Então esses ruídos eu percebo que acaba tendo um prejuízo muito grande"."

Visto isto, percebemos a necessidade de difundir da cultura da inovação no judiciário brasileiro, com vistas a potencializar não só os resultados dos projetos desenvolvidos a partir de abordagens mais criativas, integradoras e humanizadas, como também gerar nos servidores, magistrados e demais colaboradores uma relação de pertencimento e envolvimento que, atualmente, não é percebida como um valor necessário à alta administração.

3.2 Macro-temática 02: interlocução entre a prática do direito e a cultura da inovação no Poder Judiciário

Para os entrevistados, o desenvolvimento e a vivência da cultura da inovação nos respectivos tribunais dos quais fazem parte mostra-se como uma conduta necessária à atualização das práticas relacionadas à operacionalização do direito em uma sociedade em intensa transformação. É preciso entender que protocolos e metodologias tradicionais de planejamento, execução e gestão administrativa não suportam mais as demandas sociais advindas dos atores que recorrem ao sistema judicial nacional.

Segundo um dos entrevistados, "Magistrado A", para além de buscar operacionalizar como os órgãos do judiciário, deve-se incorporar cultura de inovação às suas práticas cotidianas. É preciso construir pontes com outros setores e atores, como, por exemplo, as universidades. Para o entrevistado, tal postura advoga positivamente para que o tema e as dinâmicas relacionadas à cultura da inovação no Poder Judiciário alcance as esferas táticas e estratégicas, o que pode garantir perenidade e institucionalização desta pauta. Ainda segundo o magistrado: "uso a experiência na magistratura para conectar melhor meus alunos com a realidade e uso certamente a academia para aprimoramento da [minha] atividade judicial".

Para o "Magistrado B", uma das maiores barreiras atitudinais relacionadas a implementação da cultura da inovação no judiciário está relacionada ao tradicionalismo e a intensa necessidade de formalização de protocolos de administração, representando uma visão de gestão pública nada conectada a realidade atual, a partir da necessidade de perpetuar artifícios estruturais de hierarquização e padronização de códigos voltados à manutenção do status quo. Para o entrevistado, "falar em inovação é algo novo e muito complexo na justiça. Porque o judiciário, em parte, tem que ser burocrático, já que busca a aplicação da lei e de regramentos. Então você conseguir trazer inovação nesses espaços em que foram criados na visão de palácios é algo novo e muito difícil".

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Já a partir de outro ponto de vista, destacamos aqui as ponderações do "Servidor B". O mesmo desenvolve a ideia de que a desconexão entre as atividades realizadas por quem "opera" as unidades administrativas e judiciais no dia-a-dia faz com que muito do que seja desenvolvido apenas reproduza práticas previamente avaliadas como "boas práticas". Tal decisão, conforme o entrevistado, afasta os atores da justiça brasileira da criação de uma cultura da inovação, a saber: co-criação, empatia, experiência do usuário. Segunda o servidor: "Como assessor, você chega até um pedaço do processo, você não consegue resolver, você entrega e diz: ó, chefe, não consegui. E aí segue a vida, né? Nada muda".

Complementando tal perspectiva, o "Servidor A" aponta que a desconexão entre o Poder Judiciário e sociedade pode ser apontada como uma das principais fontes de desafios para a implementação de processos de inovação nos órgãos. A partir de pequenas práticas cotidianas relacionadas à construção de uma comunicação repleta de ruídos, por exemplo, nota-se um afastamento e uma descrença por parte da população no trabalho desenvolvido pelos atores judiciais. Segundo o entrevistado: "Quando trabalhei em secretaria eu me deparei com várias situações. Uma delas que não sai da cabeça era que a mulher não conseguia entender o que era indeferido. Então, ela ficou com aquela cara meio abatida e eu pergunte: "a senhora entendeu? O juiz indeferiu o seu pedido". Aí ela falou: "tudo bem, meu filho". E ficou com aquela cara de que tudo bem, mas não estava entendendo nada. Perguntei: "A senhora entendeu o que eu falei?" Ela disse: "não". Mencionei que o juiz negou, que o pedido foi negado. Eu poderia ter dito negado antes, mas a gente está tão acostumado a falar "deferi", "pleiteou". São palavras que não interessam. São simples para gente, mas inacessível para a maioria da população."

Dito isso, podemos trazer a tona a necessidade urgente de uma difusão efetiva de valores associados à cultura da inovação no setor público, em particular, no Poder Judiciário, a saber: construção de práticas de administração pública as quais ampliem o papel do jurisdicionado na elaboração de políticas públicas voltadas a solução de demandas reais; espaço para a reflexão e autocrítica de gestores e demais colaboradores dos tribunais brasileiros acerca do trabalho realizado; desenvolvimento de estratégias de interlocução entre os diversos atores internos (servidores, magistrados, demais colaboradores) e externos (Ministério Público, Defensoria Pública, representantes da sociedade civil organizada, entre outros) que aproximem os projetos e ações classificadas como "inovadoras" dos impactos diretamente gerados no desenvolvimento de atividades cotidianas nas unidades de trabalho da justiça brasileira.

3.3 Macro-temática 02: interlocução entre a prática do direito e a cultura da inovação no Poder Judiciário

Por fim, também verificamos, após a sistematização das entrevistas, dois tópicos relacionados às experiências vivenciadas pelos participantes durante as atividades realizadas no curso de pós-graduação. O primeiro deles diz respeito à percepção dos estudantes acerca do processo de construção do curso e principais barreiras atitudinais relacionadas às práticas inovadoras no Poder Judiciário a partir da experiência coletiva proporcionada pela pós-graduação.

Visto isso, como destaca o "Magistrado A", para que uma especialização em inovação fizesse sentido, não poderia jamais ser ofertada apenas para juízes. Tal perspectiva iria ao encontro aos princípios da co-criação e da empatia, salutares para a construção de projetos com abordagens não tradicionais. Todavia, destacamos aqui a pontuação do "Servidor B", que, apesar de tal discurso proferido pelo "Magistrado A", alega não haver uma regular disponibilidade de juízes e juízas para atividades que exigem integração entre diferentes atores do judiciário: "Em determinado momento, principalmente na hora de prototipar, a gente vê uma retrancada, sabe? A gente vê principalmente os magistrados, a gente vê com essa sensação de puxar o freio mesmo, de "não isso daí não vai dar". "Ah, isso daí já foi tentado, né?" E o que eu gosto na inovação é exatamente o contrário, né? De você revisitar soluções que já foram pensadas em outra realidade, em outro contexto, com outras pessoas, com outras tecnologias e você voltar pra ela agora, né? E vamos tentar de novo diferente, né?"

Ainda sobre questões associadas a conexão entre juízes e servidores durante as atividades realizadas no curso, reforça o "Servidor A": "no momento eu vejo uma certa resistência, sabe? Eu vi tanta coisa bacana, tanta coisa interessante na pós-graduação, sobretudo essa questão de troca de experiências, processos, procedimentos que já funcionam em outras áreas, que podem se aplicar a cada adaptada pra outras situações, mas eu vejo uma certa resistência. Por exemplo, o que eu aprendi na pós eu não posso aplicar na prática sozinho aqui na vara que eu atuo, mas eu faço questão porque eu sei que esse movimento ganha força, eu sei que esse movimento é crescente e que ele é urgente, não há como fugir e eu continuo insistindo."

Já o segundo ponto a ser destacado dentro desta macro-temática descrita conecta-se às abordagens metodológicas utilizadas durante a pós-graduação acima referida. O uso de abordagens em salas de aula virtuais que ultrapassaram o uso de técnicas expositivas para apresentação de aspectos teóricos e práticos sobre inovação no Poder Judiciário mostrou-se uma modalidade percebida pelos estudantes como efetiva. Essa percepção parece apontar para a viabilidade de formações continuadas para difusão de uma cultura de inovação na modalidade a distância ou híbrida.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Para o "Servidor B": "A pós-graduação inteira vem me surpreendendo por ela mesmo, entendeu? Por si própria, assim, o jeitão como ela foi bolada. Então, por exemplo, em vez de TCC, são essas práticas. Essas práticas são soluções que vão ser apresentadas para o conselho, vão ser apresentadas para os ministros".

4. Discussão

No que diz respeito às características associadas à implantação da cultura da inovação nos órgãos que compõem o judiciário nacional, observamos inicialmente uma percepção negativa acerca dos modelos de gestão da inovação utilizados nos respectivos tribunais, a partir de características enraizadas no que Bresser-Pereira (1996) definiu como modelo Administração burocrática, a saber: "A administração pública burocrática foi adotada para substituir a administração patrimonialista, que definiu as monarquias absolutas, na qual o patrimônio público e o privado eram confundidos. O nepotismo e o empreguismo, senão a corrupção, eram a norma. Tornou-se assim necessário desenvolver um tipo de administração que partisse não apenas da clara distinção entre o público e o privado, mas também da separação entre o político e o administrador público. Surge assim a administração burocrática moderna, racional-legal. [...] Surge a burocracia estatal formada por administradores profissionais especialmente recrutados e treinados, que respondem de forma neutra aos políticos. Max Weber (1922) definiu e descreveu de forma genial esse tipo de administração no início deste século". (BRESSER PEREIRA 1996, p. 3)"

Em outros termos, e segundo os entrevistados, existe um posicionamento demasiadamente centrado na figura dos gestores. Estes ocupam cargos de destaque na hierarquia dos órgãos, e acabam por decidir monocraticamente o que deve ou não ser identificado como tema ou objeto de interesse para as estruturas administrativas responsáveis por gerenciar a inovação. Para o "Servidor B": "As mudanças de gestão se dão num prazo muito pequeno. Não é um privilégio nosso, mas o nosso tempo é muito curto e as pessoas agem muito por ego. É assim: eu quero ver a instituição? não, eu quero ver o meu nome na placa, né? Então rola ainda muito isso e daí de repente a inovação não é a prioridade daquela pessoa naquele momento ou então alguém decide desfazer o que foi feito, ignorar, não sei."

Tal ponto de vista é endossado pelo entrevistado "Magistrado B", que reforça o processo de substituição de lideranças associado ao curto tempo de gestão como uma problemática relevante para a implantação de uma efetiva política de inovação nos tribunais: "A mudança de gestão de presidência de tribunais, isso é um empecilho à inovação porque há uma mudança às vezes de política institucional por parte do gestor e acaba ou atrasando, ou mudando o foco. E nessas transições se perde muito tempo num momento que não tem como perder, né?"

Ademais, podemos destacar como outra problemática relevante para a difusão de uma cultura da inovação no judiciário o distanciamento entre os processos de planejamento e execução da prestação jurisdicional ofertada das reais necessidades do público. Para o "Servidor A", o conservadorismo e a necessidade de controle administrativo afasta a pauta da inovação do verdadeiro foco da atividade judicante que, segundo o entrevistado, é a boa prestação de serviço ao jurisdicionado.

Por fim, podemos observar que experiências ativas e inovadoras de ensino-aprendizagem que transcendam os atuais modelos de formação judicial antecipam futuro caminhos para a construção de processos de difusão da inovação para o Poder Judiciário nacional. Faz-se necessário compreender que, para que, abordagens tradicionais, com foco na exposição e na passividade do estudante, mostram-se em total desconexão com os valores e princípios a serem desenvolvidos a partir da implementação da cultura da inovação nos tribunais, a saber: empatia, desburocratização, usuário no centro do processo, humanização de serviços, entre outros.

5. Conclusões

O presente trabalho tem por objetivo analisar percepções relacionadas à construção de processos de formação continuada desenhados visando difundir a cultura da inovação, da criatividade e do empreendedorismo público junto a atores do Poder Judiciário. A partir das análises realizadas, constatamos que, para construção de futuros possíveis para a inovação no Poder Judiciário, evidencia-se, então, a necessidade de estruturar processos formativos os quais apontem para o desenvolvimento de competências individuais, coletivas e/ou organizacionais que possibilitem aos atores do Poder Judiciário refletir, produzir e compartilhar conhecimentos, metodologias, abordagens e demais processos próprios às sociedades atuais.

Ainda sobre questões atreladas às dinâmicas formativas, os protocolos específicos concernentes aos processos de ensino e aprendizagem voltados à educação contemporânea também atravessam reformatações (IMBERNÓN, 2009; FREIRE, 1997; LEAL; MIRANDA; CASA NOVA, 2018). De início, surgem os questionamentos: como estimular docentes e discentes em um contexto educacional no que se refere à formação direcionada aos novos desafios enfrentados pela sociedade? Como conectar características dos saberes formais e não-formais, muitas vezes dispersas na sociedade?

Constata-se que, o uso de Metodologias Ativas de Ensino/Aprendizagem (FUGGETTA, 2012; DIESEL,; BALDEZ,;

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

MARTINS, 2017; MATTAR, 2017), mesmo estruturas pouco inovadoras, foram percebidas como uma renovação andragógica. Esta apresenta como ponto de ancoragem o desenvolvimento de protocolos mais inclusivos, participativos e dinâmicos em ambientes de ensino e aprendizagem. Todavia, para que a pauta da inovação se perpetue e para que tais práticas formativas oferecerem resultados satisfatórios, é preciso repensar a autonomia de diferentes setores e atores do Poder Judiciário diante da prática da inovação no setor.

Atrelado a isto, formação continuada e gestão adaptada à inovação são processos necessários para a consolidação da cultura da inovação na justiça brasileira. A partir de tais características, acreditamos ser possível repensar as percepções atreladas às práticas cotidianas de servidores e magistrados do judiciário brasileiro, com evidências consistentes que podem sedimentar estratégias de promoção da inovação, criatividade e ao empreendedorismo no setor público.

Acknowledgement

- **Contributor Statement***: Author a: Conceptualisation, Writing-Original Draft; Author b: Supervision, Writing – Review & Editing.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Anderson, L. W., Krathwohl, D. R., & Airasian, P. W. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Longman.

Baxter, D., Schoeman, M., & Goffin, K. (2011). Innovation in justice: New delivery models and better outcomes. Cranfield School of Management.

Bresser-Pereira, L. C. (2015). Da administração pública burocrática à gerencial. Revista do Serviço Público, 47(1), 7–40. https://doi.org/10.21874/rsp.v47i1.702

Castro, M. P., & Guimarães, T. A. (2019). Dimensões da inovação em organizações da justiça: Proposição de um modelo teórico-metodológico. Cadernos Ebape.Br, 17(1), 173–184.

Diesel, A., Baldez, A., & Martins, S. (2017). Os princípios das metodologias ativas de ensino: Uma abordagem teórica. Revista Thema, 14(1), 268–288.

Felipe, B. F. C., & Perrota, R. P. C. (2018). Inteligência artificial no direito: Uma realidade a ser desbravada. Revista de Direito, Governança e Novas Tecnologias, 4(1), 1–16.

Fuggetta, A. (2012). 3+1 Challenges for the future of universities. Journal of Systems and Software, 85(10), 2417–2424. https://doi.org/10.1016/j.jss.2012.04.029

Freeman, C. (1995). The national system of innovation in historical perspective. Cambridge Journal of Economics, 19, 5–24.

Freire, P. (1998). Pedagogia do oprimido. Paz e Terra.

Freitas, C. S. de, & Medeiros, J. J. (2015). Social and organizational impacts of the electronic processing system of the Brazilian Superior Tribunal of Justice. Journal of Information Systems and Technology Management, 12(2), 317–332.

Freitas, C. M., et al. (2015). Uso de metodologias ativas de aprendizagem para a educação na saúde: Análise da produção científica. Trabalho, Educação e Saúde, 13(2), 117–130.

Furtado, C. (2009). Desenvolvimento e subdesenvolvimento. Contraponto: Centro Internacional Celso Furtado.

Imbernón, F. (2009). Formação permanente do professorado: Novas tendências.

Jovchelovich, S., & Bauer, M. W. (2002). Pesquisa qualitativa com texto, imagem e som: Um manual prático. Vozes.

Koury, S. C. (2011). Planejamento estratégico do poder judiciário: O papel das escolas judiciais. Tribunal Regional do Trabalho da 9ª Região.

Leal, E. A., Miranda, G. J., & Casa Nova, S. P. C. (2018). Revolucionando a sala de aula: Como envolver os estudantes

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

aplicando as técnicas de metodologias ativas de aprendizagem. Atlas.

Mattar, J. (2017). Metodologias ativas para a educação presencial, blended e a distância. Artesanato Educacional.

Mazzucato, M. (2014). O estado empreendedor: Desmascarando o mito do setor público x setor privado. Portfolio-Penguin.

Orsini, A. G. de S. (2017). O fenômeno do big data e os pressupostos para uma nova onda de acesso material à justiça. Conpedi Law Review, 3(1), 75–91.

Werneck, C., et al. (2020). Ciclos de vida de laboratórios de inovação pública. Enap.

Wiggins, G., & McTighe, J. (2005). Understanding by design. Association for Supervision and Curriculum Development.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Impacto social, econômico e ambiental da implantação de soluções de governo digital*

Bernardo Campolina[a*], Ana Paula Silva[b],*Lívio Miguel dos Santos*[c], *Lucas Resende Carvalho*[d] *Everson Lopes de Aguiar*[e], *Wagner Silva de Araújo*[f], *Ana Maria H. Camilo de Oliveira*[g], *Frederico Gonzaga Jayme Jr.*[h].

[a] Centro de Desenvolvimento e Planejamento Regional, Universidade Federal de Minas Gerais, Brasil. E-mail address: bpcdiniz@gmail.com, ORCID number 0000-0002-2728-3309.

[b] Centro de Desenvolvimento e Planejamento Regional, Universidade Federal de Minas Gerais, Brasil. E-mail: anapnunes10@gmail.com.

[c] Centro de Desenvolvimento e Planejamento Regional, Universidade Federal de Minas Gerais, Brasil. E-mail: liviomiguelds@gmail.com.

[d] Centro de Desenvolvimento e Planejamento Regional, Universidade Federal de Minas Gerais, Brasil.. E-mail: lucas.resende@gmail.com, Orcid Number 0000-0002-3618-3967

[e] Ministério da Gestão e da Inovação em Serviços Públicos. Secretaria de Governo Digital, Brasil. E-mail: everson.aguiar@gmail.com,

[f] Ministério da Gestao e Inovação em Serviços Públicos, Secretaria de Governo Digital Brasil, Universidade do Minho, Departamento de Sistemas de Informação, Portugal. E-mail: wagner.s.araujo@gestao.gov.br, ORCID Number 0000-0002-5348-6169.

[g] Centro de Desenvolvimento e Planejamento Regional, Universidade Federal de Minas Gerais, Brasil. E-mail: ahermeto@cedeplar.ufmg.br, 0000-0001-8331-1928

[h] Centro de Desenvolvimento e Planejamento Regional, Universidade Federal de Minas Gerais, Brasil. E-mail:gonzaga@cedeplar.ufmg.br, Orcid Number: 0000-0002-4617-0107

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1000

Resumo. Este artigo busca analisar os impactos da digitalização dos serviços públicos em amostra de serviços digitais disponibilizados pelo governo federal brasileiro. Foi desenvolvido um instrumento metodológico de avaliação, que permite a mensuração de impactos econômicos, sociais e ambientais da iniciativa de soluções de governo digital. Para tanto, foram simulados dois estudos de caso, a saber: Solicitação de aposentadoria por idade (Instituto Nacional do Seguro Social) e Obtenção de passaporte (Polícia Federal). As simulações realizadas indicam que a implementação do governo digital no Brasil possui impactos expressivos em termos econômicos, sociais e ambientais. Observa-se que a redução do tempo dedicado ao deslocamento e aos atendimentos presenciais é um fator fundamental na composição dos impactos, especialmente os de natureza econômica. Em se tratando dos impactos ambientais, verifica-se que a digitalização contribui para a redução de desmatamento e emissões de CO_2, alinhando-se a políticas de transição verde. No entanto, cumpre destacar a necessidade de considerar contrapartidas ambientais, como o aumento de emissões relacionadas à maior demanda por armazenamento de dados e dispositivos mais avançados. Apesar das limitações, os resultados reforçam o papel do governo digital como uma ferramenta estratégica para a formulação de políticas públicas inclusivas, sustentáveis e baseadas em evidências, promovendo maior eficiência e impacto positivo na sociedade. Sugere-se aprimorar o modelo com variáveis adicionais, como idade, renda e modais de transporte, além de adaptar o cálculo do rendimento médio para diferentes perfis de usuários e serviços. A inclusão de custos relacionados ao consumo energético, segurança cibernética e gestão de lixo eletrônico também se mostra essencial para uma análise mais abrangente.
Palavras-chave. Governo digital, avaliação de impactos, simulação.

Abstract: This article aims to analyze the impact of the digitalization of public services in Brazil. A methodological evaluation tool was developed to measure the economic, social and environmental impacts of the Digital Government Solutions initiative. For this purpose, two case studies were simulated: Applying for a retirement pension (National Social Security Institute) and obtaining a passport (Federal Police). The simulations carried out indicate that the implementation of digital government in Brazil has significant economic, social and environmental impacts. The reduction of time spent on travel and face-to-face services is a fundamental factor in the composition of the impacts, especially those of an economic nature. In terms of environmental impacts, digitalization contributes to reducing deforestation and CO2 emissions, in line with green transition policies. However, environmental trade-offs need to be considered, such as the increase in emissions associated with greater demand for data storage and more advanced equipment. Despite the limitations, the results reinforce the role of digital government as a strategic tool for formulating inclusive, sustainable and evidence-based public policies, promoting greater efficiency and positive impacts on society. It is suggested that the model be improved with additional variables such as age, income and transport mode.
Keywords. Digital government; impact assessment, simulation.

* Este trabalho é parte do resultado de uma parceria desenvolvida entre o Ministério da Gestão e Inovação em Serviços Públicos e a Universidade Federal de Minas Gerais, por meio do Termo de Execução Descentralizada No. 31/2023.

1. Introdução

A transformação digital impactou organizações públicas e privadas nos últimos anos e a Pandemia da Covid-19 acelerou este movimento. A aplicação das Tecnologias da Informação e Comunicação (TICs) no Governo tem levado a avanços na prestação de serviços públicos, incentivado o engajamento dos cidadãos, além de possibilitar que governos se tornem mais responsáveis, transparentes e eficazes (Acharya et al., 2008; United Nations Educational Scientific and Cultural Organization, 2019).

A associação das TICs ao Governo, conhecida como Governo Digital, é uma iniciativa complexa. Promover serviços centrados nos cidadãos enquanto se fortalece a transparência, a efetividade, a inclusão e a confiança no Estado representa um desafio crescente (United Nations, 2018). Embora traga novas oportunidades, essa transformação exige a formulação e implementação de políticas públicas inovadoras, cuja execução ainda carece de clareza, especialmente na integração dos mundos físico e digital (Janowski, 2015). É importante destacar que, por seu caráter multidisciplinar, o Governo Digital é influenciado por diversas áreas do conhecimento, como ciência política, ciência da informação, administração pública, sistemas de informação, gestão de tecnologias da informação, economia, dentre outras. Esta compreensão é multifacetada e abrangente pois está relacionada ao suporte para a modelagem e automação de processos e procedimentos internos, a gestão de tais processos nas instituições públicas, bem como à melhoria da disponibilização de serviços públicos finalísticos e viabilização de ferramenas com vistas a ampliar a transparência e responsabilização dos agentes públicos no uso destas ferramentas e processos.

No entanto, o conceito de Governo Digital vai além da mera informatização de processos, exigindo uma reestruturação sistêmica das instituições públicas para garantir integração, interoperabilidade, segurança, mecanismos robustos de identificação e autenticação e inovação contínua respeitando a privacidade do cidadão.. No Brasil, essa transformação vem sendo construída desde a década de 1960, com iniciativas voltadas à modernização dos serviços governamentais. A criação do Programa de Governo Eletrônico (e-GOV) no início dos anos 2000 representou um marco nessa trajetória, estabelecendo diretrizes para a governo digital e promovendo a integração de tecnologias em diversas esferas da administração pública, algo que só se tornou efetivo em 2016 com a política de governança digital. Alguns exemplos de iniciativas desenvolvidas neste programa, foram as estratégias gerais de tecnologia do governo federal, a Infovia Brasília, os Padrões de Interoperabilidade (e-Ping) e o Modelo de Acessibilidade de Governo Eletrônico (e-MAG).

A preocupação com a avaliação e o monitoramento das iniciativas de Governo Digital tem sido constante. Já em 2002, a Secretaria de Logística e Tecnologia da Informação do Ministério do Planejamento (SLTI/MP) divulgou a primeira avaliação do e-GOV, identificando avanços e desafios. Posteriormente, em 2004, a criação do Departamento de Governo Eletrônico impulsionou o desenvolvimento de métricas para a avaliação da qualidade dos serviços digitais, considerando aspectos como usabilidade, transparência e acessibilidade. A implementação de indicadores específicos tem permitido um acompanhamento mais preciso dos impactos da digitalização sobre os cidadãos e a gestão pública.

Para a consolidação da transformação digital dos serviços públicos, os avanços devem ser constantes. Entre 2017 e 2018, recomendações da Organização para a Cooperação e o Desenvolvimento Econômico (OCDE), destacaram a necessidade de fortalecer as estratégias de governo digital no Brasil. Como resposta, foram adotados mecanismos para tornar a administração pública mais ágil e eficiente. Um exemplo é a adaptação do *Standard Cost Model*, metodologia originalmente desenvolvida na Holanda, que possibilitou a mensuração do impacto financeiro da digitalização dos serviços públicos. A Calculadora de Economia com Interoperabilidade representa outro avanço significativo no campo da transformação digital. Essa ferramenta quantifica os benefícios financeiros decorrentes da eliminação de processos burocráticos, estimando o tempo economizado por cidadãos e agentes públicos e convertendo esses dados em valores monetários.

No âmbito regulatório, a promulgação da Lei nº 14.129, em 2021, consolidou diretrizes fundamentais para a transformação digital no Brasil, estabelecendo princípios para a modernização dos serviços públicos e o fortalecimento da transparência e eficiência administrativa. Um dos destaques dessa legislação é a exigência de plataformas digitais que possibilitem a avaliação contínua dos serviços pelos usuários, garantindo maior controle sobre a qualidade do atendimento público. Além disso, a implementação do Autodiagnóstico em 2024 resultou na criação do Índice de Maturidade em Governança em Tecnologia da Informação do Sistema de Administração dos Recursos de Tecnologia da Informação - iGOVSISP, um conjunto de indicadores que avalia a maturidade das instituições federais em diversas dimensões, como governança de TIC, proteção de dados e infraestrutura digital.

Diante desse panorama, torna-se evidente que a avaliação e o monitoramento das políticas de transformação digital são componentes essenciais da modernização da administração pública. Contudo, permanecem os desafios de aprimorar as metodologias de mensuração e assegurar que a inovação digital esteja alinhada às necessidades dos cidadãos e dos governos. Assim, o presente estudo propõe-se a contribuir com essa temática por meio da construção de uma ferramenta de avaliação, que permite a mensuração de impactos econômicos, sociais e ambientais da iniciativa de soluções de governo digital. Para tanto, os impactos da digitalização foram simulados a partir de dois estudos de caso: Solicitação de aposentadoria por idade (Instituto Nacional do Seguro Social) e

Obtenção de passaporte (Polícia Federal).

Para tanto, este trabalho se organiza em cinco seções, além desta introdução. Na próxima seção é apresentado o arcabouço teórico que subsidia a construção deste estudo. A terceira seção se dedica ao desenho da pesquisa, detalhando a construção dos indicadores e o roteiro de execução das simulações. A quarta seção reporta os resultados obtidos para cada um dos estudos de caso, desagregando os impactos econômicos, sociais e ambientais. A quinta seção discute os principais resultados e implicações. Por fim, na sexta seção, dispõem-se as considerações finais.

2. Contexto e fundamentação teórica

A avaliação de políticas públicas se consolidou ao longo das duas últimas décadas como componente central do planejamento dos governos em função, principalmente, da necessidade de uma melhor alocação dos recursos e de se elaborar um instrumento de controle democrático dos governos (Arretche, 2013). Presente em diversos países e sob diferentes contextos, a situação do Brasil, no que diz respeito ao âmbito federal, não é diferente. Pode-se observar um esforço sistemático de se estruturar um sistema e instrumentos de governança e o desenvolvimento de um arcabouço teórico voltado para avaliação de políticas públicas.

Um aspecto importante na avaliação de políticas públicas consiste no objetivo e no foco definidos para a avaliação. Isso inclui uma análise abrangente da política, cobrindo sua apresentação, a teoria do programa, as atividades e produtos, os resultados e impactos, os custos e a gestão financeira, além dos indicadores de eficiência. Com base nessas evidências, pode ser desenvolvida uma análise geral da política, tendo como resultados as conclusões e recomendações para seu aprimoramento ou para o debate sobre a priorização dos recursos públicos em sua execução.

O foco principal dos estudos reside nos impactos sobre a administração pública (Gupta e Jana, 2003; Barbosa, Pozzebon e Diniz, 2013) ou sobre a sociedade (Dhaoui, 2022; Marinho, 2023; Gan, Zhang e Zhang, 2023). Dentre as pesquisas analisadas, a grande maioria trata de questões envolvendo a usabilidade e acessibilidade dos portais estatais e a provisão digital de serviços públicos (Gupta e Jana, 2003; Peters, Jassen e Engers, 2004; Barbosa, Pozzebon e Diniz, 2013; Heidlund e Sundberg, 2022; Metler et al., 2024). Nesse sentido, nota-se um foco predominante em entender se as práticas de Governo Digital são adequadas para o uso dos cidadãos, contudo nota-se uma lacuna que reside em compreender como essas práticas os impactam.

Essa característica pode ser observada nos estudos que avaliam o Governo Digital na administração pública. Nesse sentido, tanto Gupta e Jana (2003), quanto Barbosa, Pozzebon e Diniz (2013) realizaram estudos de caso para, respectivamente, Nova Délhi e São Paulo, em que os autores desenvolveram quadros multidimensionais para avaliação das políticas de Governo Eletrônico. Esses quadros partem de uma revisão de literatura e de entrevistas com agentes chave. Ambos os estudos possuem especificidades, visto que as medidas de avaliação são bastante específicas para cada administração. Nesse sentido, eles ressaltam a importância de considerar o contexto social e administrativo ao se criar os mecanismos de avaliação.

São escassos trabalhos que procuraram avaliar o impacto das políticas de governo digital e interoperabilidade em uma escala mais ampla, enquanto política pública, o que nos permite vislumbrar uma lacuna na literatura e na pesquisa. Um esforço recente foi feito por Misuraca, et al (2020) que apresenta uma proposta para avaliar o impacto da tecnologia da informação e da adoção de ferramentas de governo digital sobre diferentes aspectos e contextos variados.

2.1 Indicadores de impacto do governo digital

O objetivo desta seção é apresentar um modelo abrangente e robusto para a avaliação do impacto das políticas de governo digital. Com base no arcabouço teórico-metodológico, se buscou delinear os indicadores mais relevantes e analisar sua capacidade de resposta na construção de um modelo eficaz de avaliação do impacto da digitalização.

Partimos de arcabouço analítico mais geral voltado para avaliação de políticas públicas, proposto por Chen e Rossi (1983) que nos permitiu identificar variáveis de tratamento, intervenção e resultado. Esse framework auxilia na compreensão das variáveis exógenas que podem influenciar as variáveis de tratamento, intervenção e resultado, bem como as perturbações estocásticas que podem afetar a intervenção e os resultados. Um exemplo importante é o letramento digital, que pode influenciar tanto a intervenção quanto os resultados. Cabe destacar que a última Pesquisa de Governo Eletrônico das Nações Unidas (2024) demostrou a necessidade e a importância do letramento digital (United Nations, 2024). Outro exemplo relevante é a infraestrutura de acesso às redes, que varia significativamente em um país com as dimensões do Brasil, impactando diretamente a eficácia das intervenções e os resultados obtidos.

Se, por um lado, para avaliar a política de digitalização da oferta de serviços públicos, o sistema de intervenção e as variáveis de tratamento são bem delimitadas, a aplicação do modelo geral apresentado na Figura acima necessita de variáveis de resultados. Soma-se a isso o fato de que são poucos os estudos voltados para a avaliação de impacto

do governo digital em outros países, o que restringe os exemplos de uso de indicadores específicos. Ainda assim, há um esforço de mapeamento de indicadores de variáveis de resultados, possíveis de serem mensuradas e utilizadas no caso brasileiro em análise.

Na literatura, parte significativa dos trabalhos direcionam o foco para a análise dos impactos da implementação do governo digital sobre a criação de valor público, isto é, os benefícios que a implementação proporciona à sociedade como um todo. Luna et al. (2024), por exemplo, investigaram as percepções dos cidadãos mexicanos sobre a criação de valor público por meio de serviços digitais com dados coletados através de grupos focais. Na mesma direção, Fan et al. (2022), buscaram observar os efeitos do governo digital sobre o bem-estar subjetivo dos cidadãos, utilizando a confiança como um indicador.

No entanto, a avaliação de impacto proposta neste relatório demanda a captação de variáveis menos abstratas, com resultados mais concretos e mensuráveis nas áreas econômica, social e ambiental. Uma exigência que, por vezes, encontra obstáculos como a indisponibilidade de dados. Han et al. (2023), por exemplo, analisam o impacto do governo digital sobre a qualidade do ar na China, usando indicadores de concentração de poluentes. Avotra et al. (2021) têm como foco o impacto das políticas de governo digital sobre a "responsabilidade social corporativa", mensurada através de indicadores de qualidade institucional e corrupção, com dados coletados de um survey próprio. Por último, Gan, Zhang e Zhang (2023) utilizam dados em nível das cidades para medir o impacto do governo digital no empreendedorismo na China, usando como indicador o número de novas empresas registradas.

De forma mais ampla, o Marco Metodológico de Medição de Impacto, desenvolvido para apoiar a Rede de Governo Eletrônico da América Latina e o Caribe (Rede GEALC), consiste em uma estratégia de avaliação que delimita impactos da digitalização dos serviços públicos em diferentes dimensões. Para tanto, são construídos indicadores de impactos relacionados a tempo, dinheiro, inclusão, meio ambiente, transporte público, confiança nas instituições, dentre outros. Para além da multidimensionalidade dos impactos, outra especificidade desta metodologia é a subdivisão por segmentos da sociedade, de modo que são pensados em diferentes indicadores para cidadãos, empresas e o governo (Banco Interamericano de Desenvolvimento, 2017).

No caso proposto, indicadores de resultados nas dimensões econômica, social e ambiental precisam ser formulados para que seja possível uma avaliação abrangente da implementação de iniciativas de governo digital. Na dimensão econômica, os impactos podem ser observados por meio da redução de custos operacionais do governo, como gastos com transporte e logística, além do aumento do acesso a redes de informações que facilitam o emprego e oportunidades de negócios.

A digitalização também pode dinamizar microempresas, incentivando a abertura de novos empreendimentos, como demonstrado por Gan, Zhang e Zhang (2023). Além disso, a formalização dessas atividades econômicas no mercado de trabalho pode ter impactos significativos na arrecadação fiscal e na sustentabilidade financeira do setor público. Nesse sentido, pode ser relevante considerar indicadores específicos que capturem esses impactos, como o aumento na taxa de formalização de negócios, o crescimento da receita tributária devido à melhor fiscalização digital, e a taxa de adoção de tecnologias digitais por pequenas e médias empresas.

No que diz respeito à dimensão social, os indicadores podem abranger a inclusão social por meio da melhoria da cidadania digital e financeira, bem como da redução de assimetrias de informação entre diferentes grupos. Esses avanços ampliam o acesso equitativo a serviços digitais, fortalecendo, assim, a participação cidadã e a democracia participativa. Outra alternativa é analisar a redução de tempo proporcionada pela digitalização dos serviços, que elimina a necessidade de atendimento presencial. Essa mudança pode não apenas reduzir os custos de mobilidade e o custo de oportunidade para os cidadãos, mas também permitir que eles dediquem mais tempo a atividades produtivas ou de lazer. Outro indicador relevante é a taxa de adesão a programas governamentais por meio dos canais digitais, indo de encontro ao proposto por Marinho (2023).

Sobre a dimensão ambiental, é possível identificar efeitos positivos da digitalização, atrelados ao menor consumo de papel, redução nos custos de energia e transporte, além dos benefícios para a mobilidade urbana, decorrentes da redução da necessidade de deslocamentos físicos dos cidadãos para acessar os serviços públicos. Contudo, é importante destacar que também existem impactos negativos da digitalização para as mudanças climáticas. O aumento do consumo de energia e da produção de resíduos de Tecnologia da Informação e Comunicação (TIC), em função do ciclo de vida limitado e das constantes inovações que envolvem os produtos de TIC, são elementos que geram preocupações quanto aos efeitos de carbonização que podem resultar da transformação digital do governo (Banco Mundial, 2023).

No entanto, para além dos impactos diretos resultantes da implementação das políticas de governo digital, sejam eles sociais, econômicos ou ambientais, uma análise abrangente dos efeitos também inclui possíveis resultados indiretos. Esses resultados não são necessariamente previstos na etapa de planejamento da política, mas podem surgir como um efeito positivo delas. Nesse sentido, algumas possibilidades residem na mensuração de indicadores voltados para a transparência governamental e para a confiança que os cidadãos possuem nas instituições públicas. Esses aspectos são fundamentais para fortalecer o contrato social entre governos e cidadãos,

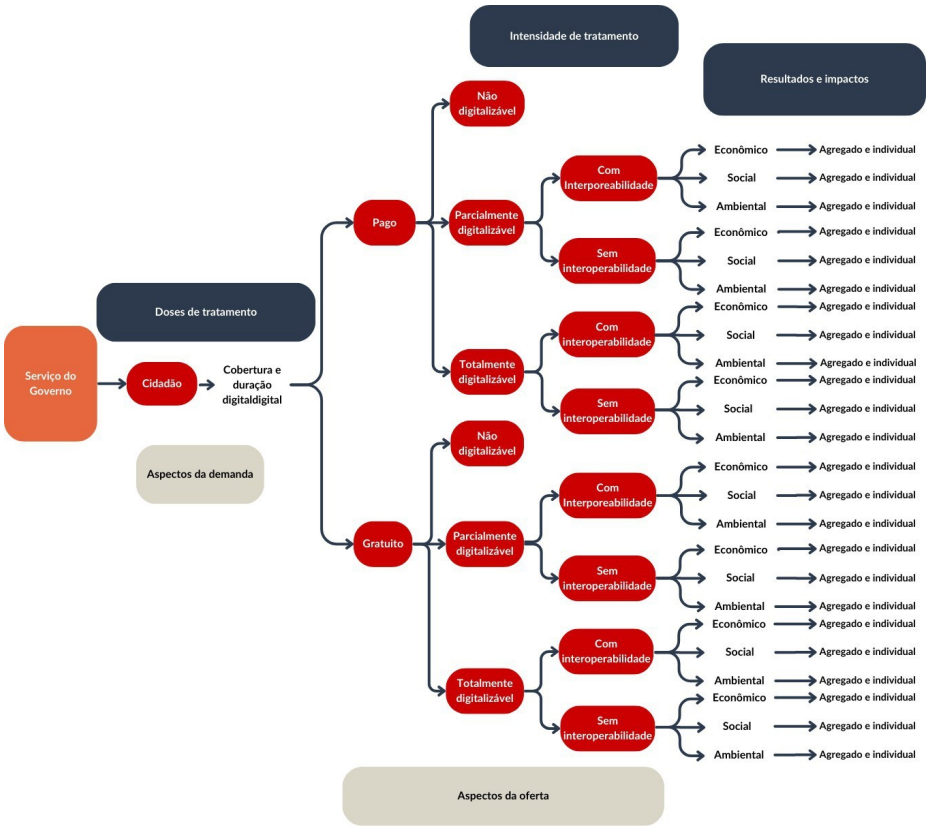
sustentando a legitimidade das políticas implementadas e incentivando uma maior participação democrática.

3. Desenho da pesquisa

A construção desta pesquisa parte de três elementos centrais: tipologia dos serviços; definições dos indicadores econômicos, sociais e ambientais; definição de dose e intensidade do tratamento; execução da simulação. É importante começar pela indicação da classificação dos serviços ofertados pelo GOV.BR. Além do segmento da sociedade, outra informação relevante para a avaliação de impacto refere-se ao órgão que oferta o serviço. A dosagem corresponde ao público-alvo do serviço, representando uma medida da parcela da população que aspectos da oferta que afetam a intensidade do tratamento, como o nível de digitalização do serviço, que indica quanto ele pode ser digitalizado. O outro elemento é a interoperabilidade, que sinaliza se o serviço está integrado à rede Conecta GOV.BR. A presença de interoperabilidade acarreta reduções nos tempos de espera e processamento das solicitações.

A Figura 1 reporta de forma esquemática a estratégia de avaliação acima descrita, para o segmento cidadão. Cumpre destacar que para os demais segmentos a figura é análoga, seguindo-se a mesma lógica.

Figura 1 – Tipologia dos Resultados e Impactos da digitalização dos serviços públicos brasileiros para o segmento Cidadão



Fonte: Elaboração própria.

Como observado, a definição de indicadores e o tratamento estatístico são elementos centrais para a avaliação de impactos almejada por este estudo. Nesse sentido, retoma-se a preocupação quanto à qualidade dos indicadores utilizados, tendo em vista a importância que eles apresentam para a medição de impacto, bem como o acompanhamento de políticas públicas. Os indicadores precisam apresentar algumas características que garantam sua relevância e utilidade prática. Assim, com base na literatura consultada, foi elaborada uma lista de indicadores relevantes, organizados segundo as dimensões econômica, social e ambiental. O Quadro 1 reporta uma breve descrição dos indicadores construídos

Quadro 1 – Indicadores de impacto econômico social e ambiental

Dimensão	Indicador	Descrição
	Custo de Oportunidade do Tempo (Cidadãos)	Mede o benefício econômico para cidadãos, associado à redução do tempo gasto em serviços digitais comparado aos presenciais
	Produtividade (Empresas)	Mede o impacto da digitalização na produtividade empresarial, reduzindo o tempo para tramitação de processos

Econômico	Produtividade (Terceiro Setor)	Mede o impacto da digitalização na eficiência do terceiro setor, com base no tempo economizado
	Produtividade (Governo)	Avalia a produtividade governamental pela redução do tempo de tramitação, como provedor de serviços públicos
	Eficiência (Governo)	Mede os benefícios governamentais decorrentes da digitalização, aumentando a eficiência administrativa
	Gastos com Gasolina	Calcula a economia nos custos com combustível devido à redução dos deslocamentos para serviços presenciais
	Gastos com Passagens	Mede a redução nos custos com transporte público devido à eliminação de deslocamentos presenciais
	Gastos com Impressão	Avalia a redução nos custos de papel, tinta e toner com a substituição de documentos físicos por digitais
	Gastos com Armazenamento	Calcula a economia nos custos de estocagem de documentos físicos pela adoção de processos digitais
	Gastos com Energia	Mede o aumento nos custos de energia devido ao uso de dispositivos eletrônicos para acessar serviços digitais
	Gastos com Internet	Analisa o aumento dos custos com internet fixa e móvel associados ao uso de canais digitais
	Gastos com Aparelhos Eletrônicos	Calcula o custo adicional com a aquisição de aparelhos celulares para acessar serviços digitais
Social	Bem-Estar Social	Mede o tempo economizado pelos cidadãos com a digitalização, expressando ganhos de bem-estar em horas
	Exclusão por limitações de letramento digital	Refere-se à parcela da população que não acessa os serviços digitais por falta de habilidades
	Redução de assimetrias	Mede a qualidade das informações disponíveis no serviço digital, por meio da proporção de avaliações positivas
	Redução de congestão urbana	Mede a redução do volume de carros em circulação decorrente da digitalização
Ambiental	Redução de uso de papel (unidades de folhas de papéis)	Significa a redução do papel consumido em função da digitalização de processos e da substituição de documentos impressos por versões eletrônicas
	Redução de árvores cortadas para produção de papel	Refere-se à diminuição do impacto ambiental relacionado ao corte de árvores para produção de papel
	Redução do uso de tinta e toner (unidades de toners de 1000 impressões)	Mede a diminuição do consumo de tinta e toner, ao transitar para soluções digitais
	Redução do consumo de CO2 (kg de CO2)	É a redução das emissões de CO2 em função digitalização, por exemplo pela redução das idas presenciais
	Aumento do gasto energético (em kWh)	Refere-se ao aumento no consumo de energia elétrica devido ao uso de tecnologias digitais, como servidores, dispositivos móveis, centros de dados, entre outros

Fonte: Elaboração própria.

3.1 Dose e tratamento: cenários

Conforme discutido, a dose depende da cobertura do serviço digital, da duração (tempo) em que o serviço é ofertado por meio de canais digitais, e varia em intensidade de acordo com o grau de digitalização de suas etapas. Além disso, a dose também é influenciada pela intensidade de uso dos serviços digitais em relação a outros canais de prestação de serviços e pela interoperabilidade. Para fins de cálculo dos impactos, os resultados são agregados para cidadãos, empresas, governo e terceiro setor.

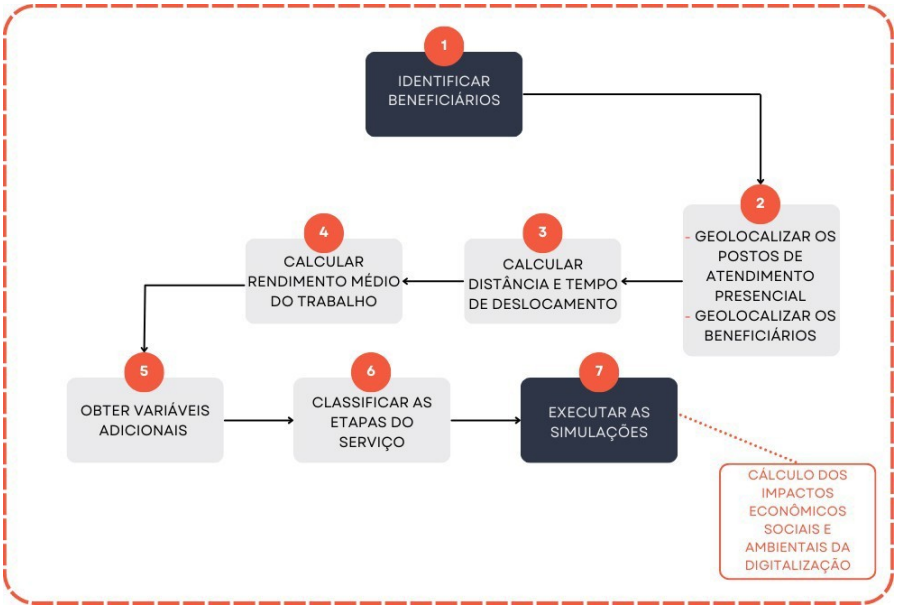
Considerando-se a ausência de informações sobre a parcela de usuários que demandam os serviços em canal digital, foram construídas duas simulações e dois cenários potenciais, que objetivam refletir o aumento da demanda por canais digitais e os benefícios da interoperabilidade.

Para efeitos das simulações foram construídas duas alternativas: A primeira simulação considera todas as etapas digitalizáveis como digitais, excluída a interoperabilidade; a segunda simulação também considera todas as etapas digitalizáveis como digitais, mas inclui a interoperabilidade, que se traduz em ganhos de tempo no preenchimento e na realização de serviços, além da otimização das etapas.

Para cada uma das simulações foram consideradas duas doses de tratamento, que refletem o percentual dos usuários do serviço por meio do canal digital, a saber: 25% e 90%. Em todos os cenários foram consideradas a intensidade máxima da digitalização e a duração, ambas para o período de um ano.

3.2 Roteiro para realização das simulações (Cookbook)

A partir de uma estrutura de etapas genéricas, o artefato possa ser aplicado a diversos serviços, com ajustes específicos conforme a disponibilidade de dados, o tipo de beneficiário e a infraestrutura de atendimento. A Figura 2 ilustra o processo que deve ser percorrido para realizar a simulação dos impactos resultantes da digitalização de um determinado serviço, em sequência são apresentados e brevemente discutidos cada um destes passos.**Figura 2 –** Roteiro para realização das simulações (Cookbook)



Fonte: Elaboração própria.

As etapas para a simulação seguem uma lógica estruturada, iniciando pela identificação dos beneficiários do serviço, que pode ser feita com base em dados cadastrais disponíveis ou, na ausência destes, a partir de listas públicas ou estimativas provenientes de fontes indiretas, como a RAIS ou cadastros administrativos. Em seguida, é necessário obter a localização dos pontos de atendimento e dos beneficiários, utilizando bases oficiais e ferramentas de geolocalização. Posteriormente, calcula-se o deslocamento necessário para o atendimento presencial, considerando distâncias e tempos estimados por ferramentas como APIs de mapas. Na sequência, utiliza-se o rendimento médio do trabalho, obtido em bases como a RAIS ou a Pesquisa Nacional por Amostra de Domicílios (PNAD-C), para calcular o salário-hora médio dos trabalhadores envolvidos no serviço.

Outras variáveis relevantes, como custos e indicadores sociais e ambientais, devem ser coletadas de acordo com a especificidade do serviço analisado. As etapas do serviço, por sua vez, são classificadas em “digitalizáveis” ou “não digitalizáveis”, identificando ganhos potenciais relacionados à redução de deslocamentos e atividades presenciais. Por fim, com base nas variáveis obtidas, são calculados os indicadores de impacto econômico, social e ambiental, ajustando as fórmulas conforme a natureza do serviço, o perfil dos beneficiários e o tipo de atendimento envolvido.

3.3 Estudos de caso

Para este artigo, apresentamos as simulações de dois serviços ofertados por órgãos federais e publicados no Portal de Serviços Federais. Os serviços escolhidos foram: “Solicitar Aposentadoria por Idade, ofertado pelo Instituto Nacional do Seguro Social (INSS)” e” Obter Passaporte, ofertado pela Polícia Federal (PF)”.

Solicitar Aposentadoria por Idade subdivide-se em quatro serviços, sendo eles: Solicitar aposentadoria por Idade Urbana; Solicitar aposentadoria por idade Rural; Solicitar aposentadoria por Idade de Pessoa com Deficiência; e Solicitar aposentadoria por Idade - Acordo Internacional. Tais serviços são ofertados pelo INSS, que objetiva conceder o benefício social a cidadãos que possuem o tempo mínimo de contribuição de trabalho e/ou idade mínima estipulada por lei. O público-alvo é composto por idosos aptos à aposentadoria, não havendo recortes de renda ou grau de instrução. O serviço possui duas etapas, sendo ambas digitalizáveis e digitais. No ano de 2023, foram concedidos 914.528 benefícios e os dados foram obtidos em nível municipal.

Obter Passaporte é um serviço destinado aos cidadãos, que desejam emitir o passaporte para realizar viagens internacionais, sendo realizado pela Polícia Federal (PF). O passaporte é um documento de viagem internacional, que identifica o viajante e pode ser utilizado por brasileiros e não-brasileiros. São seis etapas para realização do serviço, sendo que cinco delas são digitalizáveis e quatro são digitais. Em 2023 foram 2.419.986 beneficiários, na qual os dados são desagregados por UF.

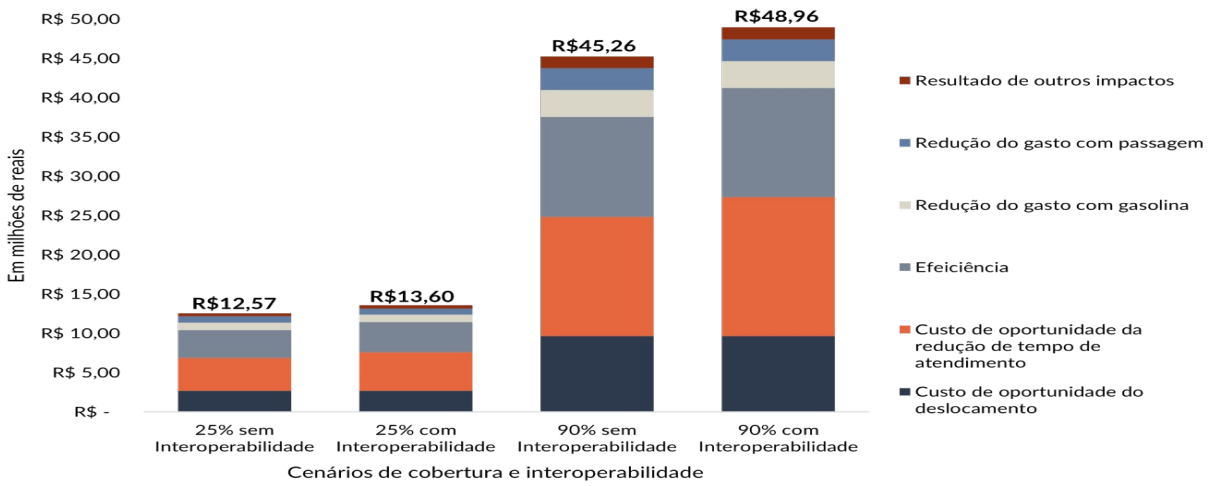
4. Resultados

4.1. Aposentadoria por idade

Os impactos econômicos foram reportados de forma agregada, a partir do somatório dos indicadores de: custo de oportunidade do deslocamento; custo de oportunidade do tempo de atendimento; eficiência; redução dos gastos com gasolina e passagem e outros impactos. A começar pelo serviço de Solicitar Aposentadoria por Idade (INSS), conforme ilustra o Gráfico 1, em um contexto com interoperabilidade, uma cobertura digital do serviço equivalente a 25%, pode gerar um impacto econômico positivo de cerca de R$13 milhões, já no cenário mais otimista, com 90% de cobertura digital, o ganho da digitalização seria superior a R$48 milhões. Na ausência de interoperabilidade os valores são próximos, porém, nos dois cenários, inferiores, indicando o benefício potencial dessa integração.

O ganho da digitalização, ao migrar de uma cobertura de 25% para uma de 90%, superou os R$ 30 milhões em ambos os cenários, com e sem interoperabilidade. Além disso, os benefícios da interoperabilidade mostram-se maiores no cenário de 90% de cobertura digital do serviço, superando 3 milhões de reais, em comparação ao cenário de cobertura digital inferior (25%), onde o ganho é de aproximadamente R$1 milhão. Adicionalmente, nota-se que os indicadores que se relacionam com ganhos de tempo, eficiência, custo de oportunidade do tempo de atendimento e custo de oportunidade do deslocamento, são os que possuem maior volume na composição do final do impacto.

Gráfico 1 – Impactos Econômicos simulados da digitalização, em diferentes cenários, do serviço Solicitar Aposentadoria por Idade, oferecido pelo INSS, em 2023



Fonte: Elaboração própria, com base nas simulações.

Os impactos sociais são compostos por indicadores que se traduzem em ganhos de bem-estar à sociedade, garantindo, por exemplo, maior equidade e inclusão no uso de plataformas digitais. É importante ressaltar que impactos sociais se diferem dos econômicos e, portanto, não se tem aqui o objetivo de quantificá-los em unidades monetárias. As horas poupadas com a digitalização dos serviços, seja por meio da redução da necessidade de deslocamento e/ou do tempo de atendimento, não necessariamente seriam despendidas em atividade laboral. O tempo ganho pode ser convertido em lazer, atividades de cuidado ou descanso, por exemplo, em todos esses casos, reduzi-lo ao ganho monetário, mostra-se limitante. Nesse sentido, os indicadores de impacto social apresentam unidades de medida diferentes, sendo eles: bem-estar social (em horas); exclusão digital, pela ausência ou insuficiência de habilidades digitais; redução de assimetrias; e redução da congestão urbana. É importante destacar que a exclusão digital possui três níveis que dependem da conjulgação de diversos fatores, como gênero, idade, perfil socio-econômico, interesse, habilidade, dentre outros Scheerder, van Deursen, van Dijk (2017),

A Tabela 1 mostra que, no cenário menos otimista, ou seja, com 25% de cobertura digital, a interoperabilidade produz um ganho para os usuários de aproximadamente 30 mil horas. Considerando-se os cenários com e sem interoperabilidade, o número de horas poupadas equivale a cerca de 370 mil horas e 400 mil horas, nesta ordem. Para o contexto mais otimista, 90% de cobertura, os ganhos com a interoperabilidade são ainda maiores, aproximando-se de 100 mil horas. Olhando-se para o montante de beneficiários excluídos digitalmente, nota-se que dos 914 mil beneficiários, quase 350 mil não possuem habilidades digitais básicas e, portanto, estão impossibilitados de utilizar o serviço em canal digital.

Sobre qualidade da informação e acessibilidade, 68% dos usuários que avaliaram o serviço, entendem que as informações disponíveis na página de acesso digital são úteis. Esse valor é acima da média dos serviços federais,

que é 46%, indicando que as informações estão bem colocadas, mas que há espaço para melhorias. Por apresentar apenas uma etapa digitalizável, em que há necessidade de deslocamento, no cenário mais otimista, quase 473 mil carros deixaram de estar na rua devido à digitalização do serviço, já no cenário de cobertura mais baixa (25%), observou-se uma redução da congestão urbana em cerca de 131 mil carros.

Tabela 1 – Impactos Sociais simulados da digitalização, em diferentes cenários, do serviço Solicitar Aposentadoria por Idade, oferecido pelo INSS, em 2023

Indicador de impacto social		**Cenário 1 – 25% de cobertura**	**Cenário 2 – 90% de cobertura**
Bem estar social - horas ganhas	Sem interoperabilidade	370 742	1.334 670
	Com interoperabilidade	399 386	1 437 789
Exclusão digital pelo Letramento Digital - Beneficiários potencialmente excluídos por falta de habilidades digitais		348 185	
Redução de assimetrias - nota de 0 a 1 da qualidade da informação do serviço		0,68	
Redução de congestão urbana - redução de carros na rua no ano pela digitalização do serviço		131 389	472 999

Fonte: Elaboração própria, com base nas simulações.

Também para os impactos ambientais, não se pretende monetizar os valores calculados. Para alguns impactos, como o aumento do gasto energético e as reduções no consumo de papel e tinta/toner, esse processo é trivial, bastando definir o preço dos produtos/serviços e, posteriormente, multiplicar pelo respectivo impacto, em unidades de kWh, folhas de papel ou toners de 1000 impressões. Para os demais indicadores, a precificação não pode ser feita de forma tão direta. Além disso, é relevante pensar no impacto dessas variáveis do ponto de vista da redução das emissões de CO2, em Kg, e do desmatamento, como o total de árvores poupadas.

Em se tratando do impacto de aumento do gasto energético, que é negativo na perspectiva ambiental, a Tabela 2 mostra que o serviço Solicitar Aposentadoria por Idade registrou um aumento de mais de 24 mil kWh, considerando-se o cenário sem interoperabilidade e com cobertura digital de 90%. Para o mesmo cenário, nota-se que a interoperabilidade promove ganhos, por meio de uma redução do gasto energético de cerca de 8 mil kWh. No cenário mais conservador, 20% de cobertura, os impactos são aproximadamente 25% dos valores em kWh, também neste caso, a interoperabilidade mostra-se benéfica.

Considerando-se o cenário de maior cobertura digital, observam-se reduções interessantes no uso de papel, com quase 3,3 milhões a menos de unidades de folhas de papéis sendo utilizados, o que resulta em cerca de 4.280 árvores, que deixariam de ser cortadas. Também se verifica uma redução no consumo de tinta/toner. Ademais, tem-se uma redução do consumo de CO2 de cerca de 880 mil kg, muito justificada pela ausência da necessidade de deslocamento.

Tabela 2 – Impactos Ambientais simulados da digitalização, em diferentes cenários, do serviço Solicitar Aposentadoria por Idade, oferecido pelo INSS, em 2023

Indicador de impacto ambiental		**Cenário 1 – Cortura de 25%**	**Cenário 1 – Cortura de 90%**
Aumento do gasto energético (em kWh)	Sem interoperabilidade	6 716	24 178
	Com interoperabilidade	4 573	16 416
Redução de uso de papel (unidades de folhas de papéis)		914 525	3 292 290
Redução de árvores cortadas para produção de papel		1 189	4 280
Redução do uso de tinta e toner (unidades de toners de 1000 impressões)		791	2 846
Redução do consumo de CO2 (kg de CO2)		244 109	878 794

Fonte: Elaboração própria, com base nas simulações.

4.2. Obter passaporte

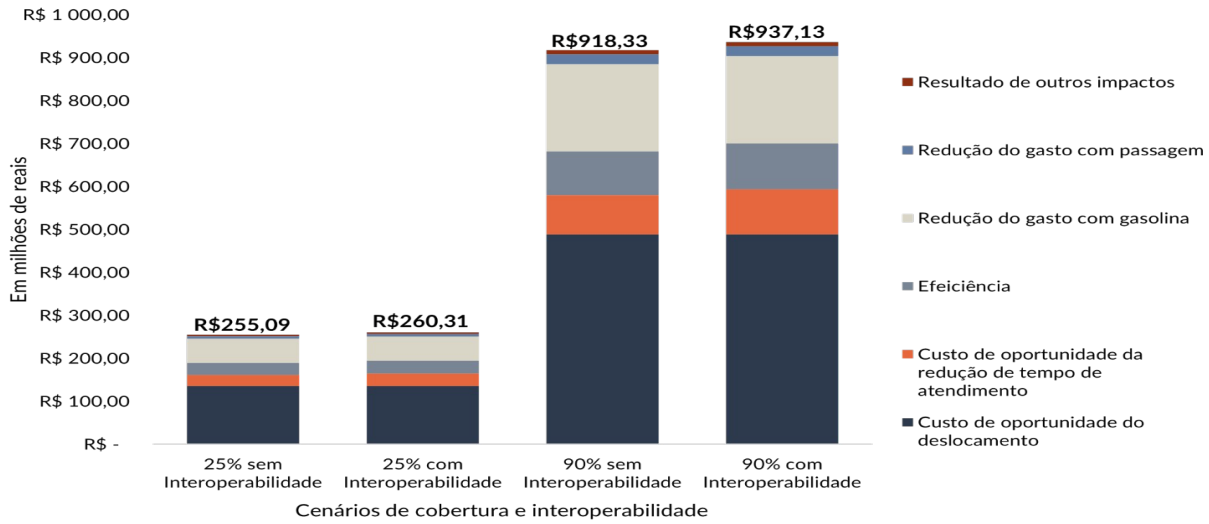
Sobre o serviço Obter Passaporte, ofertado pela PF, nota-se pelo Gráfico 2 dois aspectos fundamentais: o primeiro refere-se ao impacto econômico total ser substancialmente superior em todos os cenários simulados; o segundo é a composição deste impacto, que também diverge do serviço anterior. Nota-se que o custo de oportunidade do

deslocamento é o impacto de maior magnitude para este serviço, seguido pela redução do gasto com gasolina. Por se tratar de um serviço que apresenta um menor número de agências além de três vezes mais etapas, em comparação ao INSS, os custos associados ao deslocamento impulsionam de forma expressiva o impacto econômico total.

No contexto mais otimista, com 90% de cobertura digital, o impacto econômico é de R$918 milhões e R$937 milhões, considerando-se os cenários sem e com interoperabilidade, respectivamente. Nesse sentido, os ganhos econômicos da interoperabilidade são de cerca de R$19 milhões. Em relação ao cenário mais conservador, ou seja, com menor cobertura (25%), nota-se uma diferença que se aproxima dos R$700 milhões, havendo um ganho de interoperabilidade de aproximadamente R$5 milhões.

Um aspecto relevante é que se trata de um serviço pago. Caso for segmentado os impactos para os beneficiários e para a administração pública, a taxa de serviço deve ser levada em conta. Sendo assim, haveria uma redução do impacto econômico para os beneficiários e um aumento para a administração pública. Como exemplo, no cenário mais otimista, haveria um gasto de aproximadamente R$560 milhões com pagamento da taxa do serviço, contudo, o impacto aos beneficiários ainda assim seria positivo, aproximadamente R$260 milhões, sendo em média R$118,96 de benefício econômico. Já para a administração pública, haveria um ganho total de aproximadamente R$680 milhões.

Gráfico 2 – Impactos Econômicos simulados da digitalização, em diferentes cenários, do serviço Obter Passaporte, oferecido pela PF, em 2023



Fonte: Elaboração própria, com base nas simulações.

Além dos maiores ganhos econômicos, o serviço também apresentou maiores ganhos sociais, conforme se verifica na Tabela 3. Com a cobertura igual a 25% e sem interoperabilidade, há ganhos de mais de 8,6 milhões de horas, que podem ser convertidas em bem-estar social. Já no cenário de 90% de cobertura, os ganhos superam 31 milhões de horas. Mantendo-se a ordem dos cenários, a interoperabilidade gerou impactos positivos de cerca de 200 mil e 600 mil horas. Apesar de relevantes os ganhos com a interoperabilidade, cumpre destacar que o serviço Obter Passaporte, por ter muitas etapas e poucos postos de atendimento para realização do serviço, em termos relativos, apresenta o maior ganho de tempo associado à ausência de necessidade de deslocamento.

Adicionalmente, há uma redução da congestão urbana no cenário de 25% de cobertura que supera 1 milhão de carros, e que se aproxima dos 4 milhões de carros no cenário com 90% de cobertura digital do serviço. As informações mostram-se relativamente bem avaliadas, com 66% dos usuários avaliando que elas foram úteis. Por outro lado, cerca de 850 mil beneficiários estariam excluídos do uso digital desse serviço, em função da ausência ou de limitações no letramento digital.

Tabela 3 – Impactos Sociais simulados da digitalização, em diferentes cenários, do serviço Obter Passaporte, oferecido pela PF, em 2023

Indicador de impacto social		**Cenário 1 –**	**Cenário 2 –**
		Cobertura de 25%	**Cobertura de 90%**
Bem estar social - horas ganhas	Sem interoperabilidade	8 632 184	31 075 862
	Com interoperabilidade	8 808 641	31 711 108

Exclusão digital pelo Letramento Digital - Beneficiários potencialmente excluídos por falta de habilidades digitais	851 498	
Redução de assimetrias - nota de 0 a 1 da qualidade da informação do serviço	0,66	
Redução de congestão urbana - redução de carros na rua no ano pela digitalização do serviço	1 079 129	3 884 864

Fonte: Elaboração própria, com base nas simulações.

Por último, conforme reportado na Tabela 4, o serviço Obter Passaporte também apresentou os maiores impactos ambientais simulados, bem como econômicos e sociais. Isso ocorre por se tratar de um serviço que apresenta três vezes mais etapas que os demais e cuja distância que o beneficiário precisa percorrer para chegar a uma agência prestadora é, em média, maior.

Sobre o gasto energético, notam-se diferenças substanciais, advindas da interoperabilidade, considerando-se os cenários 1 e 2, os valores aproximam-se dos 11 mil kWh e 40 mil kWh, respectivamente. Mais uma vez a integração dos serviços apresenta um impacto ambiental relevante. Cerca de 22 milhões de folhas de papel deixariam de ser utilizadas e mais de 28 mil árvores seriam preservadas graças à digitalização dos processos. Ademais, também se observam reduções nos gastos com tinta/toner e nas emissões de CO2, que reduzem em mais de 14 milhões de Kg no cenário 1 e quase 53 milhões de Kg no cenário 2, em função da redução das necessidades de deslocamento.

Tabela 4 – Impactos Ambientais simulados da digitalização, em diferentes cenários, do serviço Obter Passaporte, oferecido pela PF, em 2023

Indicador de impacto ambiental		**Cenário 1 – Cobertura de 25%**	**Cenário 2 – Cobertura de 90%**
Aumento do gasto energético (em kWh)	Sem interoperabilidade	36 965	133 075
	Com interoperabilidade	25 168	90 604
Redução de uso de papel (unidades de folhas de papéis)		6 049 965	21 779 874
Redução de árvores cortadas para produção de papel		7 865	28 314
Redução do uso de tinta e toner (unidades de toners de 1000 impressões)		6 050	21 780
Redução do consumo de CO2 (kg de CO2)		14 676 551	52 835 582

Fonte: Elaboração própria, com base nas simulações.

5. Discussão

Os resultados apresentados mostram que a implementação do governo digital no Brasil possui impactos expressivos em termos econômicos, sociais e ambientais. As simulações indicam que avanços na digitalização dos serviços públicos podem gerar impactos ambientais relevantes, sobretudo a partir de reduções do desmatamento e das emissões de CO2. Destaca-se que existe uma contrapartida da emissão de gases de efeito estufa que, apesar de não ter sido considerada nas simulações, mostra-se importante. Trata-se de uma tendência de aumento das emissões em função da maior necessidade de armazenamento de dados e de uso de aparelhos tecnologicamente mais potentes. Nesse sentido, mesmo diante das limitações, destaca-se que a digitalização tem potencial para contribuir com políticas de transição verde.

O artefato apresentado oferece algumas possibilidades de aperfeiçoamento, que podem ser exploradas em desenvolvimentos futuros. A começar pelo rendimento médio cujo recorte dá-se apenas por Unidade Federativa (UF), sendo possível a inclusão de outras variáveis do público-alvo dos serviços, como idade, sexo e renda, especialmente para serviços voltados à população mais vulnerável. Outra possibilidade é o cálculo do rendimento médio para eficiência, levando em conta o salário médio-hora dos órgãos federais que oferecem o(s) serviço(s) em análise, que pode ser viabilizado a partir dos dados da RAIS. Pode-se calcular ainda o rendimento médio da produtividade para os serviços destinados a empresas, governos ou terceiro setor, também com base nos dados da RAIS. Em todos os casos, a obtenção de um impacto mais desagregado mostra-se interessante para se pensar o planejamento de políticas ou de avaliações direcionadas a públicos específicos.

O tempo de atendimento na realização dos serviços é outro aspecto que oferece oportunidades para melhorias. É possível, por exemplo, segmentar os serviços de acordo com o público-alvo, isso porque serviços voltados à população mais idosa e carente podem ter ganhos de tempo menores com a digitalização em comparação com serviços voltados à população de alta renda e em idade ativa. Além disso, a complexidade do serviço também pode influenciar no ganho de tempo, sendo necessário mapear as etapas do atendimento antes da digitalização para prever melhor tais mudanças. No que diz respeito à distância percorrida, seria possível diferenciar o tempo de deslocamento de acordo com o modal de transporte. No entanto, o tipo de transporte pode variar conforme as

diferentes regiões e classes sociais. Considerar esses elementos aumenta a complexidade do modelo, mas também assegura maior precisão nas simulações.

Em relação ao custo e à sustentabilidade da digitalização, alguns pontos também merecem atenção. O preço da passagem utilizado nas simulações refere-se apenas ao transporte intraurbano, o que pode não refletir a realidade de municípios menores ou de deslocamentos intermunicipais. Nesse caso, seria necessário a construção de uma base de dados detalhada sobre as tarifas de ônibus intermunicipais. O consumo de energia de dispositivos móveis ao utilizar serviços digitais também precisa ser melhor explorado. O custo de armazenagem e processamento em máquinas TIC, a segurança cibernética e a produção de lixo eletrônico não foram abordadas neste estudo. Contudo, esses aspectos são fundamentais para uma compreensão mais ampla e detalhada dos impactos gerados pela digitalização dos serviços públicos.

Se vislumbra como possibilidade de evolução e por conseguinte novos trabalhos futuros relacionados a metodologia de mensuração de impacto de Governo Digital, questões como a avaliação, adoção e uso do cidadão (*demand side*), avaliação de impactos do governo digital na agenda 2030, uma maior automação da medição e a adoção de inteligência artificial na ferramenta, juntamente com avaliação da aplicação de tecnologias emergentes, a avaliação de múltiplos canais de entrega de serviços, dentre outros. Oportunamente há interações iniciais com a Divisão de Administração Pública das Nações Unidas e com a Escola Nacional de Administração Pública com vistas a uma maior aplicação em serviços públicos, bem como evolução da metodologia e de seu artefato.

6. Considerações Finais

Em se tratando da proposta metodológica, cumpre destacar o caráter inovador, com o desenvolvimento de um instrumento capaz de avaliar os impactos econômicos, sociais e ambientais da iniciativa, considerando diferentes segmentos da sociedade, a saber: cidadãos, empresas, terceiro setor e governo. Além disso, esse artefato demonstra sua versatilidade ao ser aplicável a diferentes serviços públicos digitais, conforme evidenciado nos estudos de caso.

Além disso, é importante ressaltar que, apesar do esforço dedicado à busca de informações em diferentes bancos de dados secundários, indicadores relevantes acabaram não sendo incorporados devido à indisponibilidade, dificuldades de acesso à base de dados ou ausência de dados, que compromete a factibilidade prática dos mesmos. Um exemplo disso é a ausência de indicadores de impacto associados ao custo de armazenagem e de processamento em máquinas TIC, lixo eletrônico, cidadania, transparência/accountability, entre outros.

Referências

Arretche, M. (2013). Tendências no estudo sobre avaliação de políticas públicas. **Terceiro Milênio: Revista Crítica de Sociologia e Política, 1**(1), 126-133.

Avotra, A. A. R. N., et al. (2021). Examining the impact of e-government on corporate social responsibility performance: The mediating effect of mandatory corporate social responsibility policy, corruption, and information and communication technologies development during the COVID era. **Frontiers in Psychology, 12**, 737100. https://doi.org/10.3389/fpsyg.2021.737100.

Balbe, R. S. (2010). Uso de tecnologias de informação e comunicação na gestão pública: Exemplos no governo federal. ***Revista Do Serviço Público***, *61*(2), p. 189-209. https://doi.org/10.21874/rsp.v61i2.45.

Banco Interamericano de Desarrollo. (2017). **Herramienta para la estimación de impacto de iniciativas eGovernment (eGovImpact): Marco metodológico de medición de impacto**. Santiago.

Banco Mundial. (2023). **G20 policy recommendations for advancing financial inclusion and productivity gains through digital public infrastructure**. Global Partnership for Financial Inclusion.

Barbosa, A., Pozzebon, M., & Diniz, E. (2013). Rethinking e-government performance assessment from a citizen perspective. **Public Administration, 91**(3), 744-762. https://doi.org/10.1111/padm.12029.

Bateman, I., et al. (2002). **Economic valuation with stated preference techniques: A manual**. Edward Elgar.

Bia, M., & Mattei, A. (2008). A Stata package for the estimation of the dose-response function through adjustment for the generalized propensity score. **The Stata Journal, 8**(3), 354-373.

Brasil. (2016). **EGD - Estratégia de Governança Digital da Administração Pública Federal 2016-19.** https://www.gov.br/governodigital/pt-br/estrategia-de-governanca-digital/historico.

Brasil. (2020). Impactos Econômicos das Ações de Interoperabilidade Implementadas pelo Programa CONECTAGOV, 2020. https://www.gov.br/governodigital/pt-br/infraestrutura-nacional-de-dados/interoperabilidade/conecta-gov.br/impactos-conectagov-2.pdf.

Brasil. (2021). **Lei nº 14.129, de 29 de março de 2021, que dispõe sobre princípios, regras e instrumentos para o**

Governo Digital. https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/l14129.htm.

Brasil. (2025). Linha do tempo governo digital. https://www.gov.br/governodigital/pt-br/estrategia-de-governanca-digital/do-eletronico-ao-digital.

Chen, H.-T., & Rossi, P. (1983). Evaluating with sense: The theory-driven approach. **Evaluation Review, 7**(3), 283-302. https://doi.org/10.1177/0193841X830070030.

Dhaoui, I. (2022). E-government for sustainable development: Evidence from MENA countries. **Journal of the Knowledge Economy, 13**, 2070-2099. https://doi.org/10.1007/s13132-021-00829-6.

Diniz, E. H. (2009). O governo eletrônico no Brasil: Perspectiva histórica a partir de um modelo estruturado de análise. **Revista de Administração Pública, 43**(1), 23-48.

Fan, M., et al. (2022). The effects of e-government efficiency on subjective wellbeing. **Frontiers in Psychology, 13**, 768540. https://doi.org/10.3389/fpsyg.2022.768540.

Gan, T., Zhang, M., & Zhang, Z. (2023). The impact of digital government policy on entrepreneurial activity in China. **Economic Analysis and Policy, 79**, 479-496. https://doi.org/10.1016/j.eap.2023.07.009.

Gupta, M., & Jana, D. (2003). E-government evaluation: A framework and case study. **Government Information Quarterly, 20**(4), 365-387.

Han, H., Wu, T., Hai, C., & Zhou, N. (2023). The impact of e-government on air quality: New evidence from China. **Frontiers in Environmental Science**.

Heidlund, M., & Sundberg, L. (2022). Evaluating e-government: Themes, trends, and directions for future research. **First Monday.**

Janowski, T. (2015). Digital government evolution: From transformation to contextualization. **Government Information Quartely**. 32(3), 221–236.

Luna, D. E., et al. (2024). Creating public value through digital service delivery from a citizen's perspective. **Government Information Quarterly, 41**(2), 101928. https://doi.org/10.1016/j.giq.2023.101928.

Marinho, M. Challenges in citizens' digital interaction with the State: a scale to measure administrative burden. **Revista do Serviço Público**, v. 74, n. 3, p. 591-612, 2023.

Mettler, T.; Miscione, G.; Jacobs, C.; Guenduez, A. Same same but different: How policies frame societal-level digital transformation. Government **Information Quarterly,** v. 41, n. 2, p. 101932, 2024.

Misuraca, G. (editor), Codagnone, C.; Liva, G.; Barcevičius, E.; Misuraca, G.; Klimavičiūtė, L.; Benedetti, M.; Vanini, I.; Vecchi, G.; Ryen, E.; Stewart, K.; Hoorens, S.; Gunashekar, S. **Assessing the impacts of digital government transformation in the EU-Conceptual framework and empirical case studies.** Publications Office of the European Union, p. 12-67, 2020.

OCDE. (2018). **Digital government review of Brazil: Towards the digital transformation of the public sector.** https://doi.org/10.1787/9789264307636-en.

ONU. (2023). **Accelerating the SDGs through digital public infrastructure: A compendium of the potential of digital public infrastructure.**

UNESCO:UNESCO thesaurus. UnescoThesaurus.[Online].Available http://vocabularies.unesco.org/thesaurus/concept17004. Acessado em 31/01/2025.

Organização das Nações Unidas. (2021). **Addressing the digital divide: Taking action towards digital inclusion.** https://unhabitat.org/programme/legacy/people-centered-smart-cities/addressing-the-digital- divide.

Patil, G. P; et al (2008). "Geoinformatics of Hotspot Detection and Prioritization for Digital Governance" in Chen, H; Brandt, L; Gregg, V; et al. (Eds). **Digital Government: E-Government Research, Case Studies, and Implementation** Volume 17 de Integrated Series in Information Systems Springer Science & Business Media, 2008. ISBN 0387716114, 9780387716114.

Peters, R.; Janssen, M.; Van Engers, T. Measuring e-government impact: existing practices and shortcomings. In: **Proceedings of the 6th international conference on Electronic commerce**, p. 480-489, 2004.

Scheerder, A., van Deursen, A., & van Dijk, J. (2017). Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. **Telematics and Informatics**, 34(8), 1607–1624. https://doi.org/10.1016/J.TELE.2017.07.007

Inteligência artificial como apoio à tomada de decisão no setor público.

Camila Taciana Sandrini [a], Taiane Ritta Coelho [b], Milton Cesar Adriao[c], Edelvino Razzolini Filho[d].

[a] Universidade Federal do Paraná, Paraná, Brasil, camila.sandrini@ufpr.br, ORCID 0009-0002-7780-7307.

[b] Universidade Federal do Paraná, Paraná, Brasil, taianecoelho@ufpr.br, ORCID 0000-0003-2607-0704.

[c] Faculdade Estácio de Curitiba, Paraná, Brasil milton.adriao@gmail.com, ORCID 0000-0001-9390-1307.

[d] Universidade Federal do Paraná, Paraná, Brasil, razzolini@ufpr.br, ORCID 0000-0002-6920-9502.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Resumo: O artigo apresenta uma Revisão Sistemática da Literatura sobre a adoção de soluções de inteligência artificial (IA) como ferramenta de apoio à tomada de decisão na administração pública, destacando como essa tecnologia pode contribuir para modernizar os processos de gestão governamental. O levantamento de 38 artigos sobre inteligência artificial aplicada à tomada de decisão destaca sua versatilidade em diversas áreas, incluindo governança, serviços sociais, saúde, meio ambiente, justiça e orçamento público. Na governança, enfatizam-se a transparência, a explicabilidade e a supervisão humana, essenciais para decisões automatizadas confiáveis. Serviços sociais enfrentam desafios éticos, como impactos no bem-estar dos trabalhadores e desumanização do atendimento. Na saúde, IA otimiza cadeias de suprimentos e resposta a crises, enquanto na justiça, melhora a análise de dados e a prevenção de crimes. Na operação de sistemas de energia e em sistemas ambientais o foco está na eficiência e precisão. Embora a inteligência artificial tenha um enorme potencial para transformar a gestão pública, seu uso requer uma análise criteriosa de questões éticas, governança e transparência. Problemas como viés algorítmico e ausência de supervisão reforçam a importância de regulamentações adequadas e de diferentes abordagens que integrem a tecnologia com a supervisão humana.

Palavras-chave: Processo Decisório. Informação. Tratamento de dados. Gestão de processos. Governança.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.997

1. Introdução

A administração pública enfrenta desafios cada vez mais complexos, impulsionados pelas mudanças sociais e econômicas e pela necessidade de oferecer serviços mais eficientes e acessíveis. A recente disseminação de soluções de inteligência artificial generativa deu renovado impulso às discussões sobre o uso de soluções baseadas em IA na administração pública, para modernizar os processos de gestão governamental (Pereira *et al.*, 2021),

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

reduzindo custos e tornando-os mais eficientes e acessíveis (Brynjolfsson; McAfee, 2014) (O'Reilly, 2010) e, assim, atender melhor aos cidadãos, o que fortalece a confiança na governança (Denhardt & Denhardt, 2015).

Em 2021 foi lançada a Estratégia Brasileira de Inteligência Artificial e seus eixos temáticos, com a expectativa de permitir "que o Estado supere obstáculos burocráticos e restrições orçamentários para oferecer serviços novos, melhores e mais eficientes à população" (MCTI, 2021, p. 41). Em 2024 foi lançado o Plano Brasileiro de Inteligência Artificial (PBIA) 2024-2028 (Governo Federal do Brasil, 2024), enfatizando investimentos em infraestrutura, qualificação e avanços tecnológicos em área de IA. Essas iniciativas reforçam a necessidade de entender as funcionalidades e os impactos dessas ferramentas na administração pública em diferentes contextos, minimizando os impactos negativos de decisões equivocadas, que podem comprometer recursos, desperdiçar oportunidades, falhar em responder a ameaças ou não alcançar objetivos específicos (Maximiano, 2020). Ainda assim, as pesquisas sobre IA no governo ainda são escassas (de Sousa et al., 2019). Conforme Sampaio et al. (2024, p. 47), "é indispensável um esforço conjunto da comunidade científica nacional para questionar e superar os paradigmas tecnológicos e científicos estabelecidos". Para preencher este gap, esta pesquisa investiga as potencialidades, usos e desafios relacionados com a implantação de soluções baseadas em IA como uma ferramenta de apoio à tomada de decisão no setor público. Neste artigo, entendemos "tomada de decisão" o processo cognitivo e organizacional de escolha entre alternativas, que pode ser influenciado — ou mesmo substituído — por sistemas algorítmicos. Para tanto, foi realizada em revisão sistemática de literatura. Os resultados apontados contribuem para o entendimento de como as funcionalidades de IA auxiliam a gestão pública a se transformar em um ambiente mais dinâmico, transparente e inovado, mas também apontam os desafios e limitações relacionados à incorporação de tais tecnologias, aspectos muitas vezes negligenciados em estudos que privilegiam a eficiência técnica. A originalidade reside na articulação entre fundamentos filosóficos e práticos, oferecendo uma perspectiva crítica integradora ainda pouco explorada na literatura.

Na sequência é apresentada a revisão teórica e o percurso metodológico. Em seguida apresentam-se e discutem-se os resultados. Por fim, apresentam-se as conclusões do trabalho.

2. Tomada de decisão e inteligência artificial

A tomada de decisão em organizações requer uma abordagem estruturada para garantir escolhas bem fundamentadas e alinhadas aos objetivos estratégicos. De acordo com Simon (1997), o ciclo inicial do processo decisório é composto por etapas que envolvem a identificação do problema ou oportunidade, a coleta de informações, sua análise detalhada e a definição de alternativas para solucionar a questão. Souza e Brito (2024) propõe o Ciclo 1 - Pré-tomada de decisões, que aborda etapas para embasar decisões estratégicas. Inicialmente, é necessário compreender a situação atual, avaliando pontos positivos e negativos para definir ações corretivas ou preventivas. Em seguida, ocorre a coleta de informações qualitativas e quantitativas de diversas fontes, garantindo uma visão abrangente do problema. Essas informações são analisadas para identificar padrões, tendências e desvios que fundamentem as decisões. Com base nas análises, são propostas alternativas inovadoras, utilizando ferramentas tecnológicas, como sistemas de análise de dados e simulações, para explorar cenários e facilitar a compreensão das ações planejadas.

Na investigação sobre a influência da inteligência artificial no setor público, Silva, Silva e Rabêlo (2021) chegam à mesma conclusão, destacando que existem diversas maneiras de aplicar as ferramentas de inteligência artificial na administração pública, como interfaces de usuário, interação humano-computador para tarefas repetitivas como entrada de dados, agentes virtuais (como chatbots e avatares), análise preditiva baseada em machine learning, visualização de dados e softwares integrados a big data para análises avançadas.

Denhardt e Denhardt (2015) reiteram que a administração pública deve focar no serviço ao cidadão, enfatizando que decisões eficazes melhoram diretamente a qualidade dos serviços e fortalecem a confiança na governança. Brynjolfsson e McAfee (2014) citam que as tecnologias digitais têm permitido aos governos diminuírem os custos operacionais enquanto aprimoram a qualidade dos serviços prestados e aumentam a eficiência em suas atividades.

3. Procedimentos metodológicos

Para esta pesquisa foi adotada uma abordagem qualitativa por meio de uma Revisão Bibliográfica Sistemática (RBS), cujas etapas de entrada (definição do problema e *strings* de busca), processamento (aplicação de critérios de inclusão e filtros) e saída (análise de dados e síntese dos resultados) promovem uma análise rigorosa e sistemática, que é essencial para garantir a qualidade e a relevância dos resultados obtidos (Conforto et al., 2011). A pergunta que orientou esta RBS foi: Como a inteligência artificial está sendo utilizada na tomada de decisão pública?

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Os artigos foram pesquisados na base de dados Web Of Science, em novembro de 2024. A estratégia de busca contemplou os seguintes termos: (TS=("artificial intelligence") AND TS=("smart cit*" OR "government" OR "public sector" OR "public policy" OR "public administration") AND TI=("decision making")) AND (DT==("ARTICLE" OR "PROCEEDINGS PAPER")), considerando o período de 2019 a 2024. Foram utilizados termos em inglês para ampliar o alcance da pesquisa, considerando que mesmo artigos originalmente escritos em outros idiomas trazem título, resumo e palavras-chave nesse idioma.

Foram recuperados 66 artigos. As informações sobre os textos foram consolidadas em uma única planilha e organizados no software Microsoft Excel. Os títulos e resumos dos artigos foram lidos e avaliados. Um artigo foi excluído por ter sido retratado. Mais vinte e sete artigos foram excluídos, onze por não abordarem o tema de administração pública, treze por não disponibilizarem o texto completo e três por não abordarem inteligência artificial. Assim, o corpus da revisão contém 38 artigos, que foram lidos integralmente. O fluxograma da metodologia empregada pode ser visualizado na figura 1.

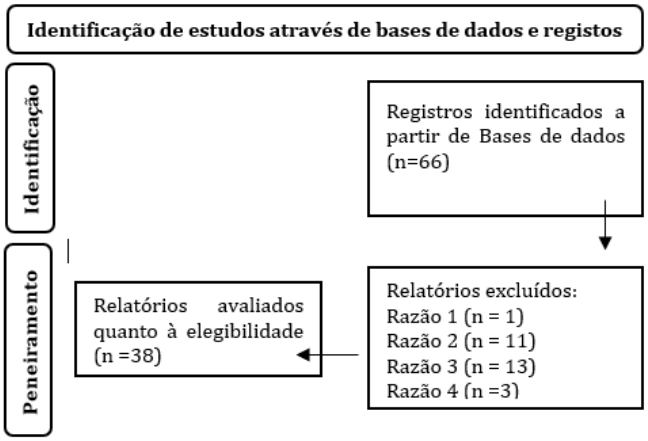


Figura 1 – Fluxograma da metodologia empregada.
Fonte: Os autores.

Os dados coletados permitiram análises quantitativas descritivas para identificar a distribuição de publicações ao longo de período. A leitura integralmente dos 38 artigos do corpus, apoiada pela técnica de análise de conteúdo (Bardin, 2010) permitiu identificar padrões, temas e categorias relevantes nos artigos.

4. Apresentação e análise dos resultados

A Figura 2 apresenta a evolução temporal dos 38 estudos selecionados. O estudo mais antigo é do ano de 2019, enquanto o mais recente é de 2024, abrangendo um período de seis anos de produção científica sobre o tema.

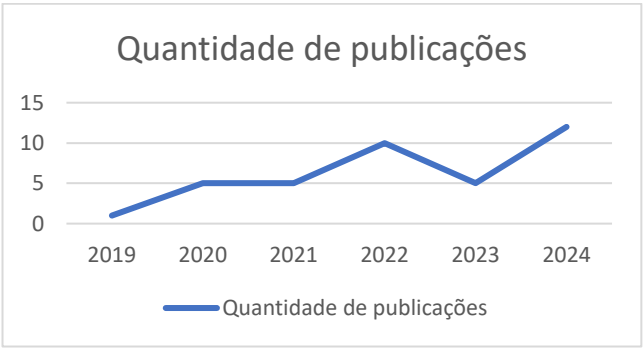


Figura. 2 Quantidade de publicações por ano.

Fonte: Os autores.

Na análise da evolução temporal das publicações, conforme figura 2, parece existir uma tendência de crescimento no número de publicações. O primeiro ano do período analisado, 2019, apresentou um número inicial modesto de apenas 1 publicação, seguido por um crescimento em 2020, com 5 publicações. Em 2021, manteve a quantidade, com 5 publicações, enquanto em 2022 atingiu 10 publicações. No entanto, em 2023, houve uma queda, com apenas 5 publicações, e em 2024 atingiu 12 publicações. Esses dados, mesmo com oscilações, sugerem uma tendência de

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

crescimento no interesse pela temática, evidenciada pelos picos em 2022 e 2024, indicando que o tema permanece relevante e ativo na literatura científica.

Quanto ao uso de IA para a tomada de decisão, identificou-se que ela tem sido aplicada em diferentes setores da administração pública. A tabela 1 sintetiza as principais informações dos artigos analisados, destacando a área de atuação e as respectivas funcionalidades ou funções, permitindo uma visão panorâmica dos usos.

Tabela 1 –Áreas de atuação e funcionalidades.

Área de Atuação	Funcionalidades/Função	Autores
Políticas Públicas, Cidades Inteligentes	Apoio à decisão política baseada em evidências tomada de decisão.	Mills et al. (2022).
Cidades Inteligentes	Tomada de decisão inteligente; Métodos de decisão aplicados em projetos de cidades inteligentes; Governança inteligente e decisão mediada por IA; Inovação social; Avaliação do impacto de respostas automatizadas na decisão cidadão.	Tayeb et al. (2024); Giang et al. (2019); Bokhari & Myeong (2022; 2023); Wang et al. (2024).
Redes e Telecomunicações	Decisão para redes autônomas em 6G e IoT.	Liu et al. (2021).
Governança	Apoio à decisão pública integrando IA e multidões; Análise da tomada de decisão algorítmica em serviços públicos; Estratégias para explicação da decisão algorítmica; Governança e desafios da IA no setor público; Transparência algorítmica e confiança nas decisões automatizadas.	Liu et al. (2020); Frost (2024); de Bruijn et al. (2022); Kuziemski & Misuraca (2020); Janssen et al. (2022); Grimmelikhuijsen (2023); Warthon (2024) .
Setor Público	Modelo integrado para decisões sustentáveis no setor público, Ferramenta para suportar decisões; Estruturas responsáveis para IA no setor público.	Wilson & van der Velden (2022), Fischer-Abaigar et al. (2024); Hirvonen (2024).
Administração Pública	Desafios na transição para gestão sem papel com IA; Automação; Suporte à decisão algorítmica e a gestão de trabalhadores; Interação humano- IA e viés de automação.	Gelashvili & Pappel (2021); Monarcha-Matlak (2021); Doring et al. (2024); Alon-Barkat & Busuioc (2023).
Governo	Uso de IA para aprimorar a tomada de decisão; Decisão racional em e-Gov.	Di Vaio et al. (2022); Salem et al. (2024).
Psicologia	Percepção cidadã da IA em decisões governamentais.	Ingrams et al. (2021).
Serviços Sociais	Discrição digital; Mapeamento de decisões automatizadas.	Ranerup & Henriksen (2022); Sleep (2024).
Meio Ambiente	Aplicação de IA para decisões baseadas em evidências ambientais; Gestão de danos causados por inundações.	Choi et al. (2021); Zabihi et al. (2023).
Energia	Gestão energética; Modelagem de desempenho energético.	Ban (2020); Seyedzadeh et al. (2020).
Saúde	Cadeias de suprimentos; Pandemia.	Virmani et al. (2024); Deveci (2023); Mourby (2020); Guo et al. (2022).
Finanças	Orçamento governamental; Processos de recuperação de dívidas.	Valle-Cruz et al. (2022); Rinta-Kahila et al. (2022).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Direito	Impacto da IA nas decisões jurídicas.	Kolkman et al. (2024).
Segurança Pública	Sistemas inteligentes para prevenção de crimes.	Choi et al. (2024).

Seis artigos abordam métodos para a tomada de decisão inteligente. Mills et al. (2022) discutem a tomada de decisão baseada em evidências para políticas públicas, explorando como a teoria existente contribui para a sustentabilidade urbana, os autores também complementam que uma tomada de decisão mais eficiente, inclusiva e cooperativa é um componente essencial das definições e das práticas implementadas em cidades inteligentes. Já Tayeb et al. (2024) destacam um modelo mediado por IA focando em como a tecnologia pode aprimorar a tomada de decisões inteligentes em cidades através de abordagens analíticas. Os autores utilizam a teoria cognitiva social e a teoria do medo integrado para investigar como o uso de IA impacta a tomada de decisões inteligentes.

Giang Tran et al. (2019) realizaram uma revisão sistemática dos métodos aplicados em projetos de cidades inteligentes: "os métodos de tomada de decisão foram classificados em quatro grupos: tomada de decisão multicritério (MCDM), programação matemática (MP), inteligência artificial (IA) e métodos integrados (MI)" (Giang Tran et al., 2019, pg 434). Os autores concluem que "MCDM é um método popular em todos os níveis de tomada de decisão e em todos os estágios de projetos de cidades inteligentes. Enquanto isso, MP e IA são amplamente usados para tomar decisões operacionais e táticas" (Giang Tran et al., 2019, pg 444). Já Bokhari e Myeong (2022) enfocam o uso da IA como uma perspectiva de inovação social para promover decisões mais eficazes.

Wang et al. (2024) trazem um diferencial ao analisar a interação entre cidadãos e decisões automatizadas, investigando as respostas automatizadas em contatos iniciados por usuários. Este trabalho diferencia sistemas de IA baseados em regras e em aprendizagem, analisando também fatores contextuais como percepção do governo, canais de comunicação, propósito do contato e a complexidade ou urgência do tema do lado do cidadão. Liu et al. (2021), que também analisam a tomada de decisão inteligente, exploram redes de 6G auto evolutivas, destacando como estas podem possibilitar decisões automatizadas em larga escala no contexto de IoT massivo, que "consiste em cidade inteligente, agricultura digital, tráfego inteligente, etc." (Lui et al. 2021, pg 1).

Monarcha-Matlak (2021) trata da tomada de decisão automatizada na administração pública, evidenciando os desafios e as vantagens desse processo. Dentre as preocupações mencionadas por este trabalho diz respeito aos algoritmos empregados em decisões administrativas, que devem passar por monitoramento, revisão e validação contínuos por funcionários da administração pública, garantindo supervisão humana no processo. A mesma preocupação pode ser observada no estudo de caso de Rinta-Kahila et al. (2022), que analisaram os impactos negativos da automação em processos de cobrança de dívidas destacando como a transferência de responsabilidades para os cidadãos e a redução da supervisão humana resultaram em decisões algorítmicas imprecisas e prejudiciais. Eles explicam que o sistema automatizado enviava notificações de dívidas sem revisão, gerando consequências adversas para cidadãos, funcionários e o governo, incluindo perda de confiança pública e prejuízos financeiros. Esse caso evidencia os riscos éticos e morais de decisões financeiras automatizadas e acabou levando à suspensão do programa analisado.

Na área de governança, há uma crescente preocupação com a aplicação sustentável da inteligência artificial, levando em consideração desafios éticos e sociais. Bokhari e Myeong (2023) citam que "para utilizar as vantagens dos sistemas de IA e IoT para tomada de decisão inteligente, os governos municipais devem ter a confiança para realmente aceitá-los", e ainda complementam que governança inteligente é fundamental para gerenciar dados, promover transparência e garantir que as decisões automatizadas estejam alinhadas com os interesses públicos. Wilson e van der Velden (2022), por sua vez, propõem um modelo integrado para a aplicação sustentável da IA na governança pública, apresentando cinco condições de contorno para IA sustentável que o setor público deve almejar: i) diversidade e inclusão; ii) capacidade de aprendizado, transparência e explicabilidade; iii) capacidade de auto-organização, agência e responsabilização; iv) significado comum e valores incorporados; e v) confiança sistêmica e implícita. Kuziemski e Misuraca (2020) analisaram três estudos de casos, examinando a governança de IA em ambientes democráticos, abordando as tensões entre automação e supervisão humana, considerando que um modelo eficaz de governança de IA precisa garantir transparência, responsabilidade e supervisão contínua, particularmente no uso de sistemas de tomada de decisão automatizada no setor público. Liu, Tang e Chen (2020) abordam a governança como um processo participativo e inclusivo, destacando a integração da inteligência artificial com a inteligência coletiva das multidões, combinação que permite o uso de mecanismos de engajamento público para fortalecer a governança democrática, promovendo decisões que refletem de forma mais ampla os interesses e necessidades da sociedade.

Outro tema citado nos artigos é transparência e responsabilidade, englobando aspectos legais, técnicos e éticos, como responsabilização, auditoria, confiabilidade, explicabilidade, publicidade de atos, mitigação de vieses e direito de acesso. Hirvonen (2024) aborda os desafios e propostas para responsabilização e segurança no uso de sistemas de decisão automatizada (ADM) no setor público, e complementa que regras legais podem promover seu

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

uso seguro. Ingrams, et al. (2021) exploram percepções cidadãs sobre o uso de IA na tomada de decisão governamental, enfatizando o papel da confiança. Grimmelikhuijsen (2023) descobriu que o efeito do fato de o tomador de decisão ser um humano ou uma IA na confiança é significativo em todas as dimensões da confiança, o que mostra que um tomador de decisão humano é percebido como mais confiável para executar tal decisão em termos de competência, honestidade e benevolência. Esses autores destacam que a confiança no uso de sistemas de decisão automatizada no setor público depende de fatores como responsabilidade, transparência e percepções cidadãs, com a preferência por tomadores de decisão humanos sendo associada a maior credibilidade em termos de competência, honestidade e benevolência.

De Bruijn, Warnier e Janssen (2022) abordam os desafios e estratégias para explicar decisões algorítmicas de forma compreensível, considerando que a adoção de soluções de IA em decisões governamentais enfrenta desafios sociotécnicos complexos, incluindo a dificuldade de explicar algoritmos ao público, a politização do contexto e o impacto significativo das decisões. A pesquisa, ainda, sugere estratégias para ampliar o foco da IA explicável, indo além da opacidade técnica e integrando aspectos sociais, como confiança, legitimidade e processos explicáveis, ao invés de apenas algoritmos. Ainda nesse mesmo contexto, Frost (2024) analisa como a "publicidade empobrecida" das decisões algorítmicas afeta o engajamento público, e com o aprendizado da máquina, afeta ainda mais esse processo, dificultando a capacidade das burocracias de promover uma interação verdadeira entre a administração e as comunidades políticas.

Alon-Barkat e Busuioc (2023), investigam como tomadores de decisão públicos processam conselhos algorítmicos, identificando dois vieses: viés de automação (tomadores de decisão podem adotar automaticamente algoritmos, mesmo quando estes oferecem conselhos errados ou reforçam estereótipos, ignorando informações contraditórias), pouco observado, e adesão seletiva (que ocorre quando os algoritmos reforçam estereótipos). Embora a confiança nos algoritmos possa crescer com a exposição repetida, o estudo alerta para o risco de viés na interação humano-IA e destaca a necessidade de supervisão humana para evitar falhas algorítmicas. Warthon (2024), por sua vez, aborda as dificuldades para lidar com o direito de acesso à informação, devido ao controle limitado sobre os sistemas de IA e à falta de conhecimento sobre a lógica do sistema.

Janssen et al. (2022) examinam se a falta de entendimento dos algoritmos pode impedir os tomadores de decisão de avaliar corretamente os resultados, comprometendo a qualidade das escolhas feitas: “garantir a capacidade de entender e rastrear decisões não é suficiente para evitar todos os erros e tomar apenas decisões corretas” (Janessen et al. 2022, pg 478). Os autores confirmam a importância da explicabilidade para garantir que as decisões apoiadas por IA sejam transparentes e compreensíveis; para estes autores, mesmo que a explicabilidade por si só não garanta transparência e melhores decisões, ela desempenhou um papel importante na obtenção de decisões mais precisas

A recorrência deste tema nos artigos selecionados evidencia a crescente complexidade e os riscos associados à implementação de sistemas de IA na administração pública, especialmente no que se refere à transparência, à responsabilidade e à necessidade de uma supervisão humana eficaz para garantir a confiabilidade e a equidade das decisões algorítmicas. Três artigos trazem um foco na aplicação de tecnologias de tomada de decisão automatizada nos serviços sociais, Ranerup e Henriksen (2022) investigaram a discrição digital nos serviços sociais, destacando o papel crescente da automação nas decisões, enquanto os assistentes sociais ainda mantêm a responsabilidade final, eles propõem um modelo híbrido de colaboração entre humanos e tecnologia. Doring et al. (2024), conduzem um experimento para avaliar o impacto de uma ferramenta de apoio à decisão algorítmica na força de trabalho dos serviços sociais, destacando como o uso de algoritmos pode gerar um impacto negativo sobre o bem-estar dos trabalhadores, tornando-os mais cínicos e fatigados, considerando ainda que a adoção de novas ferramentas “coloca uma pressão severa sobre seus membros, razão pela qual a mudança precisa não apenas ser gerenciada, mas também planejada estrategicamente” (Doring et al. 2024, pg 10). Sleep (2024) adota uma abordagem crítica ao mapear os efeitos da tomada de decisão automatizada nos serviços sociais, argumentando que a automação pode desumanizar os serviços e criar distâncias entre os profissionais e os usuários.

Os artigos de Di Vaio et al. (2022) e Salem et al. (2024) também exploram o uso de inteligência artificial (IA) e aprendizado de máquina na tomada de decisões no setor público. Di Vaio et al. (2022), a partir de uma análise bibliométrica, apontam como a IA melhora a eficácia na gestão pública, tornando as decisões mais eficientes e transparentes. Já Salem et al. (2024) investigam como o aprendizado de máquina aprimora a racionalidade e confiança nas decisões do governo eletrônico, ao possibilitar decisões mais fundamentadas e reduzir vieses. Ainda que seu trabalho tenha uma perspectiva otimista sobre tais tecnologias, estes autores também enfatizam a necessidade de regulamentação para garantir uma adoção segura dessas tecnologias. Já no estudo de Fischer-Abaigar et al. (2024) “foi descoberto que abordagens padrão de aprendizado de máquina não são necessariamente adequadas para o contexto do setor público, exigindo que os designers de modelos expandam seu kit de ferramentas para abordar efetivamente essas questões”. Fischer-Abaigar et al. (2024), ainda defendem uma mudança no enfoque da modelagem de dados, sugerindo que a atenção deixe de ser apenas voltada para a precisão preditiva e passe a focar na melhoria dos resultados da tomada de decisão. Para isso, apresentam abordagens

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

alternativas de modelagem, como métodos de aprendizado de máquina causal, previsão contrafactual e aprendizado de política, que podem ser mais eficazes para informar decisões.

Dois artigos analisam o uso da IA para a tomada de decisão na gestão ambiental. Zabihi et al. (2023) propõem um sistema para responder a enchentes, com "monitoramento, previsão e controle" enquanto Choi et al. (2021) utilizam algoritmos para prever algas nocivas. Ambos destacam melhorias na eficiência e precisão para tomada de decisão.

Seyedzadeh et al. (2020) e Ban (2020) exploram o uso de inteligência artificial para suporte à tomada de decisão em sistemas de energia. Ban (2020) trata de gerenciamento de energia para uma cidade inteligente, como modelo de estudo usou uma siderúrgica, otimizando consumo e reduzindo desperdícios. E, Seyedzadeh et al. (2020), propõe um modelo de aprendizado de máquina para prever o desempenho energético de edifícios não residenciais, permitindo intervenções mais precisas e eficientes para maximizar a economia de energia e reduzir custos operacionais, apesar do modelo estudado seguir as regulamentações da Europa os autores afirmam que "o modelo pode ser apropriado para análise de estoque de edifícios que não é limitado por nenhum país anfitrião" (Seyedzadeh et al. 2020, pg 15).

Na área de saúde e logística, Deveci (2023) analisa obstáculos e fatores essenciais na adoção de IA na gestão da cadeia de suprimentos de saúde, analisando 22 critérios por meio do modelo fuzzy. Mourby (2020) analisa o uso do NHS Data Store durante a pandemia de COVID-19, destacando a aplicação de tomada de decisão automatizada baseada em ciência de dados. Guo et al. (2022) apresentam o sistema PaCAR (*Pandemic Control decision making framework via large-scale Agent-based modeling and deep Reinforcement learning*), que combina modelagem baseada em agentes em larga escala e aprendizado por reforço profundo para apoiar o controle pandêmico, os autores afirmam que "ao modelar a dinâmica epidêmica de toda a cidade, os tomadores de decisão teriam mais dimensões de informação e poderiam até mesmo prever as tendências". Por fim, Virmani et al. (2024) propõem um framework de tomada de decisão baseado em IA para aumentar a eficácia das cadeias de suprimentos de saúde, otimizado a gestão de recursos.

Um dos artigos analisados avaliou o emprego de soluções algorítmicas para gestão do orçamento público. Valle-Cruz et al. (2022) exploram como técnicas de IA, como redes neurais e algoritmos genéticos multiobjetivos, podem otimizar a alocação de gastos públicos, promovendo crescimento econômico, redução da inflação e diminuição das desigualdades.

Os artigos de Kolkman et al. (2024) e Choi et al. (2024) tratam de justiça e direito. O artigo de Kolkman et al. (2024) explora o impacto da inteligência artificial no sistema jurídico, destacando como ela influencia a tomada de decisões legais e a autoridade discricionária de juízes, levantando questões sobre ética e imparcialidade. Já o estudo de Choi et al. (2024) investiga o uso de IA em sistemas para apoiar a prevenção de crimes em centros de controle municipal, buscando melhorar a segurança urbana através da análise de dados em tempo real.

5. Discussão

A análise dos 38 artigos revela um interesse no uso da IA para melhorar a tomada de decisões em vários setores. A aplicação de IA não se limita apenas à melhoria da eficiência administrativa, mas também envolve aspectos críticos como sustentabilidade, transparência, governança e interação social. Esses estudos estão espalhados por uma gama de disciplinas e contextos, refletindo a crescente influência da IA nas decisões públicas. Os artigos analisados convergem em destacar que a inteligência artificial oferece benefícios significativos, como otimização de processos, eficiência operacional e inovação social.

Apesar das vantagens, a implementação da IA enfrenta desafios significativos. Em governos municipais, por exemplo, as cidades estão em estágios variados de desenvolvimento como cidades inteligentes, e fatores como resistência à tecnologia, escassez de recursos e questões políticas dificultam sua adoção (Mills et al., 2022). Além disso, experiências negativas com sistemas legados de TI e custos irrecuperáveis limitam a inovação, gerando aversão ao risco e hesitação em adotar novas tecnologias (Kuziemski & Misuraca, 2020). Gelashvili e Pappel (2021) destacaram que barreiras como resistência organizacional, baixa alfabetização em TI e desconfiança na tecnologia prejudicam o desempenho e a aceitação dos sistemas.

Problemas relacionados ao viés algorítmico, transparência e ética também são frequentemente discutidos. Em finanças, algoritmos de recuperação de dívidas podem transferir excessivas responsabilidades para os cidadãos sem supervisão humana adequada (Rinta-Kahila et al., 2022). Já na justiça, embora a IA auxilie na análise de casos, a transparência e a explicabilidade são essenciais para garantir confiança e aceitação pública (Kolkman et al., 2024).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Esses desafios evidenciam a necessidade de equilibrar inovação tecnológica com políticas robustas que garantam confiabilidade, ética e segurança nos sistemas automatizados. A transparência é necessária para mitigar riscos relacionados a vieses e erros, promovendo uma governança mais justa e responsável. Como apontam Tayeb et al. (2024), "uma ansiedade pela falta de transparência em relação a mecanismos pouco claros de comportamento de IA pode desencorajar indivíduos de usá-la" (Tayeb et al., 2024, pg 21).

A inteligência artificial deve ser encarada não apenas como uma ferramenta técnica de apoio à tomada de decisões, mas também como um recurso que exige uma gestão responsável, pautada por princípios éticos e legais. Sua aplicação no setor público demanda uma atenção especial às implicações que ultrapassam os aspectos tecnológicos, incluindo o respeito à complexidade das decisões humanas, a proteção dos direitos dos cidadãos e a promoção de transparência e equidade. Essa perspectiva reforça a necessidade de equilibrar inovação tecnológica com responsabilidade social, garantindo que a IA contribua para um futuro mais justo e eficiente.

6. Considerações finais

Este artigo visou identificar como IA está sendo utilizada na tomada de decisão pública. Os resultados apontam que IA está sendo utilizada como uma ferramenta estratégica para otimizar processos, melhorar a eficiência operacional e promover a inovação social. Os resultados demonstram que a IA não está sendo utilizada de forma homogênea, mas sim adaptada a diferentes áreas e contextos decisórios. Há variações significativas quanto ao grau de autonomia dos sistemas utilizados e ao tipo de suporte oferecido à decisão, o que demonstra a diversidade das abordagens adotadas.

A revisão identificou variações nas abordagens tecnológicas empregadas, desde sistemas baseados em regras até modelos preditivos avançados como redes neurais e aprendizado por reforço. Essa diversidade técnica reflete também distintas finalidades, como a automatização de processos administrativos, a melhoria da interação com os cidadãos, a otimização de recursos públicos. No entanto, os benefícios observados vêm acompanhados de importantes desafios. Questões como transparência, explicabilidade, supervisão humana e responsabilidade ética são recorrentes e apontam para a necessidade de uma governança robusta e inclusiva. A confiança pública, por sua vez, depende não apenas da eficácia técnica dos sistemas, mas também da sua capacidade de refletir valores sociais e garantir equidade.

Assim, conclui-se que o potencial da IA para transformar a tomada de decisão no setor público é promissor, mas sua implementação exige uma abordagem crítica, interdisciplinar e comprometida com o interesse público.

Esta pesquisa apresenta algumas limitações que devem ser consideradas. Primeiramente, a análise está baseada em um conjunto de 38 artigos, o que, embora abrangente, pode não capturar completamente a diversidade de aplicações e desafios da inteligência artificial na tomada de decisão pública. Além disso, muitos dos estudos analisados tratam de contextos e setores específicos, o que pode limitar a generalização dos resultados para outros cenários. A restrição da busca a artigos em inglês e à base Web of Science pode ter excluído estudos relevantes de outras línguas ou fontes regionais. Outra limitação está relacionada à rápida evolução da tecnologia de IA, as discussões e os dados podem se tornar rapidamente desatualizados devido ao surgimento constante de novas ferramentas, metodologias e regulamentações. Além disso, o artigo aborda de forma mais ampla os benefícios e desafios, mas carece de uma análise prática ou empírica detalhada sobre a implementação da IA em contextos específicos do setor público. Questões éticas e legais são abordadas de forma geral, sem análise prática detalhada, indicando a necessidade de estudos futuros mais específicos e contextualizados.

Nesse contexto, sugerimos a condução de pesquisas comparativas para avaliar como a IA se destaca em relação a métodos convencionais de apoio à decisão, considerando critérios como eficiência, impacto e adaptabilidade, e como ela influencia aspectos qualitativos das decisões, como criatividade, flexibilidade e intuição humana. Além disso, recomenda-se a inclusão de casos empíricos que evidenciem desafios e êxitos práticos da IA, além da ampliação da revisão bibliográfica para bases e publicações em outros idiomas, a fim de enriquecer e diversificar a análise.

Reconhecimento

- **Financiamento ou subsídio:** Esta pesquisa recebeu apoio financeiro da Fundação Araucária de Apoio ao Desenvolvimento Científico e Tecnológico do Paraná, pelo Programa de Bolsas de Produtividade em Pesquisa.
- **Declaração do Colaborador**: Autor 1: Conceitualização, Metodologia, Redação- Revisão e Edição; Autor 2: Conceitualização, Supervisão, Redação – Revisão e Edição; Autor 3: Metodologia, Redação– Revisão e Edição; Autor 4: Redação – Revisão.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **Uso de IA**: Durante a elaboração deste trabalho, os autores utilizaram o ChatGPT para resumir algumas frases e para tradução de alguns trechos dos artigos estudados. Depois de usar essa ferramenta, os autores revisaram, editaram, tornaram o conteúdo seu e validaram o resultado conforme necessário, e assumem total responsabilidade pelo conteúdo da publicação.
- **Conflito de Interesse (COI)**: Não há conflito de interesses.

Referências

Alon-Barkat, S., & Busuioc, M. (2022). Human-AI interactions in public sector decision-making: "Automation bias" and "selective adherence" to algorithmic advice. *Journal of Public Administration Research and Theory*, *33*(1), 153–169. https://doi.org/10.1093/jopart/muac007

Ayat Mohammad Salem, Serife Zihni Eyupoglu, & Mohammad Khaleel Ma'aitah. (2024). The Influence of Machine Learning on Enhancing Rational Decision-Making and Trust Levels in e-Government. *Systems*, *12*(9), 373–373. https://doi.org/10.3390/systems12090373

Ban, Y. (2020). Energy decision making of steel company based on energy management system. *IFAC-PapersOnLine*, *53*(5), 608–613. https://doi.org/10.1016/j.ifacol.2021.04.151.

Bardin, L. Análise de conteúdo. Lisboa: Edições 70, 2010.

Bertoncini, C., Brito, A., Leme, E., Silva, I., Silva, T., Ferreira, Perri, R., Alves, A., & Autônomo. (n.d.). *PROCESSO DECISÓRIO: A TOMADA DE DECISÃO*. Retrieved February 9, 2025, from https://faef.revista.inf.br/imagens_arquivos/arquivos_destaque/QjxDDqGcS5r3dHL_2013-5-3-12-8-34.pdf

Bokhari, S. A. A., & Myeong, S. (2022). Use of Artificial Intelligence in Smart Cities for Smart Decision-Making: A Social Innovation Perspective. *Sustainability*, *14*(2), 620. https://doi.org/10.3390/su14020620

Bokhari, S. A. A., & Myeong, S. (2023). The Impact of AI Applications on Smart Decision-making in Smart Cities as Mediated by the Internet of Things and Smart Governance. *IEEE Access*, *11*, 120827–120844. https://doi.org/10.1109/access.2023.3327174

Brasil. Ministério da Ciência, Tecnologia e Inovações. Plano Brasileiro de Inteligência Artificial (PBIA) 2024. Laboratório Nacio nal de Computação Científica - LNCC, 7 ago. 2024. Disponível em: https://www.gov.br/lncc/pt-br/assuntos/noticias/ultimas-noti cias-1/plano-brasileiro-de-inteligencia-artificial-pbia-2024-2028.

Brynjolfsson, E., & Mcafee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies. (2025). Google Books. https://books.google.com.br/books?hl=pt-BR&lr=&id=WiKwAgAAQBAJ&oi=fnd&pg=PA1&dq=Brynjolfsson*

Choi, W., Joonyeop Na, & Lee, S. (2024). Evaluating Intelligent CPTED Systems to Support Crime Prevention Decision-Making in Municipal Control Centers. *Applied Sciences*, *14*(15), 6581–6581. https://doi.org/10.3390/app14156581

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Choi, Y., Gil-Garcia, R., Aranay, O., Burke, B., & Werthmuller, D. (2021). Using Artificial Intelligence Techniques for Evidence-Based Decision Making in Government: Random Forest and Deep Neural Network Classification for Predicting Harmful Algal Blooms in New York State. *DG.O2021: The 22nd Annual International Conference on Digital Government Research*, 27–37. https://doi.org/10.1145/3463677.3463713

de Bruijn, H., Warnier, M., & Janssen, M. (2021). The perils and pitfalls of explainable AI: Strategies for explaining algorithmic decision-making. *Government Information Quarterly*, *39*(2), 101666. https://doi.org/10.1016/j.giq.2021.101666

Sousa, W. G. de, Melo, E. R. P. de, Bermejo, P. H. D. S., Farias, R. A. S., & Gomes, A. O. (2019). How and where is artificial intelligence in the public sector going? A literature review and research agenda. *Government Information Quarterly*, *36*(4), 101392. https://doi.org/10.1016/j.giq.2019.07.004.

Denhardt, J. V., & Denhardt, R. B. (2015). The New Public Service Revisited. *Public Administration Review*, *75*(5), 664–672. https://doi.org/10.1111/puar.12347

Deveci, M. (2023). Effective use of artificial intelligence in healthcare supply chain resilience using fuzzy decision-making model. *Soft Computing*. https://doi.org/10.1007/s00500-023-08906-2

Di Vaio, A., Hassan, R., & Alavoine, C. (2022). Data intelligence and analytics: A bibliometric analysis of human–Artificial intelligence in public sector decision-making effectiveness. *Technological Forecasting and Social Change*, *174*, 121201. https://doi.org/10.1016/j.techfore.2021.121201

Erick, & Antônio, M. (2024). A IMPORTÂNCIA DA TOMADA DE DECISÕES NA GESTÃO EMPRESARIAL. *Contemporânea*, *4*(3), e3663–e3663. https://doi.org/10.56083/rcv4n3-122

Fischer-Abaigar, U., Kern, C., Barda, N., & Kreuter, F. (2024). Bridging the gap: Towards an expanded toolkit for AI-driven decision-making in the public sector. *Government Information Quarterly*, *41*(4), 101976. https://doi.org/10.1016/j.giq.2024.101976

Frost, N. (2024). The Impoverished Publicness of Algorithmic Decision Making. *Oxford Journal of Legal Studies*. https://doi.org/10.1093/ojls/gqae027

Gelashvili, T., & Pappel, I. (2021, July 1). *Challenges of Transition to Paperless Management: Readiness of Incorporating AI in Decision-making processes*. IEEE Xplore. https://doi.org/10.1109/ICEDEG52154.2021.9530905

Grimmelikhuijsen, S. (2023). Explaining why the computer says no: Algorithmic transparency affects the perceived trustworthiness of automated decision-making. *Public Administration Review*, 83(1), 12-25. https://doi.org/10.1111/puar.13483.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Governo Federal do Brasil. (2024). *Plano Brasileiro de Inteligência Artificial (PBIA) 2024-2028*. Brasília, DF: Ministério da Ciência, Tecnologia e Inovação. Recuperado de https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2024/07/plano-brasileiro-de-ia-tera-supercomputador-e-investimento-de-r-23-bilhoes-em-quatro-anos/ia_para_o_bem_de_todos.pdf/view.

Guo, X., Chen, P., Liang, S., Jiao, Z., Li, L., Yan, J., Huang, Y., Liu, Y., & Fan, W. (2022). PaCAR: COVID-19 Pandemic Control Decision Making via Large-Scale Agent-Based Modeling and Deep Reinforcement Learning. *Medical Decision Making*, 0272989X2211079. https://doi.org/10.1177/0272989x221107902

Hanne Hirvonen. (2023). Just accountability structures – a way to promote the safe use of automated decision-making in the public sector. *AI & SOCIETY*. https://doi.org/10.1007/s00146-023-01731-z

Ingrams, A., Kaufmann, W., & Jacobs, D. (2021). In AI we trust? Citizen perceptions of AI in government decision making. *Policy & Internet*. https://doi.org/10.1002/poi3.276

Janssen, M., Hartog, M., Matheus, R., Yi Ding, A., & Kuk, G. (2020). Will Algorithms Blind People? The Effect of Explainable AI and Decision-Makers' Experience on AI-supported Decision-Making in Government. *Social Science Computer Review*, *40*(2), 089443932098011. https://doi.org/10.1177/0894439320980118

Kolkman, D., Bex, F., Narayan, N., & van. (2024). Justitia ex machina: The impact of an AI system on legal decision-making and discretionary authority. *Big Data & Society*, *11*(2). https://doi.org/10.1177/20539517241255101

Kuziemski, M., & Misuraca, G. (2020). AI governance in the public sector: Three tales from the frontiers of automated decision-making in democratic settings. *Telecommunications Policy*, *44*(6), 101976. https://doi.org/10.1016/j.telpol.2020.101976

Liu, H. K., Tang, M., & Chen, K.-H. (2020). *Public Decision Making*. 214–222. https://doi.org/10.1145/3396956.3396965

Liu, B., Luo, J., & Su, X. (2021). The Framework of 6G Self-Evolving Networks and the Decision-Making Scheme for Massive IoT. *Applied Sciences*, *11*(19), 9353. https://doi.org/10.3390/app11199353

Matthias Döring, Kim Sass Mikkelsen, Jonas Krogh Madsen, & Kristian Bloch Haug. (2024). Creating a workforce of fatigued cynics? A randomized controlled trial of implementing an algorithmic decision-making support tool. *Government Information Quarterly*, *41*(1), 101911–101911. https://doi.org/10.1016/j.giq.2024.101911

Maximiano, A. C. A. (2000). *Introdução à administração* (5. ed.). São Paulo: Atlas.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Mills, D., Pudney, S., Pevcin, P., & Dvorak, J. (2021). Evidence-Based Public Policy Decision-Making in Smart Cities: Does Extant Theory Support Achievement of City Sustainability Objectives? *Sustainability*, *14*(1), 3. https://doi.org/10.3390/su14010003

Monarcha-Matlak, A. (2021). Automated decision-making in public administration. *Procedia Computer Science*, *192*, 2077–2084. https://doi.org/10.1016/j.procs.2021.08.215

Mourby, M. J. (2021). "Leading by Science" through Covid-19: the GDPR & Automated Decision-Making. *International Journal of Population Data Science*, *5*(4). https://doi.org/10.23889/ijpds.v5i4.1402

O'Reilly, T. (2011). Government as a Platform. *Innovations: Technology, Governance, Globalization*, *6*(1), 13–40. https://doi.org/10.1162/inov_a_00056

Pereira, F., Silva, L., Souza, L., et al. (2021). A transformação digital no setor público: Desafios e oportunidades da inteligência artificial. *Revista de Administração Pública*, 55(3), 451-470.

PRISMA. (2020). *Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)*. Www.prisma-Statement.org. https://www.prisma-statement.org/

Ranerup, A., & Henriksen, H. Z. (2020). Digital Discretion: Unpacking Human and Technological Agency in Automated Decision Making in Sweden's Social Services. *Social Science Computer Review*, *40*(2), 089443932098043. https://doi.org/10.1177/0894439320980434

Rinta-Kahila, T., Someh, I., Gillespie, N., Indulska, M., & Gregor, S. (2021). Algorithmic decision-making and system destructiveness: A case of automatic debt recovery. *European Journal of Information Systems*, *31*(3), 1–26. https://doi.org/10.1080/0960085x.2021.1960905

Sampaio, R. C., Sabbatini, M., & Limongi, R. (2024). *Diretrizes para o uso ético e responsável da inteligência artificial generativa: Um guia prático para pesquisadores*. São Paulo: Editora Intercom.

Seyedzadeh, S., Pour Rahimian, F., Oliver, S., Rodriguez, S., & Glesk, I. (2020). Machine learning modelling for predicting non-domestic buildings energy performance: A model to support deep energy retrofit decision-making. *Applied Energy*, *279*, 115908. https://doi.org/10.1016/j.apenergy.2020.115908

Silva, W. F. da, Silva, F. S., & Rabêlo, O. D. S. (2021). Tendências no Uso de Inteligência Artificial e sua Influência na Requalificação da Força de Trabalho no Setor Público. *Cadernos de Prospecção*, *14*(3), 824. https://doi.org/10.9771/cp.v14i3.36727

Simon, H. A**.** (1997). *Administrative behavior: A study of decision-making processes in administrative organizations* (4. ed.). New York: Free Press.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Silva, W. F. da, Silva, F. S., & Rabêlo, O. D. S. (2021). Tendências no Uso de Inteligência Artificial e sua Influência na Requalificação da Força de Trabalho no Setor Público. *Cadernos de Prospecção*, *14*(3), 824. https://doi.org/10.9771/cp.v14i3.36727

Sleep, L. (2024). "This is NOT *human* services": Counter-mapping automated decision-making in social services in Australia. *Journal of Sociology*, *60*(3), 618–642. https://doi.org/10.1177/14407833241266022

Tayeb, A., Alzubi, A., & Iyiola, K. (2024). Artificial intelligence and smart decision making in smart cities: a parallel moderated mediation approach. *International Journal of Urban Sciences*, 1–29. https://doi.org/10.1080/12265934.2024.2407796

Tran Thi Hoang, G., Dupont, L., & Camargo, M. (2019). Application of Decision-Making Methods in Smart City Projects: A Systematic Literature Review. *Smart Cities*, *2*(3), 433–452. https://doi.org/10.3390/smartcities2030027

Valle-Cruz, D., Fernandez-Cortez, V., & Gil-Garcia, J. R. (2021). From E-budgeting to smart budgeting: Exploring the potential of artificial intelligence in government decision-making for resource allocation. *Government Information Quarterly*, *39*(2), 101644. https://doi.org/10.1016/j.giq.2021.101644

Virmani, N., Rajesh Kumar Singh, Agarwal, V., & Emel Aktas. (2024). Artificial Intelligence Applications for Responsive Healthcare Supply Chains: A Decision-Making Framework. *IEEE Transactions on Engineering Management*, 1–41. https://doi.org/10.1109/tem.2024.3370377

Wang, S., Min, C., Liang, Z., Zhang, Y., & Gao, Q. (2024). The decision-making by citizens: Evaluating the effects of rule-driven and learning-driven automated responders on citizen-initiated contact. *Computers in Human Behavior*, *161*, 108413. https://doi.org/10.1016/j.chb.2024.108413

Warthon, M. (2024). Restricting access to AI decision-making in the public interest: The justificatory role of proportionality and its balancing factors. *Internet Policy Review*, *13*(3). https://doi.org/10.14763/2024.3.1801

Wilson, C., & van der Velden, M. (2022). Sustainable AI: An integrated model to guide public sector decision-making. *Technology in Society*, *68*, 101926. https://doi.org/10.1016/j.techsoc.2022.101926

Zabihi, O., Siamaki, M., Gheibi, M., Akrami, M., & Hajiaghaei-Keshteli, M. (2023). A smart sustainable system for flood damage management with the application of artificial intelligence and multi-criteria decision-making computations. *International Journal of Disaster Risk Reduction*, *84*, 103470. https://doi.org/10.1016/j.ijdrr.2022.103470

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly*, *38*(3), 101577. Sciencedirect. https://doi.org/10.1016/j.giq.2021.101577

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Plataforma Pública de Conteúdos Audiovisuais Brasileiros Sob Demanda: Tecnologia social para formação de públicos, difusão e descentralização dos espaços de exibição.

Luciana Santa Rita[a], *Thiago* Cordeiro[b*], *Anderson* Barbosa[c], *Natalício* Santos Junior[d], *Christiane* Cabral[e], *Julia* Rosa[f], *Aluísio* Rego[g], *Vitor* Braga[h], *Adriana* Gomes[i], *Lina* Távora[j], *Daniela* Fernandes[k]

[a] Faculdade de Economia, Administração e Contabilidade, Universidade Federal de Alagoas, Alagoas, Brasil, luciana.santarita@nees.ufal.br, https://orcid.org/0000-0002-6868-9014

[b] Instituto de Computação, Universidade Federal de Alagoas, Alagoas, Brasil, thiago.cordeiro@nees.ufal.br, https://orcid.org/0000-0003-0976-7040.

[c] Instituto de Computação, Universidade Federal de Alagoas, Alagoas, Brasil, anderson.barbosa@nees.ufal.br, https://orcid.org/0009-0006-1227-9346.

[d] NEES, Universidade Federal de Alagoas, Brasil; Centro de Estudos Sociais da Universidade de Coimbra, Portugal, natalicio.junior@nees.ufal.br, https://orcid.org/0009-0001-7106-7224.

[e] Centro Universitário Internacional (UNINTER), Pós em Acessibilidade e Tecnologias de Inclusão, Curitiba, Brasil, christiane.cabral@nees.ufal.br, https://orcid.org/0000-0001-7579-8107.

[f] Programa de Pós-Graduação em Políticas Públicas, Universidade Federal do Rio Grande do Sul, Rio Grande do Sul, Brasil, julia.rosa@nees.ufal.br, https://orcid.org/0000-0002-4941-8147

[g] Laboratório de Análise de Dados e Inteligência Computacional, Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte, Rio Grande do Norte, Brasil, aluisio.rego@nees.ufal.br

[h] Instituto de Ciências Humanas, Comunicação e Artes, Universidade Federal de Alagoas, Alagoas, Brasil, vitor.braga@ichca.ufal.br, https://orcid.org/0000-0002-2377-9323.

[i] Secretaria do Audiovisual, Ministério da Cultura, Brasília, Brasil, adriana.gomes@cultura.gov.br

[j] Secretaria do Audiovisual, Ministério da Cultura, Brasília, Brasil, lina.tavora@cultura.gov.br

[k] Secretaria do Audiovisual, Ministério da Cultura, Brasília, Brasil, daniela.fernandes@cultura.gov.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Resumo. As tecnologias de *streaming* audiovisual reúnem aspectos relevantes sobre o desenvolvimento tecnológico e as formas de acesso, difusão e democratização do audiovisual. No Brasil, nos últimos anos, o crescimento do número de plataformas de *streaming* audiovisual tem representado um fenômeno social, cultural, econômico e político que desperta a atenção e o interesse de corporações privadas, governos, realizadores(as) e espectadores(as) do setor audiovisual, especificamente sobre os propósitos e usos mercadológicos, públicos, democráticos, sociais e culturais dessa tecnologia. Este artigo apresenta e contextualiza o desenvolvimento de uma plataforma de *streaming* pública, gratuita e brasileira, desenvolvida pelo Governo Federal, enquanto tecnologia social com potencial para impactar significativamente o audiovisual brasileiro. A discussão deste artigo a respeito do *streaming* público é estruturada a partir de três objetivos da plataforma: (1) formação de público, (2) difusão do audiovisual brasileiro e (3) descentralização dos espaços de exibição. Por meio de uma abordagem exploratória, são analisadas as ações implementadas e os desafios enfrentados em seu desenvolvimento, considerando um contexto marcado pela concentração geográfica da produção e da exibição, predominância de conteúdos estrangeiros em salas de cinema e plataformas de *streaming*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

comerciais, bem como a fragilidade das políticas de democratização cultural. Com base em revisão de literatura - nacional e internacional - e análise de dados secundários, avaliamos se essa iniciativa pode reconfigurar as dinâmicas de acesso e difusão do audiovisual, tendo em vista a adoção estratégica de tecnologias sociais pela Secretaria do Audiovisual do Ministério da Cultura. O artigo discute o potencial de ampliação da visibilidade de produções nacionais e regionais, do(as) realizadores(as) sub-representados(as) e narrativas plurais, com vistas a promover transformações sociais, culturais e educacionais.

Palavras-chave. streaming, formação de público, difusão, ampliação do acesso, audiovisual brasileiro.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1057

1. Introdução

Uma tecnologia social é uma combinação de ideias, práticas e ferramentas que são projetadas para abordar problemas sociais complexos, frequentemente por meio de processos colaborativos que envolvem diretamente as comunidades afetadas (Mulgan, 2019). Como tal, abrange produtos, técnicas e metodologias reaplicáveis desenvolvidas por meio da interação com os grupos sociais, representando soluções de transformação social. Dessa forma, estabelece-se uma replicabilidade da inovação a diferentes grupos, tornando seu papel social mais efetivo.

No campo do audiovisual, plataformas de streaming públicas e gratuitas são entendidas como expressões de tecnologia social. Elas operam enquanto meios para ampliar o acesso a conteúdos culturais e educacionais, democratizando oportunidades e podendo fortalecer a diversidade cultural. A literatura está repleta de estudos sobre a difusão de conteúdo audiovisual por meio de plataformas gratuitas (Murray, 2021; Lobato, 2019; Hesmondhalgh, 2013; Villén Higueras & Ruiz del Olmo, 2022; Menezes, 2025) como uma estratégia em muitos países da garantia do acesso livre e democrático, inclusive na América Latina (Ministerio de Cultura de la Nación, 2022); o que significa que qualquer pessoa interessada, independentemente de sua localização ou condição socioeconômica, poderá acessar e aproveitar uma ampla gama de material audiovisual, incluindo curtas e longas-metragens, documentários, animações e videoartes.

A partir dessas tecnologias sociais, é possível oferecer à população conteúdos que refletem a diversidade étnica, linguística e regional do país. Isso contribui para o fortalecimento de saberes, modos de existir e narrativas locais que, muitas vezes, são invisibilizadas pelas grandes plataformas globais, cujo foco é atender demandas de audiências amplas e internacionalizadas (Brasil, 2020). Compreendemos como narrativas locais as histórias, as representações e as expressões culturais que emergem de contextos específicos, refletindo as experiências, tradições, identidades e valores de grupos sociais, comunidades ou região. Tais narrativas contrastam com discursos globais e hegemônicos, ao evidenciar as particularidades culturais e sociais que moldam as perspectivas locais sobre o mundo (Martin-Barbero, 2009).

A globalização do entretenimento e o domínio de produções estrangeiras dificultam a competitividade do audiovisual brasileiro, especialmente no cinema (Rosa *et al*., 2023). No Brasil, o desenvolvimento de uma plataforma de streaming pública e gratuita pode ter um impacto significativo no setor audiovisual, promovendo a ampliação da visibilidade e acesso a manifestações, bens e produtos culturais, fomentando a produção nacional e fortalecendo a diversidade cultural. Como tal, as premissas inerentes à ampliação do acesso, fomento à produção nacional, preservação e difusão da cultura, criação de novos públicos, fortalecimento da soberania cultural com a redução da dependência de produtos estrangeiros, bem como o impulso à economia, podem ser considerados os elementos condicionantes da tecnologia social de streaming pública.

Nas últimas décadas, a consolidação de leis de incentivo - Lei do Audiovisual e Lei Rouanet, por exemplo -, a criação da Agência Nacional do Cinema (Ancine), dos programas de fomento da Secretaria do Audiovisual (SAV) do Ministério da Cultura (MinC) e a criação do Fundo Setorial do Audiovisual (FSA) vêm contribuindo para o crescimento e equidade da produção cultural do país. Segundo Morais (2019), entre 2003 e 2014, os recursos para o setor cresceram 540%, e o número de longas-metragens saltou de 22 para 143 anuais – com destaque para coproduções internacionais financiadas por incentivos fiscais. Tal crescimento é resultado de uma série de fatores que envolvem estabilidade econômica, reorganização do setor e reformulação das políticas de incentivo ao cinema. Entretanto, o crescimento verificado na produção não se refletiu em um aumento de público na mesma intensidade.

Adicionalmente, em 2024, o setor audiovisual brasileiro recebeu investimentos significativos, refletindo o compromisso do governo em fortalecer e expandir essa indústria, como exemplo o FSA que destinou R$ 1,2 bilhão

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

para a cadeia produtiva do audiovisual, com foco no crescimento econômico sustentável, ampliação da produção nacional e promoção da diversidade regional e de gênero. Em junho de 2024, o Governo Federal anunciou um pacote de R$1,6 bilhão para o setor audiovisual, abrangendo diversas iniciativas para impulsionar a produção e a infraestrutura (Portal Gov.br, 2024).

Diversos autores têm analisado o impacto do streaming na produção e consumo audiovisual. Oliveira (*et al*., 2023) discutem como estes serviços modificaram a maneira das pessoas consumirem filmes e séries, gerando um impacto na indústria, originalmente dominada pelo cinema e pela televisão. Em outra perspectiva de compreensão do processo, Baute (2022) argumenta que a produção e distribuição de obras audiovisuais nessas plataformas pode resultar em processos que o autor compreende como produtores de uma homogeneização cultural. No contexto de plataformas de streaming, as produções audiovisuais tendem a se conformar a padrões e narrativas globalizadas, frequentemente moldadas por grandes corporações e mercados dominantes. Essa dinâmica ocorre porque os grandes players desse mercado buscam maximizar a audiência global, resultando em conteúdos que privilegiam histórias, linguagens, gêneros e estilos que têm maior apelo comercial.

Tais aspectos se apresentam como pilares importantes para compreender o impacto de uma plataforma pública, exemplificando o potencial transformador do streaming para a inclusão cultural, desde que apoiada por estratégias de longo prazo desenvolvidas pelo Estado – nas instâncias Federal, Estadual e Municipal.

Ao contextualizar esse cenário, este artigo tem por objetivo geral apresentar os desafios no desenvolvimento de uma plataforma de *streaming* público como uma tecnologia social de modo a cumprir três objetivos específicos: (1) formação de público, (2) difusão do audiovisual brasileiro e (3) descentralização dos espaços de exibição. Apresentamos, então, a seguinte questão de pesquisa: como um serviço de *streaming* pode contribuir para a redução das assimetrias de acesso, difusão e formação de públicos no audiovisual brasileiro, em um contexto marcado pela concentração geográfica da produção e da exibição, predominância de conteúdos estrangeiros em salas de cinema e plataformas de *streaming* comerciais, bem como fragilidade das políticas de democratização cultural?

Por meio de uma abordagem exploratória, analisamos as justificativas, os objetivos e os desafios de uma plataforma pública de *streaming*, demonstrando seu potencial como ferramenta estratégica para políticas culturais comprometidas com a democratização e a equidade na produção, difusão e recepção no audiovisual. Com base em revisão bibliográfica - nacional e internacional - e análise de dados secundários, argumentamos que essa iniciativa pode reconfigurar as dinâmicas de acesso, ampliando a visibilidade de produções regionais, realizadores sub-representados e narrativas plurais, além de discutirmos seu estágio atual de desenvolvimento.

O texto está estruturado da seguinte maneira: inicialmente, apresenta-se uma contextualização do cenário latino-americano e brasileiro, destacando os desafios e oportunidades do setor audiovisual na região. Em seguida, aborda-se o arcabouço teórico que sustenta a discussão, explorando os conceitos de tecnologias sociais e a centralidade do *streaming* no fortalecimento do audiovisual. As discussões são apresentadas em três eixos principais: formação de público, difusão do audiovisual brasileiro e descentralização dos espaços de exibição. Por fim, discutem-se as implicações práticas e as contribuições do estudo para o campo, encerrando-se com as próximas etapas do projeto e sugestões para pesquisas futuras.

2. Contextualização

Diversos estudos (Fran, 2024; Smith & Thompson, 2024; Wayne, 2020; Murray, 2021) apresentam o crescimento das plataformas de *streaming* como vetores de significativas transformações no consumo de mídia audiovisual nos últimos anos, especialmente aquelas desenvolvidas por multinacionais do mercado das empresas com base de atuação nos meios digitais - como Netflix, Amazon Prime e AppleTv, dentre outras. O mercado também testemunha a entrada de novos players, aumentando a concorrência, enquanto plataformas regionais ganham destaque ao oferecer conteúdos culturalmente relevantes. Paralelamente, o crescimento dessas plataformas está gerando debates sobre direitos autorais, regulação de conteúdo, pluralidade de obras e realizadores(as), representatividade da produção nacional e impacto na indústria tradicional de cinema e televisão. Esses fatores, combinados, destacam o *streaming* como uma das principais forças na redefinição do cenário de mídia audiovisual global.

Alguns desenvolvimentos tecnológicos têm possibilitado novas formas de consumir, distribuir e produzir conteúdo audiovisual. Assim, como elenca Shattuc (2020), o surgimento e a expansão do acesso à internet, a adoção de transmissão digital de sinais de televisão, a popularização de computadores pessoais, smartphones e tablets e o alargamento da banda de transmissão de dados para evitar que vídeos sofressem buffering ajudam a explicar a transição digital do audiovisual.

Pesquisas (Grandinetti, 2017; Lobato, 2019; Lotz, 2022) apontam que a transição em curso para plataformas de *streaming* transformou radicalmente a produção e o consumo de mídia ao introduzir serviços financiados pelos

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

assinantes e disponíveis sob demanda. Mais concretamente, o panorama atual do setor audiovisual com o seu sistema de plataformas online está, em boa medida, relacionado com o consumo de séries, filmes e documentários, segundo preconiza García-Orta (*et al*., 2019). Os autores entendem como uma mudança em curso de hierarquias historicamente estabelecidas pela indústria audiovisual em vários aspectos, como a primazia da sala de cinema, o formato do longa-metragem de ficção como produto central da cadeia, e os processos de legitimação e promoção - a exemplo de festivais e curadorias. Tal mudança decorre do processo de digitalização e o estabelecimento que os canais de *streaming* romperam enquanto forças econômicas (Bahia *et al*., 2023).

Sublinha-se que nessa arena de competição, os grandes players do setor, nacionais e internacionais, avançam na oferta de seus serviços e passam a oferecer tanto conteúdos, como infraestrutura de rede (Jambeiro *et al*., 2011). Uma característica das empresas que oferecem esse serviço é a forma como combinam a curadoria e circulação de novas produções com bibliotecas de conteúdo histórico da televisão (Gilbert, 2019).

A partir dessas premissas, quando se analisa a relevância da mídia *streaming*, Gambarato *et al*. (2022) usaram o termo "cultura da capacidade de transmissão" para descrever a lógica industrial que amplifica hoje as possibilidades da mídia conectiva. As mídias conectivas são ecossistemas formados pela convergência de tecnologias de comunicação, informação e mídia. Como tal, os autores registram que a fluidez transcende simplesmente governar atividades, objetos e relações digitalmente, gerando e respondendo aos fluxos de dados da forma mais eficiente possível. Vale ressaltar que a premissa vai além da arquitetura tecnológica das plataformas: ou autores consideram como um "campo de batalha logístico", capaz de controlar e organizar fluxos de circulação midiática.

A América Latina, com sua diversidade cultural e linguística, enfrenta assimetrias em relação à infraestrutura digital e à distribuição de conteúdos culturais. No Brasil, por exemplo, as salas de cinema estão concentradas em capitais e regiões metropolitanas, deixando vastas áreas do país sem acesso a exibições cinematográficas. Embora mais recentemente o MinC tenha apontado avanços - os últimos dados apontam que o Brasil chegou a 3.509 salas, incluindo as que foram inauguradas ou reformadas em 22 cidades do interior do país (Menezes, 2025) -, aproximadamente 7% das cidades brasileiras possuem ao menos uma sala de cinema (Rosa *et al*., 2023). Embora este número supere o recorde anterior de 3.478 salas, registrado em 2019, antes da pandemia de COVID-19, tal cenário ainda é muito distante de países como EUA - que em 2024 contava com cerca de 40.000 salas em operação (Piauí, 2022) - e China - com cerca de 90.000 salas (Xinhua News Agency, 2025).

A digitalização do setor audiovisual na América Latina ocorre ainda em um cenário de profundas desigualdades estruturais. Segundo Loureiro (2015), embora a região tenha apresentado avanços significativos na adoção de tecnologias digitais, persiste uma lacuna em relação à inclusão digital, especialmente entre populações de baixa renda e residentes em áreas remotas – distantes da zona de influência das regiões metropolitanas dos países.

Essa realidade é compartilhada por outros países da região, onde a centralização da infraestrutura cultural reflete desigualdades sociais e econômicas mais amplas. Como observa Selva (2016), a exclusão digital na América Latina é historicamente agravada por disparidades no acesso à internet de alta velocidade, particularmente em áreas rurais e periféricas. Questionamos então como o streaming – enquanto uma tecnologia que permite a transmissão de dados de áudio e vídeo pela internet, de maneira contínua e em tempo real, sem a necessidade de download completo do conteúdo antes de sua reprodução – pode apresentar-se nesse contexto como uma alternativa para superar barreiras geográficas e ampliar o acesso a conteúdos culturais.

O consumo de *streaming* audiovisual no Brasil tem crescido significativamente nos últimos anos, refletindo mudanças nos hábitos culturais e no acesso a tecnologias digitais. De acordo com o relatório Global Streaming Market Overview, o Brasil é o segundo país que mais consome serviços de streaming, ficando atrás apenas da Nova Zelândia, e pelo menos 65% dos adultos brasileiros possuem um serviço de *streaming*, enquanto a média global é de 56% (Global Streaming Market Overview, 2024).

Dados do Módulo de Tecnologia de Informação e Comunicação (TIC) da PNAD Contínua (2023) indicam que mais de 40% dos lares brasileiros com televisão tiveram acesso a plataformas de streaming de vídeo. Essa expansão é acompanhada por um aumento no tempo dedicado ao consumo audiovisual, com as plataformas de *Video on Demand* (VOD) representando aproximadamente 32% do tempo total gasto considerando todos os dispositivos (Kantar IBOPE Media, 2024). Vale ressaltar que estas plataformas são caracterizadas na referida pesquisa como aquelas que disponibilizam vídeos online, independentemente de seus modelos de negócios e de suas estratégias de produção de conteúdo - serviços financiados por assinatura e/ou por publicidade, com conteúdo gerado por seus usuários ou pela própria plataforma.

Diante desse quadro, de um mercado em crescimento e dominado por grandes corporações, de um lado, e de dificuldades de acesso aos serviços pagos por parte da sociedade, na América Latina, diversos governos têm desenvolvido plataformas de streaming gratuitas de vídeo sob demanda com o objetivo de promover a produção local e ampliar o acesso da população a conteúdos nacionais.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Há em curso uma preocupação para que governos regulamentem as empresas e identifiquem estratégias adequadas para o setor audiovisual e o seu desenvolvimento futuro (Lotz, 2022). Dentre os que tiveram maior propulsão, uma característica em comum é o fato de oferecer acesso gratuito a uma ampla gama de conteúdos, incluindo séries, documentários, filmes e animações. Temos os casos da Plataforma Contar (https://www.cont.ar), da Argentina, que também realiza transmissões ao vivo de eventos culturais; a OndaMedia (https://ondamedia.cl), do Chile, segue uma lógica parecida: disponibiliza gratuitamente obras nacionais com o objetivo de preservar e difundir a memória cultural do país; e o RTVCPlay (https://rtvcplay.co/), da Colômbia, com uma lógica que se aproxima, porém com conteúdos infantis com foco na cultura e na história nacional.

De acordo com Alvaray (2023), é possível identificar características que se assemelham entre as plataformas mencionadas, no contexto da América Latina. Temos a curadoria de conteúdos que valorizam a diversidade cultural e social do país, dando espaço a produções regionais e temáticas relacionadas à história, cultura e debates contemporâneos do país; a implementação de recursos de acessibilidade, como legendas, audiodescrição e Língua Brasileira de Sinais (Libras), para alcançar diferentes públicos, inclusive pessoas com deficiência; o investimento em parcerias com produtores locais e independentes, permitindo não apenas o financiamento de novos projetos, mas também a distribuição de obras que, de outra forma, enfrentam dificuldades para alcançar um público amplo; e a utilização de campanhas de comunicação digital para promover e engajar em torno dos conteúdos disponíveis, aproveitando as mídias sociais e canais institucionais para alcançar sobretudo o público mais jovem.

Por meio de uma parceria entre a Diretoria de Preservação e Difusão Audiovisual da Secretaria do Audiovisual do Ministério da Cultura (DPDA/SAV/MinC) e o Núcleo de Excelência em Tecnologias Sociais (NEES) do Instituto de Computação (IC) da Universidade Federal de Alagoas (UFAL), está em fase de desenvolvimento uma Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda, que pretende alcançar diversos segmentos do audiovisual, estruturando uma política pública que integra e alinha as áreas de acesso, promoção, formação, organização de dados e preservação do audiovisual nacional. A plataforma tem como meta disponibilizar produções audiovisuais de realizadores brasileiros, promovendo o acesso e a difusão desses conteúdos de forma pública e sob demanda. Entre os principais conteúdos disponíveis estarão curtas, médias e longas-metragens, além de documentários, animações e videoartes.

Para tanto, busca-se oferecer um espaço acessível a cineastas, diretores(as) de TV e vídeo, vídeo artistas, produtores(as), estudantes, entusiastas e o público em geral para compartilhar, assistir e explorar variedade de conteúdo audiovisual nacional, relativos aos domínios da ficção e não-ficção, informação e entretenimento, educação, ciência e artes.

Para tanto, dois perfis estão sendo formatados para atender aos mais diversos públicos que poderão acessar de qualquer lugar (perfil cidadão) ou ainda promover exibições das produções nos mais diversos espaços (perfil direcionado), como apresentamos na Tabela 1. Cabe esclarecer que a plataforma disponibiliza o conteúdo para o acesso público, mas a infraestrutura necessária para sua exibição e recepção - como equipamentos audiovisuais e acesso à internet - é de responsabilidade dos espaços de exibição, bem como de outras ações e/ou políticas públicas.

Tab. 1 - Definição dos perfis da Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda. Fonte: SAV/MinC.

Tipo	Descrição	Finalidades	Perfis
Perfil cidadão	Desenvolvido para o público geral, que poderá acessar a partir do direcionamento de seus públicos em seções	• Segmentar as obras de acordo com seus respectivos gêneros • Direcionar o espectador aos formatos de obras preferidos • Guiar o usuário aos conteúdos a partir de uma busca no menu principal da plataforma	Perfil único
Perfil direcionado	Criar curadorias de "trilhas espectatoriais", voltadas à formação de olhar audiovisual	• Atuar prioritariamente junto à educação, aos pontos de exibição, às mostras e festivais, à filmes de impacto e a outras direções que se mostrarem necessárias • Garantir o efetivo acesso ao audiovisual de crianças, adolescentes, idosos e outros públicos prioritários	1. Perfil educacional: escolas 2. Perfil exibidor: Cineclubes e pontos de difusão (CineCEUs, Cine Bibliotecas…), Pontos de Cultura Audiovisual, Mostras e Festivais

Fonte: SAV/MINC.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

A estratégia busca dar visibilidade à diversidade cultural e criativa do audiovisual brasileiro, garantindo a presença da pluralidade de linguagens, formatos e estéticas. Essa diversidade será abordada com atenção às questões de classe social, gênero e étnico-raciais, promovendo o reconhecimento cultural de diversos grupos sociais. Com base em princípios de equidade, a plataforma também visa fortalecer a representatividade da produção regional e local, atuando como um espaço para que jovens criadores e produtores independentes compartilhem suas criações, promovendo a descoberta de novos talentos e projetos inovadores. Em 2024, a SAV/MinC lançou o Edital de Licenciamento de Obras Audiovisuais que visa selecionar e licenciar mais de 400 obras audiovisuais já finalizadas, incluindo curtas, médias e longas-metragens, para compor o catálogo desta plataforma, que está prevista para ser lançada ainda em 2025.

3. Desafios

De acordo Sylvestre (2024), são muitos os elementos de motivação e oportunidade para a implementação de plataformas de difusão de conteúdos audiovisuais nacionais no modelo de consumo sob demanda. Sobretudo no que concerne à obrigação constitucional do Estado, prevista no artigo 215 da Constituição Federal de 1988, na qual determina a garantia a todos do pleno exercício dos direitos culturais e do acesso às fontes da cultura nacional, cabendo ao Estado apoiar e incentivar a valorização e a difusão das manifestações culturais. Outro fator relevante é o cumprimento da meta 40 do Plano Nacional de Cultura, que prevê a disponibilização na internet de conteúdos em domínio público e licenciados. Por fim, destaca-se o eixo de ações de acesso e distribuição de produção audiovisual para as escolas públicas de educação básica, no âmbito da regulamentação da Lei nº 13.006/2014 - que estabelece as diretrizes e bases da educação nacional e obriga a exibição de filmes de produção nacional nas escolas.

Considerando estes aspectos legais, Venanzoni (2021a) aponta que a democratização do audiovisual exige políticas públicas integradas que abordam os desafios de produção, distribuição e consumo de forma conjunta. O *streaming*, com sua capacidade de alcançar públicos diversos, se configura como uma ferramenta para atender parcialmente essa demanda por democratização - ainda que precise ser atrelada a outras políticas públicas e envolva dimensões políticas e econômicas, atores e recursos além da plataforma.

Baute (2022), ao destacar esse processo, aponta a necessidade de modelos alternativos que combatam a homogeneização cultural. Iniciativas como a plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda, por exemplo, são uma resposta a essa dinâmica, à medida que estejam orientadas aos princípios da pluralidade de linguagens, formatos e estéticas, promovendo a produção regional e dando visibilidade a manifestações, expressões, discursos, ideias, lugares e sujeitos que representem a diversidade social, cultural e étnica do Brasil.

As narrativas locais desempenham um papel crucial na resistência à homogeneização cultural, ao promoverem a valorização das culturas periféricas e regionais como parte integrante de uma identidade mais ampla e diversificada (Martín-Barbero, 2019). A proposta de um *streaming* público, orientado por princípios da ampliação do acesso e pluralidade de conteúdos, tem o potencial de equilibrar os interesses globais com as necessidades locais, fortalecendo a identidade cultural e a soberania audiovisual.

Nova Filho (*et al*., 2023) destacam a presença e a consolidação de plataformas nacionais de conteúdo audiovisual - quer sejam públicas ou privadas - para a promoção da cultura local. Além disso, também são agentes importantes na preservação da identidade cultural, na inclusão digital e no desenvolvimento econômico do setor criativo à medida que as plataformas nacionais de conteúdo audiovisual são ferramentas para a divulgação e valorização da cultura local.

3.1 Formação de públicos

A formação de públicos é o primeiro aspecto que discorremos para o fortalecimento do audiovisual na América Latina. A ideia central por trás do conceito de "formação de público" refere-se às estratégias, políticas e ações voltadas para ampliar, diversificar e engajar a audiência de manifestações culturais, como cinema, teatro, literatura e música. Trata-se de um processo que visa não apenas aumentar o consumo cultural, mas também criar vínculos duradouros entre os indivíduos e as obras, promovendo um senso de pertencimento e identidade cultural.

Venanzoni (2021b) argumenta que, historicamente, o foco na produção ofuscou a importância de criar estratégias para engajar os espectadores e ampliar o alcance das produções nacionais. Bernardet (2007) já destacava no início deste século que a formação de públicos sempre foi uma questão negligenciada historicamente no planejamento cultural brasileiro, resultando em um mercado que privilegia produções globais em detrimento de narrativas locais. Este quadro não obteve maiores avanços nos últimos anos, haja vista que as salas das grandes redes - que detém o monopólio do parque exibidor brasileiro - voltam-se a promover o cinema sobretudo produzido na indústria estadunidense (Rosa & Tavares Filho, 2023).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Ao adentrarmos na discussão a respeito da formação de públicos para o audiovisual, é importante destacar que a Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda propõe um modelo integrado de educação e acesso ao audiovisual. A plataforma oferece recursos como trilhas curatoriais específicas e atividades formativas para educadores e estudantes, promovendo a alfabetização audiovisual. Por meio dessas ações, não apenas amplia-se o alcance das obras nacionais, mas também fomenta-se uma relação mais profunda entre o público jovem e a produção cultural brasileira, consolidando o cinema como uma ferramenta educacional e cultural poderosa.

Venanzoni (2021a) destaca que, enquanto política pública para o audiovisual, o foco deve estar na ampliação do acesso e na redistribuição de recursos, em vez de se restringir a produções voltadas exclusivamente para a lucratividade e a autossuficiência do setor como uma indústria global. A descentralização da produção possibilita o surgimento de novos arranjos produtivos que consideram, acima de tudo, o território e as especificidades de seus agentes locais. Esse aspecto territorial, frequentemente associado ao discurso da diversidade, também pode ser analisado em um nível conceitual, contrapondo a dimensão local à global e evidenciando o território como um espaço para a construção de novas narrativas locais.

Um dos perfis direcionados da Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda é o chamado perfil exibidor, composto por pontos de exibição diversos, a exemplo de cineclubes, que são capazes de formar público e criar comunidades de interesse. Com a intenção de integrar filmes nacionais ao currículo complementar integrado à proposta pedagógica da escola ou em salas de exibição para além dos parques exibidores, a plataforma possibilita o contato direto de estudantes, realizadores(as), cinéfilos e as mais diversas audiências com obras que refletem a diversidade e os desafios sociais do Brasil. Trata-se de um esforço para criar novas gerações de espectadores(as) mais informados(as) e com conhecimento da produção nacional e, em razão disso, aptos(as) a compreender, criticamente, o papel da produção audiovisual no fortalecimento da identidade cultural e na promoção de valores democráticos.

A plataforma pública pretende ir além da disponibilização de conteúdo ao fortalecer redes locais de exibição por meio de parcerias com cineclubes, escolas e outros pontos de difusão não comercial. Essas colaborações não apenas diversificam os meios de acesso ao audiovisual, mas também incentivam a formação de públicos em áreas menos favorecidas. A plataforma surge para atender a demandas de difusão e formação de públicos por se apresentar enquanto alternativa a parques exibidores de regiões periféricas e interiores - que no geral se apresentam em menor número e limitam o alcance de produções nacionais.

3.2 Difusão

De acordo com o informe anual mais recente "Mercado Cinematográfico", elaborado pela Ancine (ver Tabela 2), os longas brasileiros representaram apenas 3,2% do público total em 2023. Este número não difere dos dois anos anteriores, quando tivemos 1,7% (2021) e 4,2% (2022) na participação dos longas-metragens exibidos no público total – por nacionalidade da obra. O relatório apresentado pela Ancine (2024) coaduna com as pesquisas mais recentes sobre o audiovisual produzido na América Latina, como já apontado anteriormente, a respeito da incapacidade de se fazer cumprir políticas públicas de difusão do audiovisual desses países.

Tab. 2 - Panorama do mercado cinematográfico no país - 2023.

Região	Público	% Público	Renda (R$)	% Renda	Longas-metragens exibidos	Longas-metragens lançados
Longas brasileiros	3.701.853	3,2%	67.095.990,16	3,0%	271	161
Longas estrangeiros	110.374.722	96,8%	2.169.980.200,26	97,0%	438	254
TOTAL	114.076.575	100%	2.237.076.190,42	100%	709	415

Fonte: SAV/MINC.

Como resultado desse maior interesse pela produção estrangeira, temos mais dias de exibição nas salas de cinema. Um resultado também apresentado pela Ancine (2024) constatou que o número médio de dias de exibição dos longa-metragens estrangeiros em 2023 permaneceu o mesmo de 2022 (46 dias), enquanto a dos brasileiros subiu de 26 para 30 dias. Avaliando em perspectiva, são 16 dias a mais em exibição para a produção estrangeira - 52% a mais.

Como observado por Hesmondhalgh (2013), a distribuição é um aspecto central das indústrias culturais, desempenhando um papel crucial na formação de identidades e no fortalecimento das economias criativas. Na América Latina, a democratização da distribuição é fundamental para garantir que as produções regionais sejam acessíveis a públicos diversos, promovendo a inclusão e a equidade cultural.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Embora as plataformas de *streaming* aparentam estar em intensa competição e o setor enfrente constantes turbulências, a chamada "guerra dos *streamings*" reflete, em essência, uma disputa entre grandes conglomerados midiáticos e tecnológicos (Bahia *et al*., 2023). Esse cenário não necessariamente contribui para a democratização e ampliação da diversidade no mercado de vídeo sob demanda no Brasil. Pelo contrário, evidencia-se um movimento de concentração de poder e padronização dos conteúdos, o que influencia diretamente os debates sobre o direito à cultura.

Partindo desse princípio, é necessário se pensar em como dar conta de cumprir essa demanda da difusão de um audiovisual nacional. Ao ser concebida como uma plataforma pública de *streaming*, a Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda oferece um meio viável e acessível para que as instituições educacionais possam atender para além das exigências legais, pois considera um perfil direcionado – classificado como perfil educacional e tendo como objetivo facilitar o acesso a conteúdos audiovisuais diversificados e representativos da cultura brasileira. Essa dimensão educacional reflete a importância da integração entre tecnologias sociais e políticas públicas como forma de potencializar impactos sociais e culturais. A Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda não só demonstra a viabilidade de usar o *streaming* como ferramenta para a inclusão cultural e educacional, mas também contribui para o debate sobre a adoção das Tecnologias de Informação e Comunicação (TICs) pelo governo como estratégia para fortalecer o setor público, evidenciando uma criação de valor não limitada a aspectos financeiros, mas centrada nos impactos positivos gerados para os envolvidos, como maior acesso, inclusão e fortalecimento do campo da cultura nacional.

Ao utilizar o *streaming* como tecnologia social (Mulgan, 2019), a plataforma em questão responde a esse contexto ao propor um modelo de difusão que prioriza a inclusão. Diferentemente das plataformas comerciais, que frequentemente replicam as lógicas de mercado global, a referida plataforma busca valorizar a diversidade cultural em um país com dimensões continentais. Essa abordagem é essencial para enfrentar o domínio da indústria cultural que movimenta esse ciclo de produtoras e redes de parques exibidores, lançando um olhar para uma economia criativa local ou regional. Entendemos aqui a economia criativa como um modelo de desenvolvimento sustentável baseado na articulação entre cultura, território, tecnologia e inclusão produtiva, no qual bens e serviços simbólicos geram valor econômico e social.

De acordo com Leitão (2015), políticas públicas devem fomentar cadeias produtivas descentralizadas, infraestrutura digital e indicadores que evidenciam impactos simbólicos e materiais. Seu trabalho destaca ainda, a necessidade de equilibrar direitos autorais com acesso democrático, posicionando a cultura como núcleo de inovação e desenvolvimento territorial — princípios que dialogam diretamente com iniciativas como a plataforma Tela Brasil, ao integrar produção audiovisual independente, formação de públicos e democratização tecnológica.

A valorização e a promoção de narrativas locais são capazes de reforçar a representatividade cultural e ampliar o repertório de histórias acessíveis ao público. Assim, pode consolidar-se como uma ferramenta de transformação social, potencializando o papel do audiovisual como vetor da diversidade e equidade cultural. Enquanto uma iniciativa estratégica para inserir a produção nacional nesse mercado em expansão do *VOD*, amplia o alcance de curtas, longas, documentários e videoartes para públicos diversos. Além disso, ao adotar um *design* inclusivo e recursos de acessibilidade, a plataforma garante uma experiência rica para diferentes perfis de usuários.

3.3 Descentralização

Ao apontarmos o terceiro desafio, referente à descentralização, cabe considerar a princípio que o cinema brasileiro muitas vezes não consegue se inserir nas salas de cinema das grandes redes multinacionais. Esse aspecto pode se configurar como um complicador da distribuição pois, muitas vezes, os filmes circulam apenas nas chamadas salas de arte – que representam um menor número de espaços e tendem a levar um menor público. Ainda, embora a produção esteja em crescimento, a distribuição ainda é centralizada, com a maioria das obras, inclusive lançamentos, concentrados em grandes centros urbanos (Ancine, 2024).

A concentração da infraestrutura cultural nas capitais e grandes centros urbanos é um problema recorrente no Brasil. Dados do informe "Mercado Cinematográfico" (Ancine, 2024), embora o parque exibidor brasileiro aponte um crescimento nas últimas duas décadas. Esse número representou apenas 8,1% das cidades com ao menos uma sala de cinema (ver Tabela 3). Com 3.468 salas em 2023, tendo a Região Sudeste mais da metade (1.815), o resultado evidencia a exclusão de grande parte da população do acesso direto ao audiovisual em espaços tradicionais.

Tab. 3 - Total de salas em funcionamento por região geográfica - 2014 a 2023.

Região	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Centro-Oeste	245	258	274	279	285	286	170	280	285	293

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Nordeste	403	446	490	513	548	586	356	529	600	597
Norte	156	194	198	212	228	235	169	204	221	222
Sudeste	2.574	1.660	1.728	1.718	1.761	1.846	1.012	1.739	1.774	1.815
Sul	455	447	470	501	525	554	153	514	535	541
Brasil	**3833**	**3005**	**3160**	**3223**	**3347**	**3507**	**1860**	**3266**	**3415**	**3468**

Fonte: SAV/MINC.

Em conformidade com esse recorte histórico a respeito da concentração dos parques exibidores, podemos inferir que a Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda apresenta-se como uma alternativa para enfrentar essa assimetria entre as regiões do país, utilizando o *streaming* como ferramenta de ampliação do acesso. Por meio de sua tecnologia de distribuição digital, a plataforma possibilita que conteúdos audiovisuais alcancem regiões remotas, descentralizando assim o consumo cultural e promovendo a inclusão de comunidades historicamente marginalizadas do circuito cinematográfico.

No contexto latino-americano, iniciativas como a Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda também enfrentam o desafio de descentralizar a produção e a distribuição. Como apontado em Canclini (2015) e Ortiz (2006), a centralização das indústrias culturais em grandes centros urbanos limitou o acesso às produções regionais e perpetua desigualdades históricas. O desenvolvimento de uma plataforma com a citada neste trabalho representa um esforço para romper com essa lógica, promovendo a descentralização do consumo e valorizando a diversidade cultural do país.

Nessa perspectiva, a plataforma pode garantir um espaço para produtoras nacionais corrigindo desigualdades históricas, garantindo que a pluralidade cultural do país possa ser representada e valorizada a partir das produções audiovisuais disponibilizadas na plataforma. Sua atuação pode se tornar um modelo para outros países latino-americanos que enfrentam desafios semelhantes, reafirmando o papel do Estado como promotor da cultura e da inclusão digital.

Conforme definido por Rubim (2007), as políticas públicas culturais visam garantir a diversidade e a pluralidade cultural, promovendo tanto o acesso aos bens e serviços culturais quanto o incentivo à produção e circulação de expressões artísticas e simbólicas. Elas devem também considerar as especificidades regionais, sociais e históricas, de modo a fortalecer identidades culturais e assegurar a representatividade de diferentes grupos sociais. Entendemos que plataformas com as características descritas neste trabalho podem, em complemento a outras ações estatais, contribuir para o fortalecimento das políticas de incentivo à produção e circulação do audiovisual brasileiro em seus diversos gêneros e formatos.

Procurando oferecer a visibilidade à diversidade cultural e criativa do audiovisual brasileiro, garantindo a presença da pluralidade de linguagens, formatos e estéticas e o reconhecimento cultural dos diversos grupos sociais - considerando o âmbito das questões de classe social, gênero e étnico-raciais -, a Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda pode promover uma agenda de diversidade que está intrinsecamente ligada aos valores de inclusão e equidade social.

4. Considerações Finais

Em conformidade com as discussões ora levantadas, este trabalho teve como objetivo apresentar a iniciativa da Plataforma Pública de Acesso e Difusão de Conteúdos Audiovisuais Brasileiros Sob Demanda como tecnologia social para formação de públicos, difusão e descentralização dos espaços de exibição. Apontamos no texto que, ao adotar o *streaming* como uma tecnologia social, a plataforma oferece uma alternativa para superar as limitações da infraestrutura física, descentralizar a distribuição e promover a inclusão cultural a partir de uma abordagem integrada, que combina a distribuição digital com ações educativas e culturais voltadas para a formação de públicos.

A proposta da plataforma ora apresentada exemplifica a adoção estratégica de tecnologias sociais pela Secretaria do Audiovisual do Ministério da Cultura do Brasil para promover transformações sociais, culturais e educacionais, pois procura integrar uma rede que perpassa alguns perfis de usuários: voltados para os cidadãos ou direcionados – escolas e pontos de exibição.

Conforme Sylvestre (2024), conclui-se pela necessidade de assegurar que a formulação dessa política não apenas se some às muitas outras iniciativas públicas e, essencialmente, gratuitas de difusão. Mas, que o Governo Federal viabilize tal ação se posicionando como agregador e fomentador da difusão audiovisual, consultando atores institucionais relacionados à temática e no desenho de um modelo "que traga proeminência às iniciativas públicas e gratuitas já desenvolvidas, congregando e potencializando todos os esforços e investimentos públicos e privados

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

(de interesse público) já desenvolvidos no segmento".

Com base em princípios da equidade, a plataforma tem o propósito de conferir a representatividade da produção regional e local, servindo como um espaço para que jovens criadores(as) e independentes compartilhem suas criações, promovendo a descoberta de novos talentos e projetos inovadores. Por outro lado, ao democratizar o acesso, a plataforma rompe as barreiras geográficas e dá aos produtores nacionais o alcance que, de outra forma, seria restrito.

Neste contexto de grande discrepância em relação a outros mercados, as tecnologias de *streaming* audiovisual configuram-se como marcos no avanço do consumo mediado por plataformas digitais, transformando hábitos culturais e impactando as formas de produção, distribuição e acesso a conteúdos. No Brasil, o crescimento das plataformas de *streaming* reflete não apenas a incorporação de tecnologias globais, mas também um debate sobre inclusão, democratização e o papel do audiovisual na formação de públicos, no conhecimento e promoção da diversidade cultural.

Trata-se, nessa perspectiva, de uma política pública cultural ao utilizar toda sua infraestrutura digital planejada de modo a superar os limites físicos de distribuição, um ponto crítico em países da América Latina, onde - como discutimos - apresentam no geral uma concentração dos parques exibidores para os centros metropolitanos.

Podemos considerar que o projeto não só pode ser capaz de ampliar a circulação de obras que antes ficavam restritas aos circuitos tradicionais, mas também, a médio prazo, estimular as indústrias criativas locais, potencializando a diversidade cultural como um ativo estratégico para o desenvolvimento social e econômico do Brasil.

Os resultados alcançados nesta pesquisa não levam a conclusões definitivas, uma vez que foi baseado em uma pesquisa documental. Esta deve ser organizada por meio de debates acadêmicos e políticos, resultando em políticas centradas numa combinação de estratégias do audiovisual brasileiro, incluindo a distribuição, o financiamento e a formação dos públicos para a acessibilidade da plataforma.

Acknowledgement

- **Grant:** Secretaria do Audiovisual do Ministério da Cultura (Termo de Cooperação 0882120230034).
- **Declaração de contribuição:** Luciana Santa Rita: Conceitualização; Escrita - Rascunho Original; Thiago Cordeiro: Escrita, Revisão e Edição; Anderson Barbosa: Conceitualização; Natalício Santos Junior: Supervisão, Escrita - Revisão e Edição; Christiane Cabral: Supervisão, Escrita - Revisão e Edição; Julia Rosa: Revisão; Aluísio Rego: Metodologia, Vitor Braga: Escrita - Revisão e Edição, Conceitualização; Adriana Gomes: Conceitualização; Lina Távora: Conceitualização; Daniela Fernandes: Conceitualização.
- **Uso de IA**: Durante a elaboração deste trabalho, os autores utilizaram o ChatGPT com o objetivo de melhorar o texto. Após a utilização desta ferramenta/serviço, os autores revisaram, editaram, tornaram o conteúdo seu e validaram o resultado conforme necessário, assumindo total responsabilidade pelo conteúdo da publicação.
- **Conflito de interesses (COI):** Não existe qualquer conflito de interesses.

References

Alvaray, L. (2023). Of how streaming platforms are changing the audiovisual space in Latin America. *Transnational Screens, 14*(1), 1–19. https://doi.org/10.1080/25785273.2023.2170762

Ancine. (2024). Mercado Cinematográfico: Informe Anual. https://www.gov.br/ancine/pt-br/oca/publicacoes/arquivos.pdf/informe-mercado-cinematografico-2023.pdf

Bahia, L., Butcher, P., & Tinen, P. (2023). O setor audiovisual e os serviços de streaming: Da necessidade de repensar a regulação e as políticas públicas. *Revista Eletrônica Internacional De Economia Política Da Informação Da Comunicação E Da Cultura, 24*(3), 101–116. https://doi.org/10.54786/revistaeptic.v24i3.17814

Baute, L. F. (2022). Apontamentos para um estudo sistemático de SVOD's: uma análise da plataforma Netflix. *XVI Colóquio Internacional em Economia Política dos Sistemas-Mundo.*https://gpepsm.paginas.ufsc.br/files/2023/01/Baute.pdf

Bernardet, J. (2007). *Brasil em Tempos de Cinema.* São Paulo: Cia. das Letras.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Brasil, A. (2020). *Audiovisual Brasileiro no Contexto Digital: Desafios e Oportunidades.* Belo Horizonte: UFMG.

Canclini, N. G. (2015). *Culturas Híbridas: Estratégias Para Entrar e Sair da Modernidade* (4. ed). São Paulo: Edusp.

Fran, A. (2024). Streaming wars: Navigating the Competitive Landscape. *Global Media Journal, 22*(70), 150–172.

Gambarato, R. R., Heuman, J., & Lindberg, Y. (2022). Streaming media and the dynamics of remembering and forgetting: The Chernobyl case. *Memory Studies, 15*(2), 271–286. https://doi.org/10.1177/17506980211037287

García-Orta, M. J., García-Prieto, V., & Suárez-Romero, M. (2019). New audiovisual consumption habits among minors: Approximation through the analysis of survey data. *Doxa Comunicación, 28*, 241–260. https://doi.org/10.31921/doxacom.n28a01

Geraldes, E., & Carvalho, M. T. (2014). Políticas culturais de acesso ao cinema brasileiro: Trajetórias e desafios. *Revista Comunicação Midiática, 9*(2), 82–97. https://www2.faac.unesp.br/comunicacaomidiatica/index.php/CM/article/view/187/188

Gilbert, A. (2019). Push, pull, rerun: Television reruns and streaming media. *Television & New Media, 20*(7), 686–701. https://doi.org/10.1177/1527476419842418

Global Streaming Market Overview. Reportlinker. https://www.reportlinker.com/market-report/Broadcasting/726697/Streaming-Platform?term=streamingplatformstatistics

Grandinetti, J. (2017). From primetime to anytime: Streaming video, temporality and the future of communal television. In C. Barker & M. Wiatrowski (Eds.), *The Age of Netflix: Critical Essays on Streaming Media, Digital Delivery and Instant Access* (pp. 11–30). Jefferson, NC: McFarland and Company, Inc.

Hesmondhalgh, D. (2013). *The cultural industries* (3rd ed.). London: SAGE.

IBGE. Instituto Brasileiro de Geografia e Estatística (2023). PNAD Contínua: Indicadores trimestrais. https://www.ibge.gov.br/estatisticas/sociais/trabalho/9173-pnad-continua.html

Jambeiro, O., Ferreira, F., & Torquato, C. (2011). A Convergência como condicionante da Regulação das Comunicações. *Compolitica, 1*, 45–65.

Kantar IBOPE Media. (2024). Share de Audiência – Dezembro/2024. https://kantaribopemedia.com/audiencia-de-video/

Lobato, R. (2019). *Netflix Nations: The Geography of Digital Distribution.* New York University Press.

Lotz, A. D. (2022). *Netflix and Streaming Video: The Business of Subscriber-Funded Video on Demand.* Cambridge, UK: Polity.

Loureiro, C. B., & Lopes, M. C. (2015). Inclusão digital: Uma via para a responsabilização individual. *Momento - Diálogos em Educação, 24*(2), 122–136. https://periodicos.furg.br/momento/article/download/9235/7611/35674

Martin-Barbero. (2009). *Dos meios às mediações: Comunicação, cultura e hegemonia.* Rio de Janeiro: Editora UFRJ.

Menezes, M. (2025). O audiovisual do Brasil no lugar que merece. Agência Gov. https://agenciagov.ebc.com.br/noticias/202501/o-audiovisual-do-brasil-no-lugar-que-merece

Ministerio de Cultura de la Nación (Argentina). (2022). *Fomento audiovisual en la Argentina: Iniciativas y resultados.*

Mulgan, G. (2019). *Social innovation: How societies find the power to change.* Policy Press.

Murray, S. (2021). On video platforms: Netflix and the evolution of digital distribution. *Media, Culture & Society, 43*(2), 459–467. https://doi.org/10.1177/0163443720972314

Nova Filho, M. V. M. da, Chiarini, T., & Marcato, M. B. (2023). Plataformização do mercado audiovisual: A indústria de streaming de vídeo no Brasil. Instituto de Pesquisa Econômica Aplicada (Ipea).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Oliveira, A., Pinheiro, P., & Dutra, J. (2023). Serviços de streaming: Histórico, consumo e perspectivas. *RECIMA21 - Revista Científica Multidisciplinar, 4*(11), e4114314. https://doi.org/10.47820/recima21.v4i11.4314

Ortiz, R. (2006). *Mundialização e Cultura.* São Paulo: Brasiliense.

Portal Gov.br. (2024, 27 de junho). Governo Federal anuncia R$ 1,6 bilhão em investimentos para o setor audiovisual. Portal Gov.br. https://www.gov.br/planalto/pt-br/acompanhe-o-planalto/noticias/2024/06/governo-federal-anuncia-r-1-6-bilhao-em-investimentos-para-o-setor-audiovisual

Revista Piauí. (2022, 19 de dezembro). No Brasil há uma sala de cinema para cada 59 mil habitantes; nos Estados Unidos, proporção é de 1 para 8,5 mil. Revista Piauí. https://piaui.folha.uol.com.br/no-brasil-ha-uma-sala-de-cinema-para-cada-59-mil-habitantes-nos-estados-unidos-proporcao-e-de-1-para-85-mil/

Rosa, B. B., de Armas, M. B., & Tavares Filho, P. R. (2023). Formação de público para o cinema nacional e potencialidade das salas independentes de cinema. *Contribuiciones a las Ciencias Sociales, 16*(6), 4329–4340. https://doi.org/10.55905/revconv.16n.6-080

Rubim, A. A. (2007). Políticas culturais no Brasil: Tristes tradições, enormes desafios. In A. A. Rubim (Ed.), *Políticas culturais no Brasil.* EDUFBA.

Selva, A. R. (2016). La brecha digital en América Latina. *Congresso ALAIC 2014.*https://congreso.pucp.edu.pe/alaic2014/wp-content/uploads/2013/09/GT12-Alma-Alva.docx

Shattuc, J. (2020). Netflix, Inc. and online television. In J. Wasko & E. R. Meehan (Eds.), *A companion to television*(2nd ed., pp. 145–164). Wiley. https://doi.org/10.1002/9781119269465.ch7

Smith, J. A., & Thompson, L. M. (2024). Global streaming platforms and local content: Navigating cultural policies in the digital age. *Journal of International Media Studies, 12*(1), 45–67.

Sylvestre, A. P. M. (2024). Democratização audiovisual sob demanda: Referenciais para o Streaming público brasileiro. *Proceedings of XII Seminário Internacional de Políticas Culturais, 12*, 836–848.

Venanzoni, T. S. (2021a). Diversidade e democratização no cinema e no audiovisual brasileiro: Um panorama de 2001 a 2021. *Novos Olhares, 10*(2), 88–100. https://doi.org/10.11606/issn.2238-7714.no.2021.190170

Venanzoni, T. S. (2021b). Diversidade social e políticas culturais: Práticas discursivas e coletivas no audiovisual brasileiro contemporâneo [Doctoral dissertation, Universidade de São Paulo]. Escola de Comunicação e Artes.

Villén Higueras, S. J., & Ruiz del Olmo, F. J. (2022). La cultura hacker en las estrategias transmedia de las series de televisão: El caso de Mr. Robot (2015-2019). *ZER: Revista de Estudios de Comunicación, 27*(52), 35–56.

Wayne, M. L. (2020). Netflix, Amazon, and branded television content in subscription video on-demand portals. *Media, Culture & Society, 42*(5), 725–741. https://doi.org/10.1177/0163443720914025

Xinhua News Agency. (2025, 2 de janeiro). Receita de bilheteria da China totaliza 42,5 bilhões de yuans em 2024. *Xinhua News Agency.* https://portuguese.xinhuanet.com/20250102/a658fadd2870425e9372202b58420ea1/c.html

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Serviços eletrônicos de governo, *datafication* e *data justice:* o caso do Auxílio Emergencial no Brasil

Luiz Claudio Mendes Vargas [a*], *Marie Anne Macadar* [b],

[a] The COPPEAD Graduate School of Business, Federal University of Rio de Janeiro (UFRJ), Brazil, luiz.vargas@coppead.ufrj.br, https://orcid.org/0000-0002-9410-7153

[b] The COPPEAD Graduate School of Business, Federal University of Rio de Janeiro (UFRJ), Brazil, marie.macadar@coppead.ufrj.br, https://orcid.org/0000-0003-2744-5352

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Este artigo aborda o contexto dos casos em que o crescimento da disponibilidade de dados permite aos governos prover serviços a partir da identificação e análise automática dos beneficiários. Com o objetivo de entender como questões relacionadas a *datafication* e *data justice* estão sendo consideradas na implementação de serviços de governo eletrônico no Brasil, este estudo utilizou uma abordagem metodológica qualitativa baseada no estudo de caso do Auxílio Emergencial da COVID-19. Os resultados obtidos indicam que ainda há necessidade de evolução nos mecanismos para mitigar riscos e garantir aderência aos direitos básicos de dados, transparência, procedimentos justos e equidade nos resultados. Por não termos todos os conceitos relacionados aos riscos de desigualdade e injustiça de dados disseminados e endereçados entre os agentes públicos responsáveis pela implantação de serviços eletrônicos de governo baseados no uso intensivo de dados, o debate sobre exclusão digital se mantém relevante. Além disso. este artigo contribui para a literatura acadêmica com a apresentação de um modelo conceitual baseado no referencial teórico de *datafication* e *data justice*, aplicado a um caso real no Brasil.

Keywords. *Data justice. Datafication*. Auxílio Emergencial COVID19. Governo Eletrônico.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1002

1. Introdução

A evolução da tecnologia digital tem como um dos seus principais resultados o expressivo aumento da capacidade de geração, processamento e uso de dados. Com as novas tecnologias observamos um crescimento exponencial do volume e tipo de dados disponíveis, que têm proporcionado inúmeras possibilidades de desenvolver ações a partir do que estes dados informam, e transformar a sociedade através de novos serviços eletrônicos (UN, 2014). O avanço na aplicação das tecnologias de informação e comunicação (TIC), por parte dos governos e das empresas, fomenta a disseminação de serviços que têm os dados como motor principal e faz com que o crescimento do uso e impacto dos dados nos processos sociais seja um fenômeno mundial, inclusive no contexto do desenvolvimento econômico internacional (Heeks & Shekhar, 2019; Taylor & Broeders, 2015). À medida que o uso de serviços eletrônicos e dispositivos tecnológicos cresce, temos um crescimento na disponibilidade dos dados digitais e isso tem reflexo no desenvolvimento econômico e humano (Taylor, 2017).

Podemos considerar cinco formas principais de como os dados geram valor. Os dados podem ser utilizados para definir o tipo de pessoa e perfil alvo para produtos e serviços, para otimizar sistemas, para gerenciar de equipamentos e atividades, para desenvolver modelos probabilísticos, para apoiar na construção de coisas e aumentar o valor de ativos (Sadowski, 2019). Neste contexto torna-se fundamental coletar cada vez mais dados e de uma variedade cada vez maior de fontes, para gerar mais valor.

A comunidade acadêmica se aprofundou neste tema e vários conceitos foram criados para definir e analisar este fenômeno. Termos como *data revolution* (UN, 2014), *data innovations* (Porto de Albuquerque et al., 2021), *datafication* (Heeks & Shekhar, 2019; Taylor & Broeders, 2015) e *data-intensive development* (Heeks, 2017b; Heeks & Renken, 2016; Taylor, 2017) têm sido utilizados para caracterizar esse movimento de desenvolvimento econômico baseado nos dados. Sobre esses dois últimos, *datafication* representa o crescimento da presença, uso e impacto dos dados na sociedade (Heeks & Shekhar, 2019; Taylor & Broeders, 2015), e *data-intensive development*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

representa o uso crescente dos dados no processo de desenvolvimento socioeconômico, isto é, dados desempenhando um papel cada vez mais relevante no processo de desenvolvimento uma vez que se tornam um insumo fundamental para diversas aplicações (Heeks, 2017b; Heeks & Renken, 2016; Taylor, 2017).

Ao mesmo tempo, crescem as preocupações com questões de inclusão social e sustentabilidade no desenvolvimento econômico internacional, refletidas nos compromissos estabelecidos entre os países membros da Organização das Nações Unidas (ONU), a Agenda 2030 para o Desenvolvimento Sustentável e os Objetivos de Desenvolvimento Sustentável (ODS). Estes dois fenômenos estão interrelacionados, uma vez que a tecnologia digital é considerada um fator-chave para a implementação dos ODS (Janowski, 2016) .

Se por um lado há uma grande expectativa sobre os impactos positivos que a aplicação das TIC e o desenvolvimento baseado em dados pode gerar, por outro lado, há uma preocupação com possíveis impactos adversos relacionados ao contexto social. O conceito de *data justice* traz uma perspectiva de tratamento justo para todos no contexto da aplicação das TIC e do uso intensivo dos dados. As preocupações estão relacionadas com a exclusão social que pode ser gerada em função da existência de estruturas, processos e recursos dos sistemas de dados contaminados por desigualdades sociais, entre grupos étnicos, gêneros, classes, entre outros aspectos sociodemográficos (Heeks, 2020; Heeks & Renken, 2016; Johnson, 2014; Lutz, 2019; Taylor, 2017; Zheng & Walsham, 2021). A ótica de *data justice* está relacionada à forma como as pessoas se tornam visíveis, são representadas e tratadas em função dos dados digitais produzidos por elas (Taylor, 2017).

Em resumo, o avanço na aplicação das TIC, especialmente no setor público, e, consequentemente, o crescimento exponencial de geração, uso e circulação de dados trazem uma contribuição positiva para a evolução das sociedades e construção de um futuro mais sustentável. Entretanto, é preciso discutir sobre como as questões relacionadas às desigualdades sociais estão refletidas no processo de transformação baseada em dados e na aplicação das TIC pelos governos.

O estudo se propõe a responder a seguinte pergunta de pesquisa: **Considerando os conceitos de *datafication* e *data justice*, de que forma os riscos associados ao crescimento das aplicações baseadas no uso intensivo de dados estão sendo considerados na implementação de serviços de governo eletrônico no Brasil?** O presente artigo visa contribuir para a literatura acadêmica fazendo uma análise exploratória baseada no estudo de caso do Auxílio Emergencial implementado no Brasil durante a pandemia do COVID-19. Este auxílio consiste em um programa de assistência social baseado no uso de diversas bases de dados gerenciadas pelo governo brasileiro, seguindo um modelo de serviço de governo eletrônico *datafied*.

2. Referencial Teórico

Datafication

O conceito de *datafication* está relacionado a transformação das informações sociais em dados, à obtenção de dados sobre mais coisas, à obtenção de mais dados sobre as mesmas coisas e à obtenção de dados mais pormenorizados sobre as coisas (Heeks, 2017b). Em outras palavras, implica transformar em dados diversas ações, atitudes, registros entre outras coisas (Heeks & Shekhar, 2018; Krishna, 2021; Masiero & Das, 2019). É um fenômeno crescente, fomentado pela evolução da tecnologia digital e do uso cada vez maior de soluções tecnológicas pela sociedade. Esse processo transformou os dados em um ativo de valor, capaz de se transformar no motor de novos negócios desenvolvidos com uso da tecnologia digital, e o crescimento do uso e da dependência de tecnologias orientadas por dados na sociedade é visto como propulsor de transformações em governos, negócios e na sociedade civil (Dencik & Sanchez-Monedero, 2022).

Esse movimento crescente de uso de dados atingiu o setor público, inicialmente com o conceito de *open data* (Cukier & Mayer-Schoenberger, 2013). A crescente geração e uso de dados também foi considerada como positiva para políticas públicas voltadas para a agenda de desenvolvimento sustentável, tendo em vista que os dados seriam essenciais para orientar o desenvolvimento de políticas e medir seu impacto sobre os ODS (Heeks & Shekhar, 2019; UN, 2014). Além disso, o processo de *datafication* também gera impactos nos programas sociais de proteção de renda e combate à pobreza. A disponibilidade de dados legíveis por computadores permite o reconhecimento automatizado dos beneficiários e uma redução dos erros de inclusão e exclusão destes, visando a atribuição correta de direitos (Masiero & Das, 2019). Desta forma, os processos operacionais de programas sociais têm se tornado cada vez mais computadorizados, de forma que os dados dos beneficiários passam a ter papel determinante nos processos decisórios dos programas sociais (Valente & Fragoso, 2021).

Data-intensive development

O termo *data-intensive development* é aplicado quando expandimos a discussão para o impacto que a utilização deste grande volume de dados tem sobre o desenvolvimento econômico, e se refere à crescente presença e uso de dados nos processos de desenvolvimento econômico. Os discursos sobre a "revolução dos dados" tornaram-se

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

comuns nas diretrizes de empresas e governos para promover o desenvolvimento econômico e social (Cinnamon, 2020; Heeks, 2017a; Heeks & Renken, 2016). Conforme as tecnologias como a microeletrônica, computação em nuvem, conectividade, internet das coisas, inteligência artificial e *data analytics* evoluem, cresce o interesse na aplicação destas tecnologias para gerar e processar um volume cada vez maior de dados e utilizá-los como recursos para o desenvolvimento econômico. Esta evolução é parte integral de como a sociedade se organiza e toma decisões (Dencik et al., 2019).

A discussão em torno dos impactos do desenvolvimento baseado em dados também envolve preocupações com a possibilidade de exclusão ou discriminação de parte da população dos serviços públicos e privados, se não houver igualdade nas condições de acesso aos dados, no manuseio e elaboração de algoritmos e aplicativos baseados nestes dados. De acordo com a forma como os dados são construídos é possível que as injustiças sociais sejam incorporadas nos próprios dados. Seja por projeto ou como consequências não intencionais, o processo de construção de sistemas de dados pode incorporar valores sociais e padrões de privilégio, e quando esses valores e privilégios são injustos, a injustiça é então uma caraterística dos próprios dados (Johnson, 2014).

Data Justice

Este debate evoluiu ao longo do tempo, com contribuições de diversos autores na construção do conceito de *data justice*. Heeks & Renken (2016) definem *data justice* como padrão ético pelo qual devem ser avaliados os recursos, processos e estruturas relacionados com os dados, e argumentam que é necessário inserir este conceito em projetos relacionados ao uso, manuseio e distribuição dos dados gerados pelas diversas aplicações. A vigilância baseada em dados, a tomada de decisões e a governança relacionada ao *Big Data* são aspectos sobre os quais surgem preocupações com a incorporação de valores sociais e padrões de privilégio e que o conceito de *data justice* busca colocar em destaque (Dencik et al., 2016).

Taylor, (2017) faz uma importante contribuição para este debate, apresentando um *framework* que concilia a visão dos autores citados acima , tendo como base três pilares: visibilidade, que reforça a importância da representatividade e ao mesmo tempo a preocupação com a privacidade da informação; engajamento com a tecnologia, que envolve compartilhar os benefícios e ter autonomia para escolhas tecnológicas; e não-discriminação, que se desdobra em poder para identificar e desafiar o viés discriminatório nos dados e prevenir a discriminação. Desta forma, *data justice* representa equidade na forma como as pessoas são tornadas visíveis, representadas e tratadas como resultado de sua produção de dados digitais (Taylor, 2017).

Data justice é uma resposta a questões sobre as implicações sociais das tecnologias baseadas em dados que tendem a centrar-se em questões de eficiência e segurança, por um lado, e em preocupações com a privacidade e a proteção de dados, por outro (Dencik et al., 2019). Em uma visão mais ampla, refere-se à preocupações com justiça social nos sistemas de informação, desde ética e diretos humanos até a orientação de ativismo e movimento sociais (Dencik & Sanchez-Monedero, 2022).

Heeks & Shekhar (2018) apresentaram um *framework* com objetivo de aplicar o conceito de *data justice* na análise de sistemas de uso intensivo de dados (*datafied systems*). A expectativa era que o modelo fosse capaz de incorporar todos os tipos de justiça de dados e fosse utilizado para compreender como o poder sobre os dados é exercido no processo de desenvolvimento com uso intensivo de dados As dimensões de *data justice* propostas por Heeks & Shekhar (2018) estão relacionadas a diferentes aspectos desta interação entre o sistema de dados e o contexto que o envolve, conforme **Tabela *1***.

Tabela 1- Descrição das dimensões de *data justice*

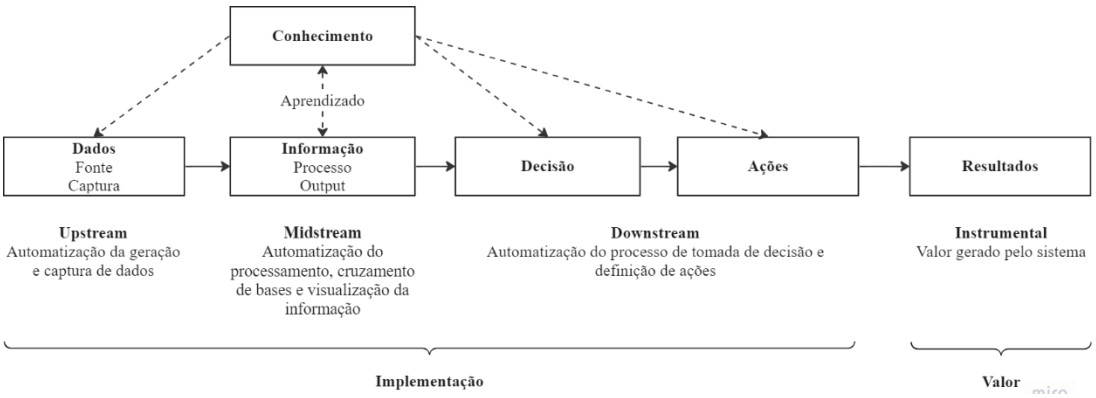
Dimensões	Descrição
Procedural	Justiça na forma como os dados são tratados.
Instrumental	Justiça no resultado do uso dos dados.
Rights-based	Aderência, em todas as fases da cadeia, aos chamados direitos associados aos dados, como representatividade, privacidade, acesso e propriedade.
Structural	Como a distribuição e o fluxo de poder e interesses suportam resultados justos ou não.
Distributive	Dimensão abrangente, como um guarda-chuva para as demais, avaliando se há resultados justos em todas as outras dimensões.

Fonte: (Heeks & Shekhar, 2018)

Neste modelo, o tratamento dos dados pode ser avaliado com base no modelo da cadeia de valor da informação (Heeks, 2017c; Heeks & Shekhar, 2018), que representa o processo de captura e coleta de dados, processamento e visualização, uso da informação para tomada de decisões e definição de ações e, por fim, entrega dos resultados (**Figura 1**).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Figura 1 - Cadeia de valor da informação



Fonte: (Heeks, 2017c); (Heeks & Shekhar, 2018)

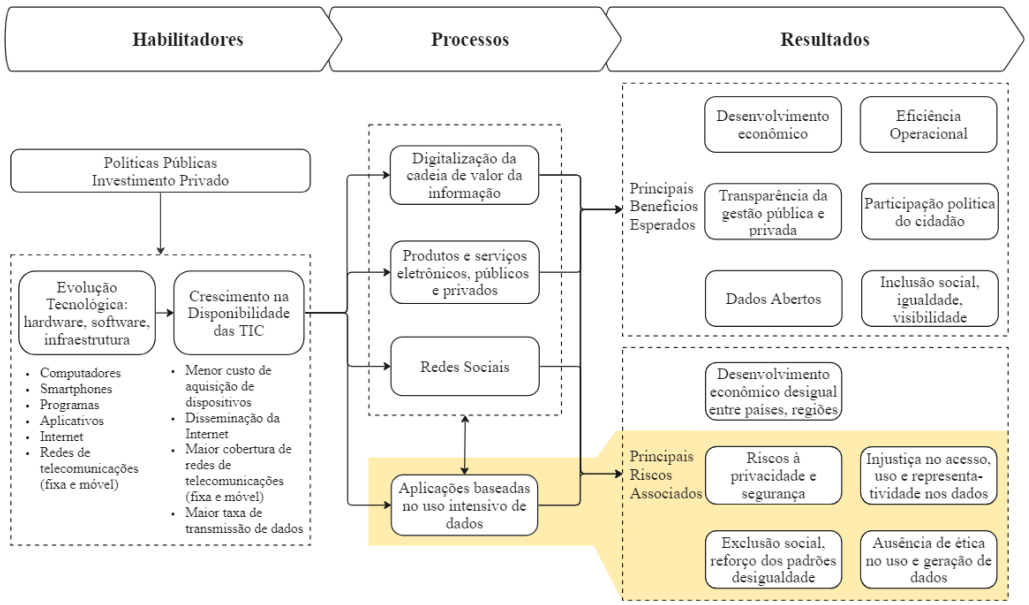
A combinação desta visão das etapas da cadeia de valor com as cinco dimensões do framework de análise de *data justice*, serve de base para as discussões sobre os desafios do desenvolvimento baseado no uso intensivo de dados e da garantia de justiça social.

3. Modelo conceitual

Para cumprir o objetivo proposto, a análise foi baseada no modelo conceitual elaborado a partir do fluxo de impacto das TIC (**Figura 2**), dos frameworks de *data justice* (Heeks, 2017a; Heeks & Shekhar, 2018) e da cadeia de valor da informação (Heeks, 2017a).

O fluxo de impacto das TIC (Vargas, 2024) ilustra que a evolução tecnológica e aumento da disponibilidade das TIC habilitaram processos de transformação digital, novos serviços eletrônicos e aplicações baseadas no uso intensivo de dados que geram benefícios para a sociedade, mas que também implicam em riscos. Tendo este *framework* como base, o foco deste estudo concentra-se nas aplicações baseadas no uso intensivo de dados e nos riscos à privacidade, segurança, exclusão social, ética e representatividade nos dados, que estão associados aos resultados gerados por estas aplicações.

Figura 2 – Fluxo de Impacto das TIC



Fonte: Vargas (2024)

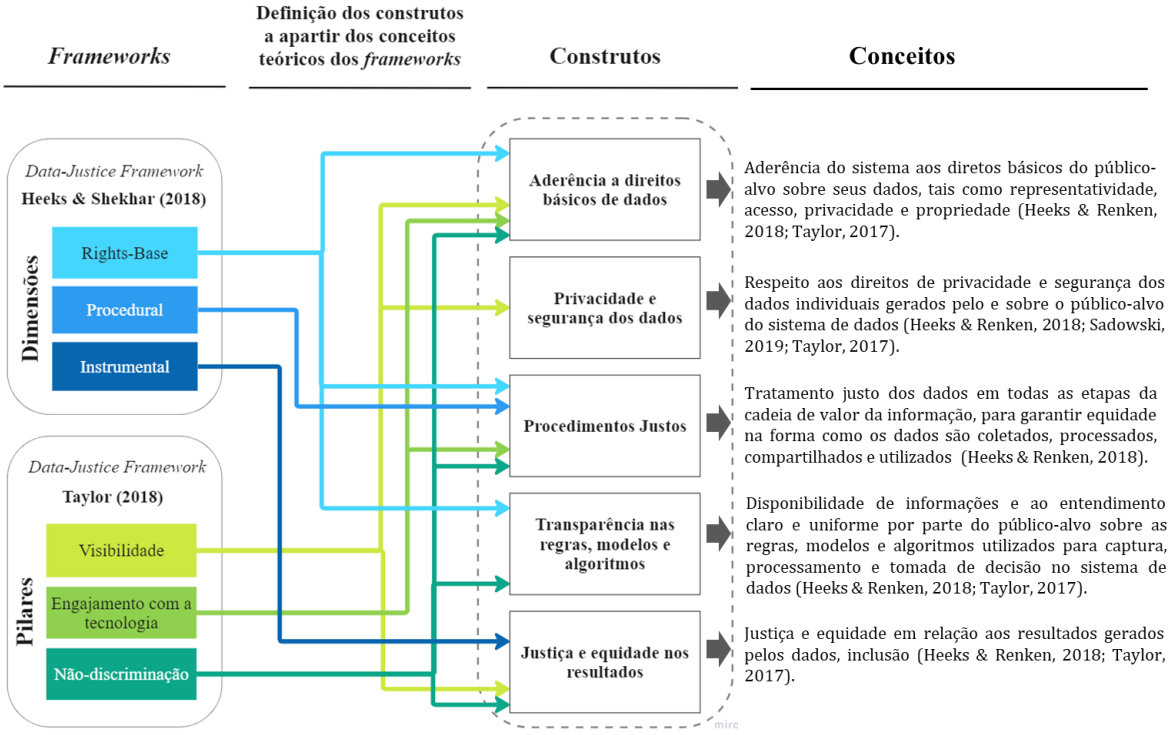
Os *frameworks* desenvolvidos por Taylor (2017) e Heeks & Renken (2018) foram utilizados para a concepção dos construtos do modelo conceitual (**Figura 3**), uma vez que estes se ocupam de temas relevantes na discussão sobre justiça no contexto de uso intensivo de dados por um programa social de proteção de renda e combate à pobreza,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

que são visibilidade, elegibilidade, representatividade, transparência sobre o tratamento e proteção dos dados da população que será beneficiada.

Figura 3 – Frameworks e Construtos

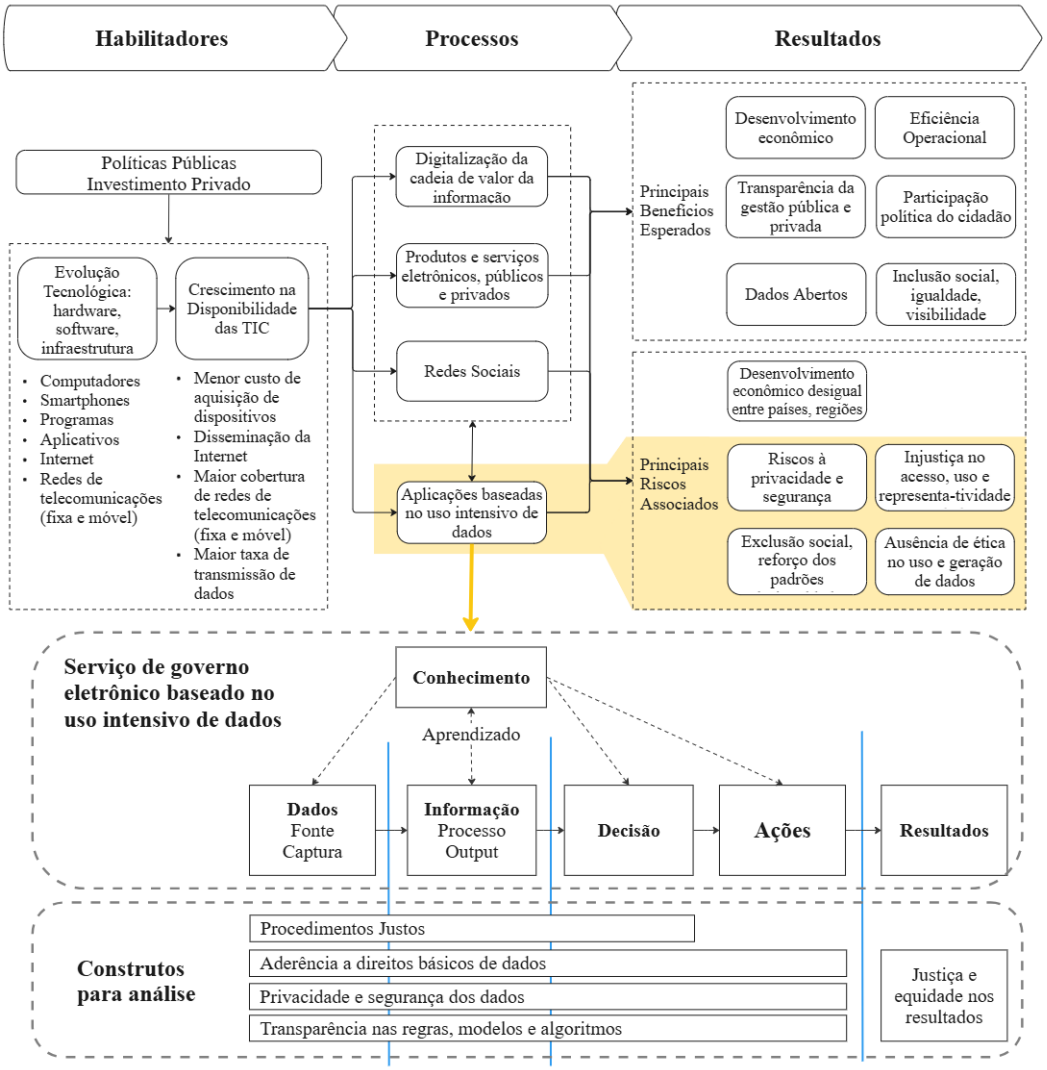


Fonte: Elaborado pelos autores

O modelo conceitual (**Figura 4**) concentra-se em aplicações baseadas em uso intensivo de dados e avalia como os riscos associados aos resultados gerados estão sendo considerados ao longo do processo operacional representado pela cadeia de valor da informação. Os construtos para a análise são relacionados às etapas operacionais da referida aplicação e servem de base para a coleta e análise dos dados do estudo de caso.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Figura 4 – Modelo Conceitual



Fonte: Elaborado pelos autores.

4. Metodologia

Este estudo utilizou uma abordagem metodológica qualitativa, baseada no método de estudo de caso (Creswell, 2007). Esta estratégia de pesquisa é aplicável quando se deseja explicar ou explorar um fenômeno cuja análise não exige controle sobre eventos comportamentais e focaliza acontecimentos contemporâneos (Yin, 2001). Assim, o caráter exploratório observado nesta pesquisa visa entender como cidadãos são impactados pelo processo de *datafication* na prestação de serviços de governo eletrônico no Brasil.

Assim foi definido como unidade de análise primária um programa social oferecido pelo pelo governo brasileiro, o Auxílio Emergencial da COVID-19, que teve enorme visibildiade e relevância como ação governamental. Este caso foi selecionado porqe o fluxo de cadastramento e controle se baseia na coleta, análise e tomada de decisão baseada em dados da população, logo podemos considerá-lo como um exemplo de *datafication* no contexto de serviço eletrônico em governo.

A coleta de dados se deu por meio de três tipos de fontes: entrevistas com agentes públicos que atuaram no caso, artigos acadêmicos (Bacchiegga et al., 2022; Cardoso, 2020, 2021; Marins et al., 2021; Valentin et al., 2022), que analisaram o caso, documentos como atos normativos publicados entre abril de 2020 e março de 2023 e relatórios (CNJ, 2022; Dataprev, 2020, 2021, 2022). O objetivo das entrevistas era capturar a visão de uma amostra de agentes públicos que atuaram no Auxílio Emergencial sobre a aplicação dos conceitos de *data justice* na construção do serviço de governo eletrônico. O objetivo da análise de artigos acadêmicos e documentos era descrever e construir o histórico do caso, para servir de referência para a narrativa e triangulação com as entrevistas.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

Com base no levantamento inicial de informações feito através da pesquisa documental e no referencial teórico, foram realizadas entrevistas semiestruturadas com um grupo de 12 agentes públicos que atuavam no Ministério da Cidadania, na Caixa Econômica Federal e na Dataprev, no período de vigência do Auxílio Emergencial. Estas entrevistas foram realizadas entre os meses de dezembro de 2023 e fevereiro de 2024.

A análise dos dados ocorreu em seis etapas (Creswell, 2013): (i) organização e estruturação dos registros das entrevistas; (ii) leitura preliminar dos dados; (iii) codificação dos dados; (iv) descrição e organização temática do conteúdo; (v) avaliação de como os temas poderão ser representados em uma visão qualitativa; e (vi) interpretação dos significados dos resultados obtidos através da análise do conteúdo. Este trabalho análise do conteúdo foi realizado com auxílio do software Atlas.TI e a codificação do conteúdo foi realizada a partir dos construtos e do modelo conceitual desta pesquisa. Inicialmente, alguns códigos foram pré-estabelecidos e serviram de ponto de partida para a análise, mas outros códigos que emergiram do conteúdo foram incorporados à estrutura, e agrupados em categorias relacionadas aos construtos.

5. Auxílio Emergencial da COVID-19

O Auxílio Emergencial foi uma das medidas de enfrentamento da pandemia estabelecidas pelo Decreto 10.316/2020 que regulamentou a Lei 13.982, de 2 de abril de 2020, criada para garantir uma renda mínima aos brasileiros em situação mais vulnerável, beneficiando trabalhadores desempregados, informais, autônomos que ficaram desprovidos de renda em função da pandemia.

Previsto para durar 3 meses, o Auxílio Emergencial de R$ 600,00 (seiscentos reais) foi prorrogado por mais dois meses através do Decreto 10.412 de 30 de junho de 2020, em função da continuidade da pandemia e, consequentemente, do isolamento social. Em 3 de setembro de 2020, a Medida Provisória Nº 1.000 instituiu o Auxílio Emergencial Residual, a ser pago em 4 parcelas de R$ 300,00 (trezentos reais) aos beneficiários do Auxílio Emergencial. A Medida Provisória Nº 1.039 estabeleceu Auxílio Emergencial 2021, benefício pago em quatro parcelas mensais R$ 250,00 (duzentos e cinquenta reais), aos trabalhadores beneficiários do Auxílio Emergencial. O Auxílio Emergencial foi encerrado em 30 de outubro de 2024, com a liberação da última parcela para o último lote de beneficiários.

Desde o início, o Ministério da Cidadania atuou como gestor do Auxílio Emergencial e definiu os critérios para identificação dos beneficiários em conjunto com o Ministério da Economia , conforme estabeleceu o Decreto 10.316/2020 (Cardoso, 2020). A Portaria 351 de 7 de abril de 2020 regulamentou os procedimentos de que tratava o Decreto 10.316/2020, designou a Dataprev como agente operador considerando sua infraestrura e experiência com processamento de dados em grande escala Esta portaria cita a figura do agente pagador, mas sem definir uma instituição financeira como responsável por esta função (Cardoso, 2020). A Caixa Econômica Federal (CEF) tornou-se a instituição financeira encarregada de ser o agente pagador, uma vez que já era responsável pelo pagamento de outros programas assistenciais como o Bolsa Família e o Seguro-Desemprego.

Fluxo Operacional

O desafio imposto pela pandemia era a implantação de um benefício com amplitude nacional em curtíssimo tempo e identificar os beneficiários e conceder o benefício sem que houvesse contato presencial entre os cidadãos e os agentes públicos. Com a definição do público-alvo, as bases de cadastro do Bolsa Família e do Cadastro Único tornaram-se os pilares do processo operacional.

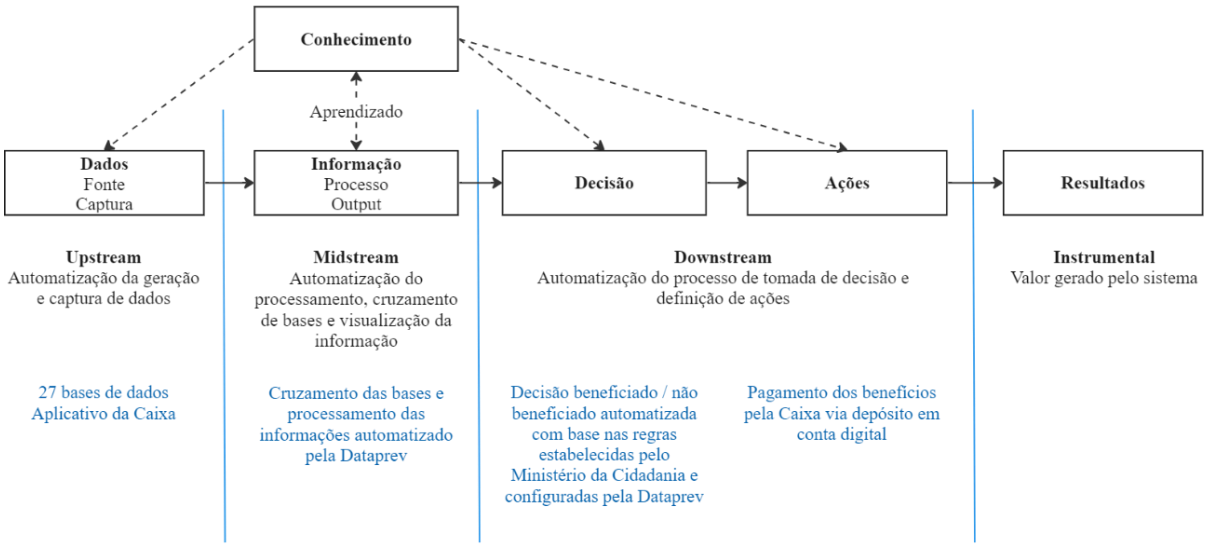
O aplicativo de solicitação da CEF foi criado para incluir o público que não estava mapeado nestas bases, evitando a ida dos requerentes aos Centros de Referência da Assistência Social (CRAS), unidade pública de atendimento à população e que servia de apoio para cadastramento de cidadãos e famílias nos programas assistenciais.

Portanto, o Auxílio Emergencial nasce com a necessidade de ter um fluxo operacional eletrônico e automatizado, usando as bases de dados existentes no governo brasileiro como fonte de informação. Foi necessário utilizar outras bases de dados para validação dos critérios de elegibilidade, uma vez que o benefício seria concedido por unidade familiar e apenas para aquelas pessoas que, de fato, estavam privadas de alguma renda para subsistência. Ao todo, a Dataprev utilizou 8 bases de dados internas e 19 externas, de órgãos como Receita Federal, Sistema Penal, Tribunal Superior Eleitoral, entre outras.

Desta forma, o Auxílio Emergencial foi um exemplo de aplicação do governo baseada no uso intensivo de dados, cujo fluxo pode ser representado de forma simplificada através do *framework* da cadeia de valor da informação (Heeks & Shekhar, 2019), conforme **Figura *5***.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Figura 5 - Cadeia de valor da informação para o Auxílio Emergencial



Fonte: Adaptado de Heeks & Shekhar (2019)

6. Análise e Discussão dos Resultados

Considerando as informações coletadas, pode se entender que o Auxílio Emergencial foi um exemplo de serviço de governo baseado no uso intensivo de dados, dentro do conceito de *datafication* e que alguns conceitos de *data justice* se fazem presentes na sua construção.

É importante destacar que a pandemia foi um fator relevante no contexto do Auxílio Emergencial, por ter motivado a criação deste programa de proteção de renda, por ter influenciado a arquitetura do sistema de dados, que precisava ser totalmente digital devido o isolamento social, pela influência na velocidade de implantação e no engajamento dos órgãos públicos envolvidos.

As entrevistas indicam que havia uma preocupação com situação de vulnerabilidade de uma parcela significativa da população, e isso fez com que discussões que antes levavam muito tempo para evoluir, como troca de informações entre órgãos, fossem tratadas rapidamente em prol da celeridade necessária para a concessão do benefício.

Aderência a direitos básicos de dados

Representatividade e responsabilização foram categorias com quantidade significativa de citações nas entrevistas. Os relatos afirmam que os órgãos de controle tiveram presença ativa no processo do Auxílio Emergencial visando garantir que houvesse o pagamento correto dos benefícios para quem de fato deveria recebê-lo. Podemos considerar que a atuação dos órgãos de controle, com foco na concessão justa dos benefícios, através da identificação e coleta de dados do público-alvo, e no direcionamento de questionamentos da população vai de encontro à visão de *data justice*.

> *Então, o que eles estavam preocupados se a gente não estava, vamos dizer, excluindo algumas pessoas que teriam direito e incluindo pessoas que não têm direito. Isso era uma preocupação tanto do Ministério Público como da Justiça. (Entrevistado 2)*

Os entrevistados comentaram sobre a responsabilidade que eles tiveram com relação ao tratamento dos dados e tomada de decisão sobre os benefícios. Os relatos demonstram que na Administração Pública em geral a responsabilização e suas consequências legais são pontos de atenção e determinantes para o desenvolvimento de iniciativas como o Auxílio Emergencial.

Contudo, os entrevistados não mencionaram a necessidade de consentimento dos cidadãos para uso dos seus dados. O Auxílio Emergencial considerou informações que foram coletadas originalmente para outros fins, mas sem que houvesse mecanismo de consentimento prévio para utilização dos dados. Apenas um entrevistado trouxe

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

uma situação na qual houve tentativa, que não se manteve na sequência, de buscar o consentimento do cidadão para aproveitamento de dados previamente obtidos no Cadastro Único para o Auxílio Emergencial.

Da mesma forma, os mecanismos de contestação tiveram pouco destaque nos relatos dos entrevistados. Em um dos relatos este ponto foi considerado como uma das premissas para inclusão da DATAPREV no processo, tendo em vista sua experiência com os requisitos de armazenamento de dados para eventuais contestações.

> *Desde a primeira discussão, a gente aportou toda essa nossa experiência para debater como vai controlar, como vai ser o judicial depois, como a gente vai garantir a consistência das famílias, como que a gente vai fazer a disponibilidade? Então, toda essa cercania de coisas que parecem acessórias, mas que no dia seguinte se tornam principais, foram colocadas desde o primeiro momento. (Entrevistado 12)*

Em contrapartida, outro entrevistado relatou que não houve uma preocupação em criar canais e mecanismos específicos de contestação dos dados. Na sua visão isso é reflexo de uma premissa adotada na Administração Pública em geral que diz respeito a assumir que a informação que consta nas bases de dados do governo é válida até prova contrária. Mas não há mecanismos que facilitem o acesso aos dados e a sua validação por parte do cidadão.

> *Então, esse foi um processo que foi, na minha visão, negligenciado, né, e quando você fala em data justice, eu entendo que não houve essa justiça de dados, né? Ouvi assim, a informação que tá aqui é que eu vou utilizar e você que se vire para provar o contrário. Isso é algo que é comum na administração pública. (Entrevistado 1)*

Garantir que os cidadãos estejam conscientes e de acordo com o uso de dados sobre e por eles gerados é um desafio, impacta a velocidade do processo, mas é crítico para inibir o uso indevido e injusto (Dencik et al., 2016; Hintz et al., 2018; Taylor, 2017). No contexto da pandemia, seria inviável uma ação de consentimento do uso dos dados pelo volume de pessoas no universo do público-alvo e pela urgência em conceder o benefício no momento de isolamento social.

A ausência de mecanismos claros para contestar os dados vai contra a ótica de *data justice*. No caso do Auxílio Emergencial houve a possibilidade de acionar o Judiciário para contestar a negativa do benefício e, consequentemente, os dados. Ou seja, o Judiciário é um caminho para contestação, mas que extrapola o escopo do sistema de dados que deveria prever canais de contestação.

Privacidade e segurança dos dados

No que diz respeito à privacidade das informações dos cidadãos, a percepção dos entrevistados é que o processo do Auxílio Emergencial dava essa garantia aos requerentes, sendo que nove entrevistados afirmaram que houve cuidado com aspectos de privacidade das informações e cinco destes mencionaram que as regras da Lei Geral de Proteção de Dados (LGPD) foram seguidas.

> *Então a questão da LGPD desde o início, e a gente sabe que a LGPD já tem alguns anos aí de estrada, então ela sempre foi uma preocupação do Ministério com suas bases de dados, seja dentro do próprio Ministério ou com as partes que se relacionam. (Entevistado 8)*

Em relação à segurança de dados, oito entrevistados afirmaram que havia procedimentos e condições estruturais para garantir a segurança dos dados. A participação da Dataprev e da CEF gerou confiança para os agentes do Ministério da Cidadania.

> *Do ponto de vista técnico, tecnológico, aí aplicam-se os nossos processos de segurança que a gente usa na previdência, que a gente usa nos outros processos todos, que são as seguranças dos nossos data centers, que são certificados e tudo mais. (Entrevistado 12)*

Apenas um entrevistado apresentou dúvidas quanto a se houve uma avaliação criteriosa por parte da equipe de implementação em relação às necessidades de procedimento de segurança de dados, mas sem ser conclusivo.

> *... a impressão que eu tenho é que num primeiro momento isso ficou em um certo segundo plano, tá? (...) Mas, por exemplo, eu não lembro das pessoas falarem assim, a gente precisa usar uma plataforma XYZ que ela é mais protegida ou garante criptografia ponta a ponta ocorre desse gênero. Eu não me recordo de nada dessa natureza. (Entrevistado 6)*

As entrevistas revelam que estar em conformidade com a legislação vigente relativa à privacidade e proteção de dados foi uma premissa básica do Auxílio Emergencial. Aqui não houve uma discussão sobre eficácia da LGPD em proteger o direito à privacidade dos cidadãos, mas é importante que a legislação vigente esteja sendo observada e respeitada. Portanto, estas constatações indicam que houve preocupação em mitigar os riscos relacionados à privacidade e segurança e que este é um tema presente nas discussões sobre uso de tecnologia pelos governos, em especial quando envolve dados pessoais.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Procedimentos justos

Os relatos apontam que houve preocupação dos agentes públicos com o risco de as bases não cobrirem totalmente o público-alvo do Auxílio Emergencial e, consequentemente, em fornecer alternativas para acesso ao sistema. As entrevistas destacam a implementação do aplicativo de cadastro e a implementação de processo via Correios como medidas necessárias para garantir que os cidadãos que não estavam contemplados nas bases de dados pudessem ter acesso ao Auxílio Emergencial.

> *...tinha muita gente que não estava no cadastro. aqui, o tal do invisível, né? Então, tinha várias pessoas que não estavam no cadastro, mas estavam necessitados, eles não tinham como comer mesmo, não. Por isso que nós contratamos a Caixa (...) Para conseguir fazer o cadastro do pessoal o mais rápido possível. (Entrevistado 2)*

O cadastro via Correios tinha foco na parcela mais vulnerável da população, constituída por moradores de rua e pessoas sem acesso a celular. Entretanto, a baixa adesão, conforme relato das entrevistas, é um indício é que essa parcela da população recorreu a ajudas informais para requerer o benefício ou desistiu.

> *Não se sabe se a população já estava cansada de pedir. A população mais vulnerável, eu tenho uma visão que muitas vezes quem tá mais vulnerável cansa de buscar o Estado ou não acredita mais no Estado ele se vira. (Entrevistado 10)*

A assimetria, falhas de informação e defasagem de atualização dos dados foram os principais pontos citados nas entrevistas em relação ao processamento dos dados. O alto volume de bases de dados utilizadas se justifica pela necessidade de buscar informações de maior qualidade para atender um dos principais objetivos que era pagar corretamente para quem precisava.

> *Primeiro que, como eu falei, nós tínhamos bases muito amplas e maduras, mas ainda assim, naquele momento mostrou-se insuficiente, dado o tamanho do desafio (...) Mas sim, havia gaps, coisas que não estão dentro dessas áreas principais de atuação dessas bases, por exemplo, candidatos, militares, coisas que a gente via que estavam fora de alguns dados da Receita Federal. (Entrevistado 12)*

Integração e interoperabilidade entre as bases de dados foram dois pontos críticos apontados nas entrevistas. Há uma constatação que as bases de dados do setor público eram específicas para cada órgão e não havia interesse político para prover essa integração com padrões de governança de dados que garantissem fluidez em situações de alto impacto em processamento como o Auxílio Emergencial.

> *A questão da interoperabilidade, a questão da integração, isso quando se trabalha com grande base de dados, uma coisa que sempre se buscou, mas de difícil execução barra operação, porque cada ministério se acha dono do seu quintal, entendeu? (Entrevistado 8)*

Desde o início havia a preocupação com a lacuna dos dados em relação à identificação do público-alvo, e este é um ponto importante na discussão de procedimentos justos porque aborda uma questão que impacta toda cadeia, uma vez que havendo discriminação na coleta dos dados, esta tende a se perpetuar nas demais etapas.

O benefício de eliminação dos erros de exclusão e inclusão gerados pelo movimento de *datafication* (Masiero & Das, 2019) não foi verificado no Auxílio Emergencial. Este fato traz risco relevante para iniciativas futuras e precisa ser discutido de forma mais ampla, fora dos limites das áreas. A interoperabilidade e integração é um tema latente nos discursos dos entrevistados, mas observa-se que uma iniciativa estruturante ainda está distante.

A característica do Auxílio Emergencial faz com que a discussão sobre procedimentos justos se concentre na questão das bases de dados. A teoria sobre *data justice* traz uma preocupação com a discussão sobre algoritmos de inteligência artificial e modelos de *machine learning*, em especial em soluções voltadas para vigilância de dados (Hintz et al., 2018; Taylor & Broeders, 2015), mas a arquitetura do Auxílio Emergencial estava baseada nos cruzamentos de bases seguindo regras de inclusão e exclusão, sem a aplicação de algoritmos mais sofisticados.

Transparência nas regras, modelos e algoritmos

Neste ponto os entrevistados ficaram bem divididos entre visões positivas e visões críticas sobre a forma como a comunicação com o público foi realizada. Aqueles que demonstraram opinião positiva sobre a transparência do processo destacaram o cuidado com a forma de comunicar as regras, os caminhos para entender o motivo de corte ou negativa do benefício, a utilização de Internet, atendimento telefônico e programas de TV como canais de comunicação e o processo de transparência ativa, quando as informações disponibilizadas pelos órgãos e entidades, independentemente de solicitação, utilizando principalmente a internet.

> *No nosso processo de comunicação também teve um zelo com as expressões que a gente deveria usar, essa população muitas vezes tem um limite de compreensão. Então até um glossário de termos diferentes*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

> *a gente precisou construir ao longo do tempo e no auxílio emergencial a gente também aplicou isso. (Entrevistado 3)*

Por outro lado, outros entrevistados destacaram a ausência de clareza das regras para o público e até dos motivos de negativa de benefícios. Os relatos citam que no início do processo, havia uma preocupação muito grande com iniciar o pagamento e a comunicação sobre quem teria direito ficou confusa. Posteriormente, foram feitas ações de comunicação, mas ainda havia dificuldade de entendimento do público sobre as regras, que passaram por mudanças à medida que surgiam questionamentos dos órgãos de controle e ações judiciais.

> *Não, no início houve uma confusão infernal de quem que era o público-alvo. A priori foi entendido assim, o governo está dando dinheiro para o povo e as pessoas queriam saber se poderiam ter ou não, e uma das formas que elas descobriam isso era justamente fazendo o requerimento. A área que eu trabalhei lá criou algumas cartilhas, que são documentos em PDF. (Entrevistado 1)*

O conceito de transparência que está consolidado no setor público foca na questão dos dados abertos, ou seja, dar visibilidade dos resultados e insumos relacionados às ações. Entretanto, aqui espera-se que a preocupação vá além, com uma comunicação clara sobre o processo e suas premissas. Havia lacunas de informação que impactavam os critérios de aprovação dos pedidos, mas estas fragilidades ficaram transparentes somente quando houve denúncia ou questionamento judicial. Em resumo, o caso do Auxílio Emergencial indica que transparência é um tema que demanda um debate mais amplo.

Justiça e equidade nos resultados

Não há uma percepção dominante entre os entrevistados sobre justiça e equidade nos resultados. Há um entendimento comum que conceder o benefício para todos que realmente precisavam era uma premissa do Auxílio Emergencial, e como a definição do público-alvo era baseada nas condições de emprego e renda, não haveria discriminação em função de fatores sociodemográficos.

> *Creio que sim, acho que porque quando a gente escreveu ou colocou na rua o auxílio emergencial não importa a cor da pele, não importa o sexo, não importa de onde ele era, a única coisa que importava naquele momento era um público mesmo, que era público-alvo, que era uma população de baixíssima renda ou sem nenhuma renda. (Entrevistado 8)*

Entretanto, as opiniões do grupo apontam dúvidas com relação a ter atingido ou não este objetivo.

> *Olha, eu acredito que é sempre possível que alguns grupos tenham ficado de fora, ou não tenham recebido a cobertura que deveriam, né? Mas eu acho, sinceramente, que essa possibilidade é pequena, pelo menos olhando no agregado. (Entrevistado 6)*

Para os que entendem que o resultado do uso dos dados não garantiu justiça e equidade, a ausência de mecanismos para contestação e correção dos dados e as dificuldades de acesso à tecnologia da população residente em áreas mais afastadas foram fatores determinantes para esse resultado.

> *Eu não acho que a gente alcançou todo mundo, faltou, tem o pessoal do, sei lá, ribeirinho, será que a gente chegou nessas pessoas? A gente chegou lá no interior da Bahia? Não sei, eu de vez em quando me pergunto isso, mas acho que é algo muito ousado para tentar levantar quem ficou fora, né? (...) eu acho que a gente não chegou em todo mundo. (Entrevistado 5)*

Quando o conteúdo das entrevistas indica que não há uma avaliação dominante em relação ao Auxílio Emergencial ter proporcionado ou não um resultado justo, isso significa que este ainda é um ponto que precisa ser discutido pensando na evolução do uso de TIC pelo governo. Em tese, se alguém que deveria ter sido beneficiado pelo resultado do sistema de dados foi excluído indevidamente, não houve total justiça no resultado. E, havendo essa consciência, a questão passa a ser entender o que gerou a exclusão e combater, para evitar que essa situação se perpetue (Dencik et al., 2016; Dencik & Sanchez-Monedero, 2022; Heeks, 2017b; Masiero & Das, 2019).

É fato que o Auxílio Emergencial atingiu resultados expressivos, beneficiando uma parcela muito significativa da população brasileira. Foram 68 milhões de cidadãos elegíveis em 2020 e 39 milhões em 2021 (Dataprev, 2022), se considerarmos pessoas impactadas tendo em vista que o benefício era voltado para a unidade familiar, estima-se 119 milhões em 2020 e 78 milhões em 2021. Quando olhamos para o agregado, isso gera a percepção que o benefício chegou para quem estava precisando, atingindo seu objetivo.

Entretanto, o entendimento que uma pequena parcela de potenciais beneficiários não foi alcançada deve despertar discussões para melhoria no processo e eliminação das causas. Os relatos trazem indícios de que há dificuldade de incluir as populações residentes em áreas mais remotas, como áreas rurais e territórios indígenas, assim como populações em situação de vulnerabilidade como moradores de rua. Ou seja, se não houver uma discussão sobre mecanismos para incluir esses perfis nas bases de dados, o desenvolvimento de serviços eletrônicos de governo baseados no uso intensivo destes dados tende a perpetuar essa exclusão.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

7. Considerações finais

O caso do Auxílio Emergencial demonstra que os principais riscos de discriminação e exclusão social estão sendo considerados, mas ainda há necessidade de aprofundamento da discussão em aspectos relacionados a aderência aos direitos básicos de dados, procedimentos justos, transparência e justiça e equidade nos resultados. A preocupação com riscos relacionados à privacidade e segurança de dados parece estar bem consolidada na perspectiva dos agentes públicos, sendo considerada premissa básica para a operação. E, em relação à aderência a direitos básicos de dados, a responsabilização é um tema consolidado e de muita atenção por parte dos agentes públicos.

Contudo, ainda há necessidade de se evoluir nas discussões sobre transparência. A divulgação de resultados ou investimentos realizados através dos portais de transparência é importante, mas deve-se discutir como melhorar a comunicação com o público visando o entendimento claro de todo processo, suas regras e consequências. Deve-se discutir mecanismos para garantir aderência aos direitos básicos sobre os dados e questões como ausência de representatividade e consentimento de uso dos dados para que os cidadãos possam exercer sua autonomia e participar das escolhas relacionadas ao sistema de dados.

A discussão sobre procedimentos justos precisa ser recorrente, e, possivelmente, ser considerada como item padrão de análise na concepção de qualquer aplicação. No Auxílio Emergencial, percebe-se a presença deste tema nas discussões. Mas esta discussão precisa estar incorporada a qualquer processo similar.

É importante destacar que havia a preocupação com a justiça e equidade nos resultados, mas, por se tratar de um conceito impactado pelos demais citados acima, é importante que seja discutido com mais profundidade e com foco nas minorias. Observa-se através dos relatos um viés de avaliação pelo agregado, que é importante, mas que pode esconder riscos de exclusão.

Este estudo propõe um modelo conceitual inspirado no referencial teórico de *datafication* e *data justice* e o aplica em um caso real, trazendo a discussão sobre estes conceitos para o contexto do Brasil e ampliando a análise sobre os países do Sul Global.

Além disso, traz algumas contribuições importantes para futuras iniciativas de implementação de serviços baseados no uso intensivo de dados. A primeira delas é a necessidade de uma legislação que sustente e confira clareza em relação às regras, público-alvo e benefícios que serão concedidos. A LGPD garante que os agentes públicos e as instituições estejam preocupados com as regras de proteção de dados. Da mesma forma, os atos normativos foram a linha-mestra para todo processo de implantação do auxílio e favoreceu, de certa forma, a transparência na comunicação com o público.

A segunda contribuição está relacionada à importância que as empresas públicas de tecnologia da informação (TI) podem ter para processos como este. A Dataprev, em função da sua infraestrutura de TI e da experiência com processamento de dados em larga escala foi fundamental para a operação. Portanto, uma discussão sobre a ampliação de uso de TIC para serviços de governo eletrônico deve considerar o papel das empresas públicas de TI, bem como deve-se avaliar como essas estruturas podem contribuir para avanço no debate sobre interoperabilidade e integração de bases de dados.

A terceira contribuição refere-se ao fato de que, apesar da evolução da tecnologia, ainda temos desigualdades no que diz respeito ao uso da tecnologia pelos cidadãos no Brasil. Apesar do alcance obtido pelo Auxílio Emergencial em termos de cidadãos e famílias, determinados grupos precisaram encontrar alternativas informais para acessar o aplicativo para se cadastrar. Essa desigualdade de acesso e capacidade de uso da tecnologia ainda precisa ser discutida.

Por fim, considerando que a pandemia foi um fator relevante no contexto do Auxílio Emergencial, questiona-se como a implantação do benefício teria evoluído se não fosse este cenário pandêmico.

Em relação às limitações da pesquisa, há uma preponderância de entrevistados do Ministério da Cidadania (líder da iniciativa), fato que pode acarretar um viés na perspectiva das respostas. A pesquisa não considerou a perspectiva dos usuários que, apesar do objetivo ser obter a perspectiva dos agentes públicos, poderia trazer reflexões importantes sobre as desigualdades no processo.

Desta forma, recomenda-se que estudos futuros ampliem a análise para outros casos que tenham ocorrido pós pandemia da COVID19 e que seja feita uma análise voltada para outras modalidades de serviços de governo eletrônico, como por exemplo, aqueles voltados para a área de segurança pública, onde os riscos relacionados a vigilância de dados são críticos.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

Acknowledgement

Funding or Grant

À Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) pelo suporte financeiro.

Contributor Statement

O Autor 1 foi responsável pela conceptualização, tratamento de dados, metodologia e escrita do manuscrito. O Autor 2 foi responsável pela supervisão, metodologia e escrita do manuscrito (revisão e edição).

Use of AI

As entrevistas foram transcritas com a utilização de software suportado por inteligência artificial denominado Reshape. Após o uso do software, os autores revisaram o conteúdo das transcrições para detectar e corrigir eventuais erros de transcrição, assumindo total responsabilidade pelo conteúdo deste artigo.

Conflict Of Interest (COI)

Não há conflito de interesse.

References

Bacchiegga, F., Freitas, L. F. S., & Vasconcellos, M. D. P. (2022). Políticas públicas, enfrentamento da covid-19 e invisibilidade social. *Revista de Direito Da Cidade*, *14*(1), 248–276. https://doi.org/10.12957/rdc.2022.54249

Cardoso, B. B. (2020). A implementação do Auxílio Emergencial como medida excepcional de proteção social. *Revista de Administração Pública*, *54*(4), 1052–1063. https://doi.org/10.1590/0034-761220200267

Cardoso, B. B. (2021). *Transformação digital e ação pública: como a digitização de instrumentos da ação pública pode afetar a implementação das políticas públicas. Dissertação (Mestrado em Políticas Públicas e Desenvolvimento)*. IPEA.

Cinnamon, J. (2020). Data inequalities and why they matter for development. *Information Technology for Development*, *26*(2), 214–233. https://doi.org/10.1080/02681102.2019.1650244

CNJ. (2022). *O impacto da COVID-19 no Poder Judiciário*.

Creswell, J. W. (2007). *Projeto de pesquisa: métodos qualitativo, quantitativo e misto* (2a edição). Artmed.

Creswell, J. W. (2013). *Qualitative Inquiry & Research Design: Choosing among five approaches*. Sage.

Cukier, K. N., & Mayer-Schoenberger, V. (2013). The rise of big data. *Foreign Affairs*, *92*(3), 28–40.

Dataprev. (2020). *Relatório Integrado de Gestão*. https://www.azores.gov.pt/NR/rdonlyres/D21CF49B-EF59-4E76-88BD-5D0EEC3A2D4F/1098978/PlanoARPLAlcool.pdf

Dataprev. (2021). *Relatório Integrado de Gestão*.

Dataprev. (2022). *Relatório Integrado de Gestão*. *7*.

Dencik, L., Hintz, A., & Cable, J. (2016). Towards data justice? The ambiguity of anti-surveillance resistance in political activism. *Big Data and Society*, *3*(2), 1–12. https://doi.org/10.1177/2053951716679678

Dencik, L., Hintz, A., Redden, J., & Treré, E. (2019). Exploring Data Justice: Conceptions, Applications and Directions. *Information Communication and Society*, *22*(7), 873–881. https://doi.org/10.1080/1369118X.2019.1606268

Dencik, L., & Sanchez-Monedero, J. (2022). Data justice. *Internet Policy Review*, *11*(1), 1–16. https://doi.org/10.14763/2022.1.1615

Heeks, R. (2017a). A Structural Model and Manifesto for Data Justice for International Development. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3431729

Heeks, R. (2017b). An Structural Model and Manifesto for Data Justice for International Development. *Development Informatics Working Paper Series Improve ICT4D Project*, *July 2011*, 1–15.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://doi.org/10.13140/RG.2.2.31885.90084

Heeks, R. (2017c). Information and Communication Technology for Development (ICT4D). *Information and Communication Technology for Development (ICT4D)*. https://doi.org/10.4324/9781315652603

Heeks, R. (2020). From the digital divide to digital justice in the global south. *WebSci 2020 - Companion of the 12th ACM Conference on Web Science*, 10–11. https://doi.org/10.1145/3394332.3402821

Heeks, R., & Renken, J. (2016). Data justice for development: What would it mean? *Information Development*, *34*(1), 90–102. https://doi.org/10.1177/0266666916678282

Heeks, R., & Renken, J. (2018). Data justice for development: What would it mean? *Information Development*, *34*(1), 90–102. https://doi.org/10.1177/0266666916678282

Heeks, R., & Shekhar, S. (2018). An Applied Data Justice Framework: Analysing Datafication and Marginalised Communities in Cities of the Global South. *Center for Development Informatics - Univertity of Manchester*, *32*(University of Manchester), 45. http://www.digitale-chancen.de/transfer/downloads/MD280.pdf

Heeks, R., & Shekhar, S. (2019). Datafication, development and marginalised urban communities: an applied data justice framework. *Information Communication and Society*, *22*(7), 992–1011. https://doi.org/10.1080/1369118X.2019.1599039

Hintz, A., Dencik, L., & Wahl-Jorgensen, K. (2018). *Digital citizenship in a datafied society*. Polity Press.

Janowski, T. (2016). Implementing Sustainable Development Goals with Digital Government – Aspiration-capacity gap. *Government Information Quarterly*, *33*(4), 603–613. https://doi.org/https://doi.org/10.1016/j.giq.2016.12.001

Johnson, J. A. (2014). From open data to information justice. *Ethics and Information Technology*, *16*(4), 263–274. https://doi.org/10.1007/s10676-014-9351-8

Krishna, S. (2021). Digital identity, datafication and social justice: understanding Aadhaar use among informal workers in south India. *Information Technology for Development*, *27*(1), 67–90. https://doi.org/10.1080/02681102.2020.1818544

Lutz, C. (2019). Digital inequalities in the age of artificial intelligence and big data. *Human Behavior and Emerging Technologies*, *1*(2), 141–148. https://doi.org/10.1002/hbe2.140

Marins, M. T., Rodrigues, M. N., Silva, J. M. L. da, Silva, K. C. M. da, & Carvalho, P. L. (2021). Auxílio Emergencial em tempos de pandemia. *Sociedade e Estado*, *36*(2), 669–692. https://doi.org/10.1590/s0102-6992-202136020013

Masiero, S., & Das, S. (2019). Datafying anti-poverty programmes: implications for data justice. *Information Communication and Society*, *22*(7), 916–933. https://doi.org/10.1080/1369118X.2019.1575448

Porto de Albuquerque, J., Anderson, L., Calvillo, N., Coaffee, J., Cunha, M. A., Degrossi, L. C., Dolif, G., Horita, F., Klonner, C., Lima-Silva, F., Marchezini, V., Martins, M. H. da M., Pajarito-Grajales, D., Pitidis, V., Rudorff, C., Tkacz, N., Traijber, R., & Zipf, A. (2021). The role of data in transformations to sustainability: a critical research agenda. *Current Opinion in Environmental Sustainability*, *49*(August 2020), 153–163. https://doi.org/10.1016/j.cosust.2021.06.009

Sadowski, J. (2019). When data is capital: Datafication, accumulation, and extraction. *Big Data and Society*, *6*(1), 1–12. https://doi.org/10.1177/2053951718820549

Taylor, L. (2017). What is data justice? The case for connecting digital rights and freedoms globally. *Big Data and Society*, *4*(2), 1–14. https://doi.org/10.1177/2053951717736335

Taylor, L., & Broeders, D. (2015). In the name of Development: Power, profit and the datafication of the global South. *Geoforum*, *64*, 229–237. https://doi.org/10.1016/j.geoforum.2015.07.002

UN. (2014). A World that Counts: Mobilising the Data Revolution for Sustainable Development. *Trusted Data*. https://doi.org/10.7551/mitpress/12439.003.0018

Valente, M. G., & Fragoso, N. (2021). *Presa na rede de proteção social*.

Valentin, A., Urquidi, V. G. F., Valentin, A., Grace, V., & Orgs, F. U. (2022). *Políticas Públicas e Covid-19 : a experiência brasileira*. https://doi.org/10.11606/9786588503225

Vargas, L. C. M. (2024). *ASPECTOS SOCIAIS SOBRE A APLICAÇÃO DE TECNOLOGIAS DE INFORMAÇÃO E COMUNICAÇÃO PELO SETOR PÚBLICO NO BRASIL: Serviços de Governo Eletrônico e implicações sobre*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

.

inclusão digital e justiça de dados.

Yin, R. K. (2001). *Estudo de Caso: Planejamento e Métodos* (Bookman (ed.)).

Zheng, Y., & Walsham, G. (2021). Inequality of what? An intersectional approach to digital inequality under Covid-19. *Information and Organization*, *31*(1), 100341. https://doi.org/10.1016/j.infoandorg.2021.100341

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Smart Communities in Climate Disasters: A Case of Porto Alegre, Brazil

Carolina Tavares Lopes [a*], *Edimara* Luciano [a*], *Lucas* Roldan [a*].

[a] Graduate Program in Business Administration (PPGAd), PUCRS Business School, Pontifical Catholic University of Rio Grande do Sul (PUCRS), Porto Alegre, Brazil, email address [carolina.lopes004@edu.pucrs.br], ORCID number [0009-0004-4654-8503].

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. This study explores the role of smart communities in responding to climate disasters, focusing on the 2024 floods in Porto Alegre, Brazil, as a case study. Grounded in existing concepts of smart communities and based on 23 in-depth semi-structured interviews with community leaders, community members, community collaborators, and local government authorities, this research employs an existing framework designed to understand how these communities evolved into smart communities and whether their adoption of smart governance practices helped them mitigate the disaster's impacts and navigate the recovery process more effectively. The findings, derived from a qualitative data analysis, reveal that pre-existing smart communities demonstrated greater effectiveness in coordinating disaster response efforts, mobilizing resources, and building resilience. Community cohesion was reinforced during the crisis, largely due to established networks, collective trust, and decentralized governance mechanisms. However, the study also identifies significant challenges, particularly concerning the availability and reliability of ICT-based communication systems during crises, difficulties in coordinating across different levels of government, and broader governance barriers that are especially pronounced in developing countries like Brazil. By highlighting these dynamics, this study offers valuable insights into how smart communities can be strengthened to enhance disaster response and resilience, particularly in urban areas facing increasing climate risks. More than just showcasing best practices, this study emphasizes the importance of human connections, local knowledge, and governance innovations, demonstrating that integrating community-led governance into formal disaster planning is essential for proactive and adaptive urban resilience.

Keywords. Smart Community, Climate Disaster, community-led governance, urban resilience, disaster governance.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1026

1. Introduction

Over half of the world's population lives in urban areas, a figure expected to reach 75% by 2050 (McKinsey, 2011). This rapid urbanization, combined with climate change, heightens vulnerability to climate-related hazards, such as urban flooding and extreme weather events (United Nations, 2019). Densely populated cities, particularly in Latin America, are highly susceptible to extreme weather events such as heavy rainfall and urban flooding, exacerbated by the urban heat island effect (Shastri et al., 2015; Li et al., 2020).

This reality is evident in Latin America, where 80% of the population already resides in cities, a figure expected to reach 85% by 2040 (UN-Habitat, 2022). Nearly half of Latin America's capital cities are at extreme risk due to climate change (CAF, 2014), emphasizing the need for resilience strategies in urban governance.

The growing frequency and severity of climate disasters further highlights the urgency of urban resilience strategies. According to the World Meteorological Organization (WMO), between 2020 and 2022, 88% of extreme events recorded in Latin America were caused by meteorological, climatic, and hydrological factors, accounting for 40% of disaster-related deaths and 71% of economic losses (WMO, 2022). As the frequency and intensity of these

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

disasters escalate, it becomes evident that enhancing urban resilience is not just necessary but urgent. Among these hazards, flooding stands out as one of the most recurrent and destructive, driven by climate change projections and rapid urban expansion (Rozer et al., 2021). The economic and social costs of flood-related damages continue to rise, disproportionately affecting low-income and socially vulnerable urban communities (Nkwunonwo et al., 2020; Nasiri et al., 2016).

As Latin American cities grapple with increasing climate risks, Porto Alegre, Brazil, stands out as a compelling case study, particularly due to its long-standing tradition of participatory governance and community engagement. The devastating 2024 floods, which affected large parts of the city, faced the urgency of understanding how urban communities can build resilience in climate disasters (World Meteorological Organization [WMO], 2024). On top of that, this event triggered urgent discussions on disaster governance and flood resilience.

Porto Alegre's pioneering participatory governance, notably through the Participatory Budgeting (PB) process, provides a unique lens to examine how smart communities can enhance resilience in disaster scenarios (Baiocchi, 2003; Goldfrank, 2011). This long-standing tradition of community participation in municipal decision-making offers a valuable lens through which to examine the role of smart communities in disaster response. Additionally, the city has been actively involved in smart communityinitiatives and innovative governance practices, making it a compelling case for understanding how local governance contributesto disaster resilience (Pereira et al., 2017).

While *smart cities* have been extensively explored (Harrison & Donnelly, 2011; Komninos, 2013; Caragliu et al., 2011), research on *smart communities*, particularly in the context of disaster resilience, remains limited. Much of the existing research emphasizes technological solutions (Janssen, Charalabidis, & Zuiderwijk, 2012) and infrastructure-driven adaptation strategies (Alawadhi et al., 2017), while the role of community-led governance in climate disasters remains understudied (Craig et al., 2004). There is limited research on how smart communities develop in crisis contexts, particularly in urban areas of developing countries, where challenges such as institutional fragmentation, lack of coordinated response mechanisms, and social vulnerabilities pose additional complexities (Reardon & Forester, 2015).

This study examines how Porto Alegre's *smart communities* adapted to the 2024 floods, offering insights into how localized governance and community-driven initiatives can enhance resilience in the face of climate disasters. More specifically, it investigates whether their adoption of smart governance practices played a role in mitigating the disaster's impacts and how facilitating an effective recovery.

To guide this discussion, the paper is organized as follows: Section 2 reviews the concept of smart communities and introduces the conceptual framework used to analyze their structure. This is followed by an overview of Porto Alegre's geographic and historical context, with a focus on the 2024 floods. Section 3 details the research methodology, outlining the data collection process, which combined in-depth interviews with document analysis of secondary data sources. Section 4 presents the key findings, exploring how communities engaged with the disaster response and recovery efforts. The discussion that follows cross-analyzes these results, offering insights into the mechanisms of community governance and the role of smart communities in fostering resilience. Finally, the conclusion highlights the importance of strengthening smart local communities and ensuring their integration into decision-making processes as a strategy to enhance climate disaster resilience.

2. Theoretical Background

This section introduces the concept of smart communities and their role in urban resilience, followed by a conceptual framework to analyze how these communities' function in Porto Alegre, particularly during the 2024 floods. Finally, we provide an overview of the city's geographic and historical background, highlighting the factors that influence its governance and disaster response strategies.

2.1 Smart community and Climate Disasters

Smart communities, an extension of smart cities, focus on collaborative governance, technological integration, and social resilience, especially in the face of urban challenges like climate disasters. Unlike traditional top-down governance models, smart communities prioritize citizen engagement, participatory decision-making, and decentralized problem-solving (Komninos, 2013; Craig et al., 2004). Smart communities leverage technology and local resources to enhance governance and community well-being, playing a critical role in building urban resilience during climate disasters (Ahvenniemi et al., 2017). They also function as microcosms of larger urban ecosystems, subdividing cities into smaller, interconnected networks that facilitate more efficient governance and localized problem-solving (Tang, 2022).

Instead of depending exclusively on top-down government policies, smart communities promote a participatory approach that enhances local governance, improving urban planning, and social cohesion (Bartoletti & Faccioli, 2016). In this sense, smart communities operate through intersectoral collaboration, promoting active citizen

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

participation in decision-making, public service monitoring, and direct engagement with government agencies (Alawadhi et al., 2017).

O'Toole et al. (2010) reinforce that community governance flourishes when residents feel a sense of ownership and collective responsibility, making them key actors in shaping local policies and ensuring that resources are allocated effectively. In this context, smart communities thrive when supported by strategic collaborations with local governments and other entities, ensuring that services align with the specific demands of the population. These partnerships enhance the adaptability of governance models, making policies more responsive to evolving social and environmental challenges. Differ than functioning independently, smart communities work alongside existing governance structures, using citizen participation and technology to enhance decision-making (Bowles & Gintis, 2002). Instead of replacing governments or markets, they act as interconnected actors that reinforce governance through collaboration. O'Toole & Burdess (2004) expand on this argument, showing that when local governance structures actively encourage community participation, residents and organizations take on a more proactive role in shaping and delivering public services.

Smart communities rely on social capital, fostering trust between citizens and institutions, which is essential for effective governance during crises (Hautekeur, 2005). However, the sustainability of these governance models is not always guaranteed. While self-organized communities enhance urban resilience, particularly through organic adaptation strategies, their long-term success depends on alignment with formal governance structures (Marasco et al., 2022). Nam & Pardo (2011) point out that maintaining adaptability is a growing challenge, as communities must continuously evolve with technological advancements, ensuring that residents can fully engage with and benefit from smart governance structures.

Yet, the reality is that many community-driven initiatives struggle to sustain long-term engagement. Farmer et al. (2015) argue that despite initial enthusiasm, many of these efforts face significant challenges in translating participation into lasting structural changes. One of the key barriers is the lack of integration with formal governance structures, which can result in community-led solutions being overlooked or failing to gain institutional support. Without clear mechanisms for long-term implementation, mobilizing local actors can lead to frustration and disengagement. Berardi (2013) and Alawadhi et al. (2012) echo this concern, showing that while smart communities represent an evolution of social governance, their effectiveness depends on a continuous process of innovation, adaptation, and institutional backing.

Despite these challenges, smart communities play a key role in urban governance, especially in disaster scenarios like the 2024 floods in Porto Alegre, where institutional inefficiencies hinder rapid response (Phong & Shaw, 2009). In developing countries like Brazil, issues such as fragmented governance, limited digital infrastructure, and a lack of coordinated response mechanisms often exacerbate the impacts of climate disasters (Mutiarni et al., 2022). Community-led adaptation strategies, such as those seen in Indonesia — a country frequently impacted by climate disasters — have been shown to improve disaster mitigation and post-crisis recovery by formally recognizing and supporting local climate action efforts (Azizi et al., 2022). Moreover, Parvin et al. (2023) emphasize that addressing climate risks effectively requires expanding collaboration beyond government agencies, incorporating a diverse network of stakeholders, including local communities, private organizations, and international institutions.

A key element of disaster-resilient smart communities is the integration of ICT-based communication systems**,** which allows for real-time information sharing and enhanced coordination between citizens and public authorities (Pereira et al., 2017). Communities with well-established governance structures and active digital platforms are often more effective at mitigating disaster risks and accelerating recovery efforts (Janssen, Charalabidis, & Zuiderwijk, 2012). However, technology alone is not enough — without strong social cohesion and well-structured governance models, digital solutions may fail to achieve their full potential in crisis situations. Reardon & Forester (2015) illustrate this risk through the example of post-Katrina New Orleans, where institutional efforts to increase urban resilience ultimately resulted in the exclusion of vulnerable communities from the recovery process, reinforcing socioeconomic disparities rather than reducing them. This case presents the importance of ensuring that smart governance frameworks prioritize inclusivity, preventing marginalized groups from being left out of resilience-building efforts.

The intersection between smart governance and climate resilience highlights the need for cross-sector collaboration, particularly in urban contexts where government agencies, NGOs, local businesses, and community representatives must work together to strengthen disaster preparedness (Reardon & Forester, 2015). Tedong & Zyed (2021) further emphasize that communities serve as the foundation of sustainable urban development, reinforcing the idea that resilient communities are essential to the long-term success of smart city initiatives. The case of Porto Alegre provides an opportunity to explore how smart communities emerge in times of crisis, offering insights into both their strengths and the challenges they face when integrating community-led initiatives with formal governance frameworks.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2.2 Conceptual Framework for Smart Communities in Porto Alegre

Building on existing theoretical perspectives, this study applies a previously developed conceptual framework to analyze how communities in Porto Alegre develop and function as smart communities. This framework offers a relevant foundation for understanding the governance mechanisms and institutional responses that shape their evolution. Illustrated in Figure 1, the model is grounded in insights from 25 in-depth interviews conducted with community leaders, community social center personnel, citizens, entrepreneurs and consultants, and city hall representatives. Its primary objective is to map the interactions between community-driven governance mechanisms and institutional response strategies, providing a structured perspective on how these communities emerge, evolve, and establish smart governance practices.

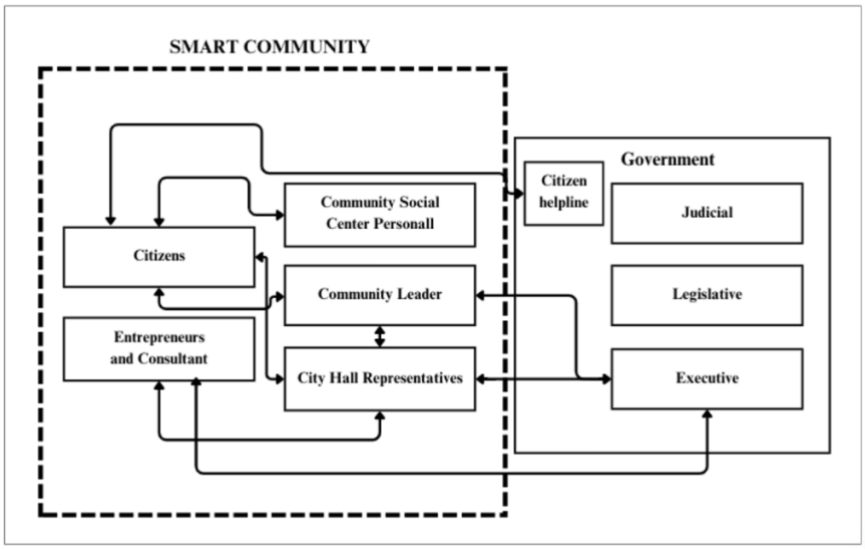


Fig. 1 - Figure caption. Smart Community Framework (Lopes et. al.,2024)

This framework presents how communities address local challenges, filling communication gaps and compensating for inefficiencies in government action. These communities are not formed arbitrarily; rather, they emerge as individuals come together, building networks to draw attention to pressing issues, advocate for public services, and, in some cases, bypass bureaucratic barriers to implement solutions themselves.

The framework reveals the diverse roles that smart communities play — not just as spaces for collaboration, resource sharing, and civic engagement, but also as meeting points that foster local innovation. Participants express a shared need for governance structures that are more inclusive and responsive, where citizen input is not only acknowledged but actively incorporated into decision-making processes. Over time, these communities establish credibility, making it harder for institutions to overlook their demands.

The proposed framework seeks to understand how communities become smart, shedding light on the mechanisms that allow a group of individuals to self-organize, communicate, and advocate for solutions that address local challenges. Ideally, once a community identifies its needs, leaders engage directly with local representatives, such as city councilors, to push for improvements, facilitating dialogue and resource allocation. However, if direct engagement with government structures remains ineffective over time, communities seek alternative channels — whether through city council representatives, local media, or the legislative chamber — to escalate their concerns. In certain cases, organized demonstrations, advocacy campaigns, or legal actions are necessary to ensure that institutional actors acknowledge and respond to their demands.

This model, grounded in the data collected, portrays a pragmatic vision of smart communities—one that is not solely focused on long-term structural change but also on the capacity to address recurring challenges through collective action and strategic partnerships. In the Section 4, we explore how this structure operates in the context of climate disasters, examining the role of smart communities in mitigating risks and enhancing local resilience.

2.3 Porto Alegre's geographic and historical context

Porto Alegre, the capital of Rio Grande do Sul, is Brazil's southernmost state, bordering Uruguay and Argentina. Founded in 1772 as a strategic port city, it quickly became an economic and political hub, shaped by waves of European immigration that played a central role in the city's urban development and social fabric (Constantino, 1998). German, Italian, Portuguese, and other immigrant communities settled in distinct neighborhoods,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

establishing businesses, industries, and civic institutions that contributed to the city's economic growth and cultural identity. Over the decades, Porto Alegre has distinguished itself as a leader in participatory governance, particularly through its internationally recognized Participatory Budgeting (PB) initiative, which has influenced urban management models worldwide (Baiocchi, 2003; Goldfrank, 2011).

Geographically, Porto Alegre is located along the Guaíba River, a defining feature that has historically shaped its economy, infrastructure, and urban expansion. However, this proximity to a vast hydrographic system also makes the city highly susceptible to flooding, a vulnerability that has been exacerbated by rapid urbanization, insufficient drainage infrastructure, and climate change effects (Rozer, Vogel, & Costa, 2021). The topography of the city, characterized by low-lying areas interspersed with hills, further complicates flood management, with several neighborhoods frequently experiencing inundation during extreme weather events (Silveira, 2023).

Historically, Porto Alegre has faced severe flooding events, with two particularly significant disasters shaping urban resilience strategies. The 1941 flood was one of the most catastrophic in the city's history, when extreme rainfall caused the Guaíba River to rise to an unprecedented 4.75 meters, submerging large parts of the city, including its downtown area. Nearly 70,000 people — approximately 26% of the city's population at the time— were displaced, and a third of the city's businesses and industries wereaffected (Silveira, 2023). The flood lasted approximately 40 days, marking it as one of the most extreme climate events recorded in southern Brazil. In response, authorities implemented structural flood control measures, culminating in the Porto Alegre Flood Protection System, completed in 1974, which includes a network of levees, pumping stations, and the controversial Mauá Wall, built along the waterfront to prevent future disasters (Guimaraens, 2009).

Despite these structural interventions, Porto Alegre continues to face significant flood risks. As highlighted by Valenti, Rolim & Rocha (2012), the city is particularly vulnerable due to its low altitude, with an average elevation of 4 meters above sea level, making floodwaters harder to control. The hydrographic system of Porto Alegre is complex, with the Guaíba River receiving water from four major tributaries — the Jacuí, Sinos, Caí, and Gravataí Rivers — which significantly increases runoff volume during heavy rainfall events. Moreover, the impermeabilization of urban surfaces due to rapid expansion has further reduced natural drainage, exacerbating flood impacts.

The 2024 floods, one of the most devastating climate disasters in the city's recent history, reinforced these concerns (WMO, 2024). As seen in previous flood events, community-led initiatives played a critical role in response and recovery, stepping in where governmental structures faced delays or inefficiencies. The disaster renewed urgent discussions on urban resilience and disaster governance, emphasizing that while Porto Alegre has a history of participatory governance, its institutional framework and infrastructure must continue evolving to address increasing climate risks.

Given Porto Alegre's historical legacy of civic participation and its ongoing exposure to climate risks, it serves as an important case to analyze the role of smart communities in disaster resilience. Understanding how grassroots networks interact with formal governance structures allows for a broader discussion on disaster preparedness, crisis management, and long-term climate adaptation strategies.

3. Research Method

This section outlines the methodological approach used in the study, applying qualitative research frameworks to explore governance within smart communities. The methodology follows Arksey and O'Malley (2005) and Godin et al. (2015), integrating literature reviews, semi-structured interviews, and grey literature analysis to explore how smart communities respond to climate disasters. The research examines smart community responses to the 2024 floods in Porto Alegre, structured into five phases: 1) Analysis of a previously developed conceptual framework on how communities become smart. 2) A systematic literature review to establish a theoretical foundation on smart communities and climate resilience. 3) First-hand observation of the 2024 floods and how smart communities mobilized during the crisis. 4) Reanalysis of semi-structured interviews with diverse stakeholders conducted before the disaster, and 5) a scoping review of grey literature and secondary data sources to further understand institutional responses and governance gaps. Each phase contributed to a deeper understanding of how community-driven governance mechanisms operate before, during, and after climate disasters. The combination of multiple qualitative research methods allowed for a comprehensive analysis, ensuring methodological rigor while capturing the complexity of smart community dynamics in crisis contexts.

3.1 Research design

This study employs a qualitative approach to examine governance dynamics within smart communities in Porto Alegre. Since this study aims to understand how communities mobilize, organize, and interact with governance structures, qualitative methods offer the depth needed for an in-depth exploration (Pozzebon, 2004). However, considering the use of secondary data and the scoping review of grey literature, the study also integrates elements

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of a mixed-methods approach, allowing for a broader analysis that includes policy reports and institutional documents.

The study builds upon a pre-existing conceptual framework, presented in 2.2, (Lopes et al., 2024) that explores how communities adopt governance practices and use technology to engage with public authorities and other stakeholders. This framework serves as a reference for analyzing the governance structures of smart communities in Porto Alegre.

Following this, a systematic literature review was conducted to strengthen the theoretical foundation on smart communities and climate disasters. The review followed Ridley's (2012) methodology, involving the selection and organization of relevant studies, the interpretation of key texts, and the synthesis of findings in alignment with the research objectives. The search focused on the terms "smart community" and "climate disasters" in the Scopus database, yielding 24 relevant academic sources, which were analyzed and integrated into the study.

3.2 Data collection

To better understand governance mechanisms in smart communities, we conducted semi-structured interviews, which provided flexibility for open-ended responses while ensuring comparability across participants (Benz & Eberlein, 1999). Given the complexity of governance structures, we adopted a multi-level approach to capture diverse stakeholder perspectives.

We conducted 25 interviews in Porto Alegre over two months in 2023, focusing on governance in climate-related contexts. A total of 23 interviews were selected for analysis. Participants were chosen based on their involvement in Community governance and their ability to provide insights into how smart communities function during crises. The selected interviews included representatives from four primary groups: a) Community leaders who organize and advocate for local initiatives, b) community collaborators who work within these communities, often sharing the same values and goals, c) community members who actively participate in governance and neighborhood associations, and d) local government representatives responsible for urban policies and disaster response efforts.

Interview sessions lasted between 40 and 100 minutes and were recorded with participant consent. The discussions focused on how smart communities interact with public authorities, coordinate internally, and organize around collective challenges. The interviews also provided a means of triangulating insights gathered from literature reviews and document analysis, reinforcing the study's findings.

Following the floods of May 2024, the lead author conducted additional fieldwork, initially as a volunteer supporting affected communities. This direct engagement provided an opportunity to observe smart community dynamics in real-time. Unlike the previous phase, no new interviews were conducted due to the sensitivity of the situation. Instead, observations focused on identifying how previously studied governance structures adapted in response to the crisis. Given the scale of the disaster, extensive secondary data was also available from reports produced by community organizations, local governments, and research institutions.

To complement primary data, a scoping review of grey literature was undertaken, drawing on reports from international and national institutions, including the World Bank, IBGE, and municipal research centers. Arksey and O'Malley (2005) note that scoping reviews are particularly useful in emerging research areas where empirical studies may still be limited. Similarly, Godin et al. (2015) highlight the value of grey literature in bridging academic research with policy and practice. Our review included policy briefs, governmental documents, and community-led publications, offering broader institutional perspectives on urban resilience and governance.

3.3 Data analysis

Data was analyzed using qualitative content analysis to identify governance patterns and themes within smart communities. A deductive coding strategy was applied, drawing from theoretical insights and key themes identified in the literature (Pozzebon, 2004). All interview recordings were transcribed using the qualitative data software Transkriptor. The transcripts were then imported into NVivo for thematic analysis, enabling the identification of central themes and recurring concepts. The analysis followed three stages: 1) Coding of key governance interactions and smart community structures. 2) Clustering of themes into broader categories aligned with research questions. 3) Identifying patterns across stakeholder groups to detect trends in governance models. In parallel, the scoping review of grey literature was analyzed using document analysis techniques to extract relevant policy insights and governance responses. This allowed us to integrate multiple sources of evidence, further validating the study's findings.

The final phase of analysis involved revisiting the conceptual framework to incorporate insights from the case study. By examining how smart communities in Porto Alegre mobilized before, during, and after the 2024 floods, the study refined the existing framework, expanding it into a more comprehensive model—Smart Communities

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2.0. This revised model accounts for the practical governance challenges faced by communities in crisis situations, emphasizing adaptive mechanisms and multi-stakeholder collaboration.

By combining literature review, semi-structured interviews, ethnographic fieldwork, and grey literature analysis, the study provides a nuanced examination of how smart communities navigate climate disasters. The integration of these methodological steps ensures that findings are grounded in both theoretical perspectives and empirical observations, offering valuable insights into the intersection of community resilience and urban governance.

4. Discussion

This discussion synthesizes insights from 23 in-depth interviews with community leaders, local residents, and government officials, along with documentary analysis, to explore how smart communities responded to the 2024 floods in Porto Alegre. It examines the challenges faced and the role of community governance in enhancing urban resilience.

4.1 The Porto Alegre 2024 Floods: A Case Study

The May 2024 floods reached unprecedented levels, with the Guaíba River peaking at 5.37 meters at Cais Mauá, surpassing the highest recorded flood in the city's history by 45 cm (Serviço Geológico do Brasil [SGB], 2024). The disaster had a devastating impact on urban infrastructure, exposing Porto Alegre's vulnerability to climate-related hazards. The city's main bus terminal remained closed for a month due to flooding (Prefeitura de Porto Alegre, 2024), while the Salgado Filho International Airport was shut down for over eight months, severely disrupting mobility, and logistics across the state (Governo do RS, 2024). Additionally, several stations of the Trensurb urban train system were submerged, interrupting railway connections between the capital and its metropolitan region for four months. By December 2024, three stations were still closed, further complicating daily commutes for thousands of residents (Governo do RS, 2024).

The social impact of the disaster was equally severe. More than 377 people remained displaced months after the event, while many families were relocated through the Compra Assistida program, which provided homes worth up to R$ 200,000 to those who lost their properties (United Nations, 2024). The destruction of residential areas was exacerbated by the failure of the Muro da Mauá, a flood protection structure built over fifty years ago. Its floodgates, designed to prevent water from entering the historic downtown area, failed to seal properly, allowing extensive inundation in one of Porto Alegre's oldest and busiest districts (Prefeitura de Porto Alegre, 2024).

Institutional analyses of the event indicate that the flooding was intensified by a combination of the El Niño phenomenon and the effects of climate change. El Niño, characterized by the abnormal warming of Pacific Ocean waters, disrupts weather patterns, and leads to increased rainfall in southern Brazil (World Meteorological Organization [WMO], 2024). This scenario underscores the urgent need to strengthen urban resilience by enhancing local governance mechanisms to mitigate the impact of extreme climate events in the future.

4.2 Communities Becoming Smart Communities in Climate Disasters

The literature on smart communities highlights their ability to self-organize, engage in civic participation, and collaborate with government institutions and private ones (Komninos, 2013; Hautekeur, 2005). During the 2024 floods, these three characteristics proved essential in disaster response.

Interviewee 1 emphasized that "when a community is organized, it gains political leverage to negotiate directly with the government — whether to veto projects or demand emergency actions" (Interview 1, 2023). Similarly, Interviewee 19 noted that, while community organization has weakened in recent years, leaders still manage to mobilize people more effectively than government agencies in times of crisis (Interview 19, 2023). This mobilization was instrumental in ensuring the swift implementation of the Compra Assistida housing program, which provided housing solutions for displaced families (United Nations, 2024). Beyond political advocacy, structured community networks were key to emergency response efforts. Interviewee 6 stressed that building partnerships with the government was crucial in securing resources and ensuring assistance reached the most vulnerable groups (Interview 6, 2023).

The findings align with the DRRS Porto Alegre Report (2024), showing that community-led networks were more agile than institutional responses, particularly in organizing donations, evacuations, and rescue operations. This highlights the critical role of community governance in urban resilience during climate disasters. Additionally, the Prefeitura de Porto Alegre (2024) recognized that many emergency shelters were initially organized by community groups rather than governmental institutions, demonstrating the power of grassroots mobilization. The effectiveness of these networks also reflects previous research indicating that well-organized grassroots communities play a crucial role in disaster governance, particularly when official response systems face delays (Krongthaeo et al., 2021). The Porto Alegre case reinforces that disaster governance must include community-led

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

initiatives as an integral component of urban resilience strategies (Marasco et al., 2022).

4.3 Community Credibility and Trust

The credibility of smart communities was crucial in mobilizing resources and fostering effective engagement with governance structures, enabling them to act swiftly and effectively during the crisis. According to Hautekeur (2005), community credibility—the trust communities hold—enables effective interaction with formal institutions. The trust in community-led mechanisms was evident during the 2024 floods, particularly through organizations like Fundação Cultural Floresta, which coordinated fundraising and distribution of essential goods. This highlights how strong community networks can complement and even enhance official disaster response efforts. Meanwhile, the Ação da Cidadania Sul, a local branch of the national Ação da Cidadania initiative, was instrumental in organizing emergency shelters and ensuring food security for displaced residents (Ação da Cidadania, 2024).

The long-standing credibility of these organizations played a critical role in their ability to attract donations and mobilize volunteers, reinforcing the argument that well-established community networks are essential for urban resilience (Marasco et al., 2022). This supports previous research indicating that communities with strong credibility can influence public policies and shape disaster response strategies (Craig et al., 2004).

Another key aspect was the role of community spaces as coordination hubs. Interviewee 9 described how community centers became “meeting points for organizing relief efforts and disseminating critical information” (Interview 9, 2023). This reflects research suggesting that community spaces act as focal points for collective action and mutual support during crises (Hautekeur, 2005). One striking example was the Velejadores Solidários RS, a sailing group that mobilized boats to rescue stranded families and later shifted to organizing donations of clean clothes, personal hygiene kits, and pet food for affected communities.

4.4 ICT and Smart Communities

The use of Information and Communication Technologies (ICTs) during the floods showed the potential of smart governance to improve climate resilience. For example, the interactive mapping platform by the municipal government helped track flood levels and coordinate emergency actions, demonstrating how ICT can enhance disaster response (Prefeitura de Porto Alegre, 2024b). Additionally, the ObservaPOA platform provided real-time data on the most affected neighborhoods, allowing communities to organize relief operations more effectively (Prefeitura de Porto Alegre, 2024a).

Digital governance research suggests that data-driven decision-making significantly improves crisis management (Lassa, 2019). Social media also played a critical role in facilitating decentralized coordination during the floods (Krongthaeo et al., 2021). However, technological solutions alone are insufficient—smart disaster governance must integrate local knowledge, citizen participation, and institutional support to be effective (Nam & Pardo, 2011). The Porto Alegre case illustrates that pre-established community hubs significantly enhance urban resilience, accelerating coordination and resource distribution.

4.5 Porto Alegre’s Institutional Coordination and Smart Community Gaps

Despite the effectiveness of community-led networks, several governance challenges were identified. A major issue was the lack of coordination among different levels of government, which delayed response efforts. The DRRS Porto Alegre Report (2024) found that there were 3,500 open emergency protocols during the disaster, highlighting bureaucratic inefficiencies and response fragmentation.In a 2023 interview, a local government representative acknowledged these difficulties, stating that "there is no alignment between the objectives of secretaries, council members, and the mayor. Each has their own priorities, with no clear strategy” (Interview 18, 2023). This confirms findings by Takara (2018) and Meijer & Rodríguez (2016), which highlight administrative fragmentation as a barrier to adaptive governance.

The breakdown of official communication systems further complicated the response. According to the Prefeitura de Porto Alegre (2024), the collapse of ICT-based monitoring systems and early warning alerts left many residents without real-time updates, forcing them to rely on community networks for critical information.

Interviewee 17 recalled that during a smaller flood in September 2023, "Civil Defense came to talk to us, but did nothing. It was through the internet and community networks that we learned how to respond” (Interview 17, 2023). This sentiment was echoed in the DRRS Porto Alegre Report (2024), which noted that government agencies lacked real-time situational awareness due to system failures, increasing reliance on informal communication channels.

Another significant challenge was infrastructure failure, which exacerbated the flood’s impact. The Muro da Mauá

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

flood barrier, built over 50 years ago, failed to prevent water from entering downtown Porto Alegre due to structural weaknesses in its floodgates (Prefeitura de Porto Alegre, 2024). The United Nations (2024) attributed part of the disaster's severity to the combination of El Niño and climate change, highlighting the urgent need for urban resilience planning.

The Porto Alegre case highlights the need for disaster response strategies that integrate multi-level governance, community engagement, and resilient digital infrastructure. Institutionalizing hybrid governance models that include smart community networks is crucial for improving crisis management in the future.

5. The Role of Smart Communities in Disaster Response

The 2024 floods in Porto Alegre presented significant challenges to urban governance and the city's response capacity. In this crisis, smart communities played a critical role in mobilizing resources, advocating for political action, and providing emergency support, effectively filling the gaps left by institutional responses. This experience reinforces the importance of community-driven governance models in strengthening resilience, fostering local coordination, and building trust networks (Hautekeur, 2005).

During the disaster, citizen-led initiatives proved essential in mitigating damages and organizing recovery efforts. Community-led mapping efforts utilized georeferenced tools to identify the hardest-hit areas, ensuring the efficient allocation of resources and prioritizing aid distribution. (Prefeitura de Porto Alegre, 2024a). Additionally, emergency relief coordination — largely driven by collaborative networks and social media — enabled faster distribution of food, medical supplies, and temporary shelter to displaced individuals (United Nations, 2024). In the aftermath of the floods, volunteers organized large-scale cleanup efforts, removing more than 13,000 tons of debris, demonstrating the power of collective action in disaster recovery (Prefeitura de Porto Alegre, 2024b).

The effectiveness of these community-driven responses not only helped alleviate the immediate crisis but also highlighted structural governance deficiencies that complicated disaster management. Local governments faced logistical and bureaucratic barriers, a common issue in Latin America, where institutional fragmentation hampers public sector efficiency (O'Toole & Burdess, 2004). The Porto Alegre case exemplifies this issue, revealing the urgent need to strengthen coordination between governments and communities to ensure a more agile and integrated response to future disasters. Based on the 2024 flood experience and insights from interviews, we identified three layers of community governance that played a pivotal role in disaster response:

Internal Community Dynamics – Autonomous grassroots networks that organize self-managed crisis responses, mobilizing resources and providing immediate support independently of government agencies.

Intermediary Actors – Social organizations, entrepreneurs, and non-profits that act as connectors, bridging the gap between communities, institutional resources, and the private sector to enable decentralized yet effective solutions.

Government Interaction and Institutional Support – Public policies and listening mechanisms that foster community engagement, reduce bureaucratic hurdles, and integrate grassroots efforts into official disaster response strategies.

These interconnected layers demonstrate the need for hybrid governance models, combining digital technologies, community engagement, and coordinated public policies, to build resilient urban environments capable of responding to climate crises (Reardon & Forester, 2015). Learning from the 2024 floods, we propose an updated Smart Communities Framework (Smart Communities 2.0) that integrates governance and technological innovations to enhance urban resilience (see Figure 2).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

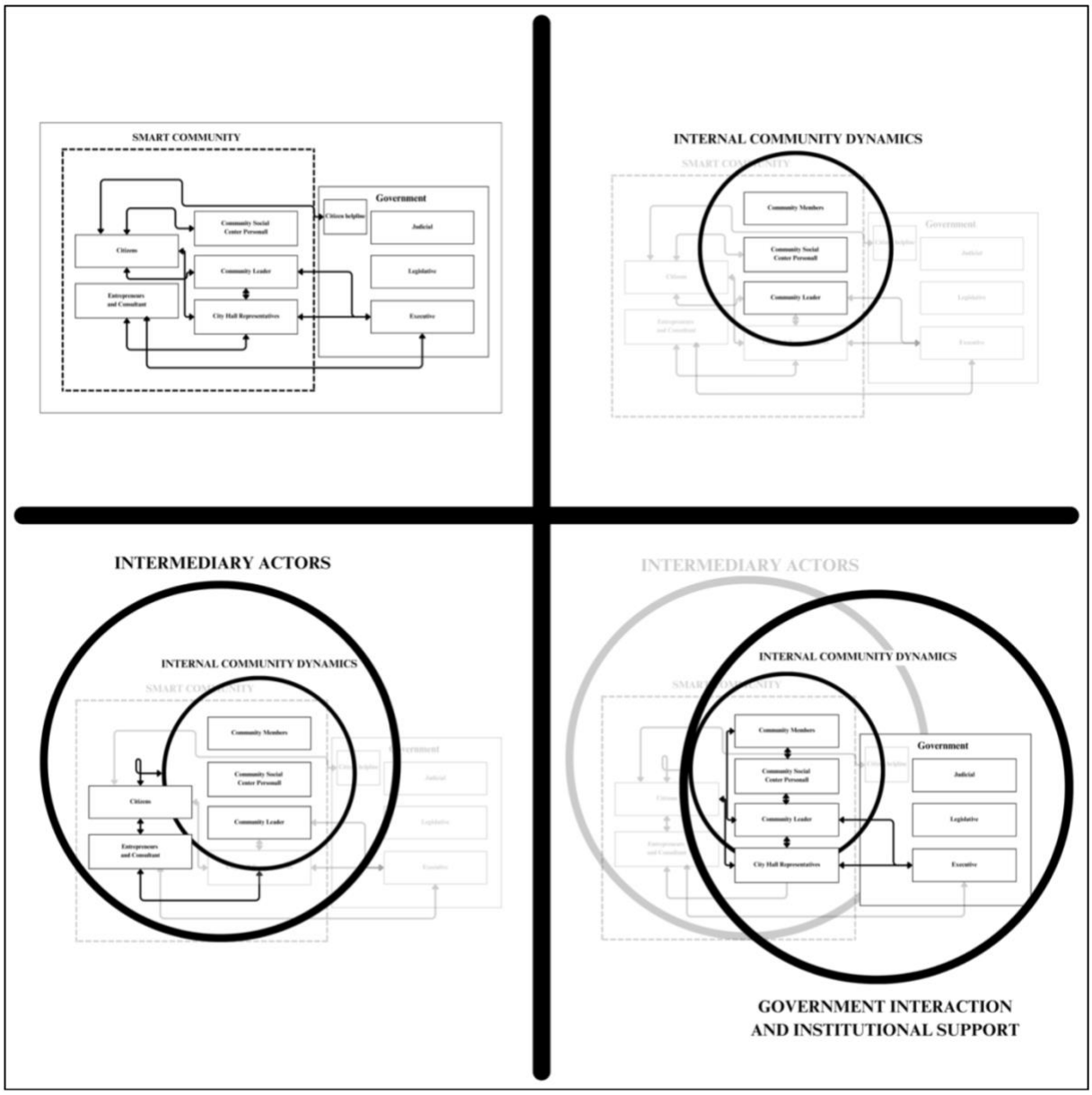


Fig. 2 - Smart Community Framework 2.0 (Created by the authors)

The evolution of Smart Communities as a concept is crucial for understanding their role in climate resilience. The Smart Communities 2.0 Framework aims to define how these networks function as key resilience-building actors, ensuring that climate-vulnerable cities are better equipped to withstand extreme events. This model is based on systematic literature review, qualitative interviews, fieldwork observations, and institutional reports, reinforcing the idea that decentralized governance structures are essential for disaster management.

Despite the proven effectiveness of community-led responses, there is still a significant gap in institutional policies recognizing and integrating smart communities as legitimate urban planning stakeholders. The Porto Alegre case illustrates this disconnect, while institutional responses were slow and fragmented, community-led initiatives were rapid, well-coordinated, and highly effective, forming support networks and accelerating recovery efforts. This finding highlights the importance of incorporating decentralized, participatory models into crisis governance, reducing the sole dependence on state agencies, and strengthening civil society's response capacity.

In the Latin American context, where challenges like inadequate infrastructure, social inequality, and political instability amplify the impacts of climate disasters, adopting the Smart Communities 2.0 Framework represents a transformative step forward. This model not only addresses immediate disaster response needs but also provides structural, long-term solutions, integrating technology, governance innovation, and community networks to create cities that are more resilient and prepared for future climate risks.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

6. Final remarks

The 2024 floods in Porto Alegre underscored the crucial role of smart communities in resource mobilization, emergency response, and urban recovery. While institutional responses faced logistical and bureaucratic challenges, community networks proved to be more agile and effective, reinforcing the importance of decentralized governance in crisis scenarios. The collaboration between citizens, intermediary actors, and government agencies was crucial in mitigating the disaster's impacts and ensuring direct assistance to affected populations.

This study emphasizes the importance of the Smart Communities 2.0 Framework, illustrating how hybrid governance models can enhance urban resilience and better equip cities to respond to future climate disasters. Porto Alegre serves as a real-world case study that bridges theory and practice in the fields of adaptive governance and disaster management. Additionally, this research contributes to the broader discourse on smart governance, multi-level governance, and social innovation, offering new perspectives on the role of communities in crisis management.

Based on these findings, governments must institutionalize smart communities in disaster response, ensuring direct access to resources, information, and decision-making processes. This requires the development of formal support mechanisms, ensuring that community networks have direct access to resources and information. Moreover, policies promoting digital infrastructure and real-time communication are vital to empowering community-led responses and improving disaster preparedness. Advancing decentralized governance, where communities have greater autonomy in coordinating local responses, can reduce over-reliance on state intervention and foster more resilient cities.

This study has some methodological limitations, including the lack of post-flood interviews, which could offer further insights into the long-term impacts of community-led governance. Additionally, quantitative research is needed to measure how smart communities contribute to urban resilience. Future studies should explore comparative analyses between Porto Alegre and other Latin American cities facing similar climate challenges to validate the framework in diverse contexts.

Another crucial area for further research is the vulnerable communities residing in high-risk areas, such as riverside settlements and hillside neighborhoods. Many of these groups faced forced displacement and difficulties in resettlement, exposing critical gaps in urban planning and disaster preparedness. Understanding how these communities organized themselves, accessed emergency support, and navigated institutional responses would provide valuable insights for developing more effective policies to prevent similar crises in the future.

In conclusion, this study emphasizes that urban resilience requires a collective effort, where governments, communities, and technologies collaborate to enhance disaster preparedness and recovery. The experience of Porto Alegre demonstrates that organized communities are strategic actors in disaster response. If cities aim to be better prepared for climate crises, they must embrace new governance models that balance citizen participation, technological innovation, and institutional support. Resilience is not just a theoretical concept, it is a practice built collectively.

Acknowledgement

- **Grant:** This research was supported by the Coordination for the Improvement of Higher Education Personnel (CAPES), Brazil – Scholarship for Doctoral Studies, Grant Code 001.
- **Contributor Statement***: Carolina Tavares Lopes: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Visualization, and Writing – original draft.
  Lucas Roldan: Conceptualization, Investigation, Methodology, Supervision, Validation, Writing – review & editing.
  Edimara Luciano: Conceptualization, Investigation, Methodology, Project administration
  All authors have read and approved the final manuscript.
- **Use of AI***: During the preparation of this work, the authors used ChatGPT (OpenAI) to improve grammar and fluency, given that their native language is Portuguese. In addition, Canva AI tools were used to assist in the visualization and conceptual development of the proposed frameworks. After using these tools, the authors reviewed, edited, and validated all content, taking full responsibility for the final version of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

Ação da Cidadania. (2024). Emergency shelters and food security response to the Porto Alegre floods. Porto Alegre, Brazil.

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between smart, sustainable, and resilient cities? Cities, 60, 234–245. https://doi.org/10.1016/j.cities.2016.09.009

Alawadhi, S., Aldama-Nalda, A., Chourabi, H., Ramon, J., Leung, S., Mellouli, S., Nam, T., Pardo, T. A., Scholl, J., & Walker, S. (2017). Building understanding of smart city initiatives. In International Conference on Electronic Government (pp. 40–53). Springer. https://doi.org/10.1007/978-3-319-64677-0_4

Ariyaningsih, D., & Shaw, R. (2023). Community-based approach for climate resilience and COVID-19: Case study of a Climate Village (Kampung Iklim) in Balikpapan, Indonesia. Land, 12(3), 650. https://doi.org/10.3390/land12030650

Azizi, K., Kofi, S., Saija, L., Ghadir, M., & Meier, C. I. (2022). Urban climate-integrated community-based approaches to urban pluvial flooding research, trends, and future directions: A review. Urban Climate, 44, 101237. https://doi.org/10.1016/j.uclim.2022.101237

Baiocchi, G. (2003). Participation, activism, and politics: The Porto Alegre experiment and deliberative democratic theory. Politics & Society, 31(1), 43–72. https://doi.org/10.1177/0032329202250169

Bartoletti, R., & Faccioli, F. (2016). Public engagement, local policies, and citizens' participation: An Italian case study of civic collaboration. Social Media + Society, 2(3), 1–11. https://doi.org/10.1177/2056305116662187

Berardi, U. (2013). Sustainability assessments of urban communities through rating systems. Environment, Development and Sustainability, 15(6), 1573–1591. https://doi.org/10.1007/s10668-013-9462-0

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. Journal of Urban Technology, 18(2), 65–82. https://doi.org/10.1080/10630732.2011.601117

Craig, G., Mayo, M., Popple, K., Shaw, M., & Taylor, M. (2004). The Budapest Declaration: Building European civil society through community development. Community Development Journal, 39(4), 423–429. https://doi.org/10.1093/cdj/39.4.423

Development Bank of Latin America (CAF). (2014). Climate change and cities in Latin America: Vulnerability and adaptation. CAF Development Bank.

DRRS Porto Alegre. (2024). Final report on disaster response and resilience strategies in Porto Alegre: Lessons from the 2024 floods. Porto Alegre, Brazil.

Fundação Cultural Floresta. (2024). Emergency relief and social mobilization in disaster-affected communities: Response to the Porto Alegre floods of 2024. Porto Alegre, Brazil.

Governo do Rio Grande do Sul. (2024). Relatório de impacto das enchentes de 2024: Infraestrutura, realocação e planejamento urbano. Porto Alegre, Brazil.

Goldfrank, B. (2011). Deepening local democracy in Latin America: Participation, decentralization, and the left. Penn State Press.

Harrison, C., & Donnelly, I. A. (2011). A theory of smart cities. In Proceedings of the 55th Annual Meeting of the International Society for the Systems Sciences (pp. 1–15).

Hautekeur, G. (2005). Community development in Europe. Community Development Journal, 40(4), 385–398. https://doi.org/10.1093/cdj/bsi059

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data and open government. Information Systems Management, 29(4), 258–268. https://doi.org/10.1080/10580530.2012.716740

Komninos, N. (2013). Intelligent cities: Towards interactive and global innovation environments. Routledge. https://doi.org/10.4324/9780203072558

Li, H., Zhang, X., & Fan, J. (2020). The impact of urbanization on extreme precipitation events: Evidence from high-resolution climate models. Journal of Climate Change Research, 15(4), 112-127. https://doi.org/10.1016/j.jccr.2020.03.005

Lopes, C. T., Luciano, E., & Roldan, L. (2024). How Communities Become Smart: A Case Study of Porto

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Alegre, Brazil. In Proceedings of the 25th Annual International Conference on Digital Government Research (dg.o '24) (pp. 832–840). Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3657054.3657267

Marasco, S., Kammouh, O., & Cimellaro, G. P. (2022). Disaster resilience quantification of communities: A risk-based approach. International Journal of Disaster Risk Reduction, 70, 102778. https://doi.org/10.1016/j.ijdrr.2022.102778

McKinsey Global Institute. (2011). Urban world: Mapping the economic power of cities. McKinsey & Company.

Mutiarni, Y. S., Nakamura, H., & Bhattacharya, Y. (2022). The resilient community: Strengthening people-centered disaster risk reduction in the Merapi volcano community, Java, Indonesia. Sustainability, 14(6), 2215. https://doi.org/10.3390/su14062215

Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. In Proceedings of the 12th Annual International Conference on Digital Government Research (pp. 282–291). https://doi.org/10.1145/2037556.2037602

Nasiri, H., Yusof, M. J. M., & Ali, T. A. (2016). An overview of flood mitigation strategy and assessment of dam operation for flood control. Water Resources Management, 30(3), 925–945. https://doi.org/10.1007/s11269-015-1191-6

Nkwunonwo, U. C., Whitworth, M., & Baily, B. (2020). Flooding and flood risk reduction in Nigeria: A review of the role of the government. Environmental Management, 66(4), 719–733. https://doi.org/10.1007/s00267-020-01305-2

Parvin, G. A., Dasgupta, R., Abedin, A., Ingirige, B., Kibria, M. G., Fujita, K., Basu, M., Shaw, R., & Nakagawa, H. (2023). Disaster experiences, associated problems, and lessons in Southwestern Coastal Bangladesh: Exploring through participatory rural appraisal to enhance resilience. Sustainable and Resilient Infrastructure, 8(2), 223–236. https://doi.org/10.1080/23789689.2022.2107728

Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017). Delivering public value through open government data initiatives in a smart city context. Information Systems Frontiers, 19(2), 213–229. https://doi.org/10.1007/s10796-016-9673-7

Phong, T. V. G., & Shaw, R. (2009). Enhancing community resilience through information management: Flood risk. In Geoinformatics for Natural Resource Management (pp. 165–183). Nova Science Publishers.

Prefeitura de Porto Alegre. (2024a). Plano emergencial de resposta às enchentes: Estratégias de resiliência urbana e coordenação interinstitucional. Porto Alegre, Brazil.

Prefeitura de Porto Alegre. (2024b). ObservaPOA: Análise de dados sobre a resposta comunitária e institucional às enchentes de 2024. Porto Alegre, Brazil.

Reardon, K. M., & Forester, J. (2015). Rebuilding community after Katrina: Transformative community planning and action. Planning Theory & Practice, 16(3), 305–324. https://doi.org/10.1080/14649357.2015.1056633

Rozer, V., Vogel, C., & Costa, L. (2021). Flood risks and urban expansion: Understanding vulnerabilities in changing cities. Environmental Hazards, 20(3), 275–289. https://doi.org/10.1080/17477891.2021.1905568

Shastri, H., Ghosh, S., Paul, S., & Karmakar, S. (2015). Urban heat island intensity over major cities of India: Spatial and temporal variations. Journal of Earth System Science, 124(2), 499–514. https://doi.org/10.1007/s12040-015-0548-4

Tang, J. (2022). Design and research of intelligent community management system based on intelligent Internet of Things. Mobile Information Systems, 2022, 1–8. https://doi.org/10.1155/2022/9874056

Tedong, P. A., & Zyed, A. S. (2021). Searching for sustainable cities: Residents' perceptions on the implementation of sustainable cities in Malaysia. Community Development Journal, 56(1), 101–118. https://doi.org/10.1093/cdj/bsz027

United Nations (UN). (2024). Flooding in southern Brazil: Climate change, El Niño, and urban resilience

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

strategies. https://news.un.org/pt/story/2024/05/1831311

United Nations. (2019). World urbanization prospects: The 2018 revision. Department of Economic and Social Affairs, Population Division. https://population.un.org/wup/

UN-Habitat. (2022). World cities report 2022: Envisaging the future of cities. United Nations Human Settlements Programme.

World Meteorological Organization (WMO). (2024). State of the climate in Latin America and the Caribbean 2023. WMO. https://public.wmo.int/en/resources/state-of-climate

Appendix A

What is your vision regarding the 4th District development process?

What short-term and long-term results are expected with the implementation of +4D?

Are there specific strategies to promote social inclusion and generate employment for citizens?

How is the local community involved in the development process?

Are there specific forums or channels for residents' participation in decision-making?

How does the program collect feedback and address the needs of residents?

What are the transparency and accountability mechanisms to inform residents about decisions and allocated resources?

Is there any incentive to encourage civic engagement among residents?

What is the role of civil society in district planning?

What are the main benefits for the government in actively including communities (small governance) in Master Plans?

How are challenges of representativity and diversity addressed when including these communities in governmental planning processes?

What are the main barriers faced by citizens when trying to participate in these plans and solutions?

What is the importance of ongoing collaboration between the government and communities in building "smart city" strategies?

Should there be a more consistent approach to active public listening in the development of these plans?

How do you anticipate the evolution of citizen participation considering innovations, not only in data collection but in general collab?

How does the government establish contact and involve these groups in the development of these plans?

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Uso de DAG e IA para inovação na gestão pública e privada

Cassiano Oliveira da Motta* [a], *Guilherme* Costa Wiedenhoft [b], *Mônica* Fitz-Oliveira [c]

[a] Instituto de Ciências Econômicas, Administrativas e Contábeis: Universidade Federal do Rio Grande, Santo Antônio da Patrulha, Rio Grande do Sul, Brasil, cassianoomotta@gmail.com, 0009-0003-5552-7301

[b] Instituto de Ciências Econômicas, Administrativas e Contábeis: Universidade Federal do Rio Grande, Santo Antônio da Patrulha, Rio Grande do Sul, Brasil, wiedenhoft@gmail.com, 0000-0003-2426-4396

[c] Escola de Administração: Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brasil, eng.monica.oliveira@gmail.com, 0000-0002-3028-138X

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. O presente estudo analisa o uso de Dados Abertos Governamentais (DAG) e Inteligência Artificial (IA) para inovação em Santo Antônio da Patrulha - Rio Grande do Sul sob a ótica de gestores públicos e gestores privados. A pesquisa é de cunho qualitativo, e os dados foram coletados por meio de entrevistas realizadas com oito gestores, sendo eles cinco da administração pública e três do setor privado, e também a partir do portal de dados abertos do município. A análise revela que, apesar do reconhecimento dos potenciais benefícios advindos dos Dados Abertos Governamentais e da Inteligência Artificial, sua adoção efetiva é limitada. Foram identificadas deficiências críticas na qualidade, acessibilidade e divulgação dos Dados Abertos Governamentais, além da falta de capacitação técnica em Inteligência Artificial, especialmente no setor público. A resistência à mudança também é uma barreira significativa, contudo, os gestores vislumbram o potencial da Inteligência Artificial no intuito de otimizar processos e impulsionar a inovação, e destacam a colaboração público-privada como crucial. O estudo conclui que o município de Santo Antônio da Patrulha pode se beneficiar dessas tecnologias, mas precisa investir na melhoria dos Dados Abertos Governamentais, na capacitação técnica e na promoção de uma cultura orientada a dados. Este trabalho contribui para auxiliar na compreensão do tema ao fornecer insights sobre a realidade de um município brasileiro e delinear caminhos para a adoção bem-sucedida de Dados Abertos Governamentais e Inteligência Artificial, visando à promoção da transparência, eficiência e desenvolvimento socioeconômico. As limitações da pesquisa, como a amostra reduzida, apontam para a necessidade de estudos futuros.

Keywords. Dados Abertos Governamentais; Inteligência Artificial; Inovação; Administração Pública; Administração Privada.
Research paper, DOI: https://doi.org/10.59490/dgo.2025.999

1. Introdução

Os dados abertos governamentais (DAG) surgiram com o objetivo de promover a participação cidadã, aumentar a transparência governamental e fortalecer a accountability. No entanto, foi durante o governo de Barack Obama, em 2009, que os DAG ganharam maior destaque, impulsionando a criação de portais de dados abertos governamentais e oferecendo aos cidadãos e partes interessadas acesso facilitado a informações públicas (Attard et al., 2015). Com o avanço da tecnologia e a crescente disponibilidade de dados, qualquer indivíduo ou instituição pode aprimorar, reutilizar, inovar, compartilhar e analisar informações conforme seus interesses (Kawashita et al., 2024). Esses dados, ao serem acessíveis ao público, oferecem uma gama de oportunidades para a inovação e o

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

desenvolvimento em diversos setores. A inteligência artificial (IA), definida por Nitzberg e Zysman (2022) como "a tecnologia que usa computação avançada para realizar tarefas com capacidade cognitiva [...]", é uma ferramenta poderosa que tem o potencial de transformar a maneira como são utilizados os DAG.

No entanto, os autores Nitzberg e Zysman (2022) reforçam que a IA é altamente dependente da alimentação de dados para se aproximar ou se igualar à capacidade cognitiva humana. A integração eficaz de IA com DAG pode potencializar a capacidade de análise e interpretação de grandes volumes de dados, gerando insights valiosos e permitindo a automação de processos complexos. A combinação da IA e dos DAG abre portas para diferentes possibilidades, mas exige um cuidado especial.

Conforme apontado por Taylor (2023), a quantidade de dados gerados no mundo está crescendo exponencialmente. Essa explosão de dados representa tanto uma oportunidade quanto um desafio. Para transformar esses dados em informações acionáveis, é preciso garantir que eles sejam precisos e confiáveis. Além disso, como ressaltam Wang et al. (2022), a habilidade de captar e lapidar os dados relevantes é essencial para fomentar a inovação e otimizar processos de tomada de decisão. A capacidade de transformar grandes volumes de dados brutos em informações acionáveis é essencial para manter a competitividade e a eficiência tanto no setor público quanto no setor privado (Makridakis, 2017; Wang; Teo; Janssen, 2021). O uso da IA está se tornando cada vez mais frequente na sociedade contemporânea devido à grande quantidade de dados produzidos diariamente, a IA causa impacto em diversas áreas e indivíduos, sendo utilizada para melhorar serviços, criar novas oportunidades de negócios e resolver problemas complexos (Ghani et al., 2019).

Com base no exposto acima, diante de uma economia diversificada, que abrange desde a agricultura até o comércio e a prestação de serviços, Santo Antônio da Patrulha, um município brasileiro, enfrenta desafios constantes em várias áreas ao buscar soluções inovadoras e sustentáveis para seu desenvolvimento econômico, infraestrutura e qualidade de vida dos cidadãos. A utilização eficaz de DAG, combinada com a IA, pode ser uma solução promissora para enfrentar esses desafios.

Diante disto, esta pesquisa busca responder à seguinte questão: Como gestores da administração pública e privada de Santo Antônio da Patrulha podem utilizar Dados Abertos Governamentais com o auxílio da Inteligência Artificial para gerar inovação? A análise dessa questão permite entender se os gestores públicos e gestores privados estão aproveitando os DAG para oferecer serviços mais eficazes e impulsionar a inovação.

Além disso, é fundamental investigar como essas tecnologias podem ser adaptadas e aplicadas às necessidades específicas de Santo Antônio da Patrulha. Considerando as características únicas do município, a pesquisa pretende oferecer uma visão das oportunidades e desafios associados à integração de IA e DAG. Com isso, espera-se contribuir para o desenvolvimento de estratégias que promovam a inovação, a eficiência administrativa e o bem-estar dos cidadãos.

2. Referencial teórico

Esta seção dedica-se à apresentação dos fundamentos teóricos e a revisão da literatura utilizada neste estudo. Neste capítulo serão abordados os temas IA com ênfase em DAG e como o uso em conjunto destes podem gerar inovação no setor público e privado.

2.1 Inteligência Artificial

Na contemporaneidade, segundo Mutascu (2021), a IA não está sendo utilizada somente para o desenvolvimento de processos de automação, mas também possui grande uso na conclusão de projetos.

A IA é definida como a capacidade de um sistema interpretar corretamente dados externos, aprender a partir desses dados e utilizar essas aprendizagens para alcançar objetivos e realizar tarefas específicas por meio de adaptação, conforme Sellitto (2002). Este é um dos horizontes da ciência da computação que busca desenvolver formas de simular a capacidade humana. Suas principais características incluem a resolução de problemas, tomada de decisões, raciocínio e o reconhecimento de padrões.

De acordo com Yigitcanlar, Degirmenci e Inkinen (2022), a IA é adotada em setores privados e públicos por seu principal fator de estar disponível 24 horas por dia possuindo assistências digitais, decisões ágeis, eficiência na redução de erros humanos, auxiliando em serviços repetitivos e até assumindo riscos humanos.

Contudo, autores como Mak e Pichika (2019) alegam que a IA aprende através de máquinas e técnicas de aprendizado profundo. Ela usa métodos estatísticos para aprender sem precisar de programação direta. Com muitos dados, as máquinas podem desenvolver estratégias para realizar uma tarefa específica.

Segundo Yigitcanlar e Cugurullo (2020), as inteligências artificiais (IAs) reparam e gerenciam setores do dia a dia,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

e as áreas em que estão vinculadas vão desde agricultura, saúde, segurança, marketing, finanças, robótica e transportes, com o objetivo de adquirir conhecimento, tanto diretamente, por meio da detecção do ambiente, quanto indiretamente, por meio de grandes conjuntos de dados instalados pelos desenvolvedores, sendo classificada como um conglomerado de conhecimento que auxilia na tomada de decisões de maneira mais precisa e simples do que outros métodos, como por exemplo modelagem e gestão de indicadores.

Conforme Paschen, Pitt e Kietzmann (2020), a IA é capaz de analisar e combinar conjuntos de dados sendo possível obter excelentes resultados com ações baseadas em dados criados por ela mesma. Além disso, a IA engloba tecnologias como aprendizado automático, tecnologias de captura, análise e compartilhamento de dados, redes neurais, processamento de linguagem natural, sistemas especializados, visão computacional, reconhecimento de fala, planejamento e robótica, entre outras. A IA possui a capacidade de revolucionar diferentes aspectos empresariais, incluindo operações, processos decisórios, criação de produtos e interações com os clientes (Singh et al., 2020; Yigitcanlar et al., 2020; Alter 2022, Barns 2021).

Por fim, Sandeep Ganesh (2022) relata que a IA apresentou proficiência na resolução de problemas que vão desde: pensamento crítico, tomada de decisão, redução de erros e transferência de conhecimento. Este avanço significativo também pode ser observado no uso de DAG. A aplicação de IA no contexto de DAG potencializa ainda mais esses benefícios, proporcionando novas oportunidades para a inovação e a eficiência em diversas áreas.

2.2 Dados Abertos Governamentais

Conforme Nurakmal et al. (2022) no ecossistema de DAG, existem três participantes-chave: os provedores de DAG, os usuários de DAG e os beneficiários de DAG, respectivamente, os provedores de DAG são as partes interessadas, principalmente em órgãos governamentais, responsáveis por disponibilizar os DAG em uma plataforma online (sites ou aplicativos), os usuários e beneficiários de DAG podem ser qualquer indivíduo ou instituição que queira reutilizar, replicar, compartilhar, analisar, manipular e também replicar os DAG.

De acordo com Calaça et al. (2022), para um dado ser considerado aberto ele deve estar disponível sem qualquer custo para todos poderem usar e compartilhar sem nenhum tipo de restrição de direitos autorais, ou outros meios de controle e limitações. Pereira et al. (2017), relata que utilizando as tecnologias da informação de forma inovadora pelas administrações públicas e governos obtêm-se um aprimoramento na interação com a área de prestação de serviços, cidadãos e partes interessadas.A publicação de dados precisa de ser acompanhada por uma infraestrutura que seja capaz de lidar com os dados de uma forma fácil de utilizar, a fim de reduzir o limiar para os utilizadores (Janssen; Zuiderwijk, 2014).

Os DAG têm o intuito de fortalecer a transparência conforme Lourenço (2015), contribuindo assim para o processo na tomada de decisão de gestores públicos e também geração de valor para os cidadãos (Ruijer; Grimmelikhuijsen; Meijer, 2017), o que consequentemente irá proporcionar serviços públicos mais eficazes de acordo com Janssen, Charalabidis e Zuiderwijk (2012).

Com o adequamento dos DAG eficientes para a geração de inovação, serviços de valor agregado, empregos íntegros e de alta qualidade, esses dados são reconhecidos como high value data (HVD) e sua tradução se dá por “dados de alto valor”, na qual seu reaproveitamento traz benefícios e vantagens significativas para a sociedade, ambiente e economia (Karamanou et al., 2022).

Perante os autores como Attard et al. (2015) existem três principais razões para um governo implementar dados abertos governamentais, sendo elas:

- Transparência: Para garantir uma sociedade democrática e eficiente, é essencial que cidadãos e outras partes interessadas possam monitorar as ações e a legitimidade do governo. A transparência envolve não apenas o acesso aos dados, mas também a capacidade de usá-los, reutilizá-los e compartilhá-los. O êxito em promover a transparência resulta em um aumento considerável no controle social exercido pelos cidadãos.

- Liberando valor social e comercial: Os governos geram e coletam uma vasta quantidade de dados em muitos setores diferentes (Alexopoulos et al., 2014). Esses dados, que incluem informações como endereços de escolas, dados geoespaciais, dados ambientais, dados de transporte e planejamento, e informações orçamentárias, possuem valor tanto social quanto comercial e podem ser aplicados para diversos propósitos além dos previstos inicialmente. Ao tornar esses dados públicos, o governo encoraja as partes interessadas a inovar e criar novos serviços com base neles.

Diante de Nikiforova, Aloqaily e Alsmirat (2021), cada vez mais governos estão lançando portais abertos de dados governamentais que podem ser acessados e utilizados por todos. Com essa rápida disponibilidade, as tomadas de decisões estão cada vez mais ágeis e corretas, ocasionando a confiança, satisfação e transparência.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Nikiforova, Aloqaily e Alsmirat, por sua vez consideram que estes dados “mais inteligentes” têm fortes incentivos para uma economia sustentável e com uma grande importância na inovação das tecnologias de informação e comunicação (TIC).

Segundo Mutambik et al. (2023), uma das formas do governo enfrentar os desafios e o rápido crescimento da urbanização, é capacitando os próprios cidadãos para assim terem mais autonomia e capacidades para tomarem suas decisões através do acesso de portais online de dados abertos. Tais portais são capazes de conceder definições ainda mais esclarecidas aos profissionais e também aos cidadãos em uma grande dimensão de áreas, envolvendo temas desde saúde e trânsito até o desenvolvimento de novos negócios, sendo capaz de estimular os cidadãos a fazerem parte da criação de políticas sociais mais eficazes.

2.3 Inovação, inteligência artificial e dados abertos

Segundo Karamanou, Kalampokis e Tarabanis (2022) os DAG quando utilizados juntamente com IA resultam em novos insights produtivos facilitando a interligação e reutilização de dados oriundos de várias fontes. De acordo com Spalević et al. (2023) os governos podem utilizar IA para automatizar a análise de conjuntos de dados governamentais disponíveis publicamente, permitindo que eles reconheçam padrões, entendam os fatores socioeconômicos e tomem decisões políticas baseadas em dados de forma eficaz. Por fim, Spalević et., (2023) destacam que a aplicação da IA no governo eletrônico otimiza a alocação de recursos, aborda questões sociais e aprimora os serviços, enfatizando a importância da educação em IA para uma implementação de alta qualidade em diferentes setores.

Com o aumento da computação em nuvem e da tecnologia de IA, os governos tendem a empregar a análise de dados através da IA para criar mais valor a partir dos dados abertos (Gao; Janssen; Zhang, 2020). Pereira et al. (ibidem) relata que tecnologias da informação e comunicação (TIC) estão permitindo através de dados gerados por organizações públicas e serviços automatizados a resposta de problemas e dúvidas relacionadas às questões públicas.

Diante de Kucera e Chlapek (2014), os benefícios dos DAG são avaliados com base em sua capacidade de promover transparência, eficiência e inovação. Kucera e Chlapek também citam como benefícios dos DAG as seguintes inovações:

- Aumento da transparência: Os dados abertos permitem que os cidadãos tenham acesso a informações governamentais, promovendo a transparência e a prestação de contas.
- Melhoria dos Serviços Governamentais: Ao disponibilizar os dados abertos, os governos podem melhorar a prestação de serviços públicos e responder de forma mais eficaz às necessidades da população.
- Facilitação de Mercados: Os dados abertos podem impulsionar a inovação e o desenvolvimento de novos produtos e serviços, beneficiando tanto os consumidores quanto as empresas.
- Estímulo ao Crescimento Econômico: A disponibilidade de dados abertos pode impulsionar a economia, gerando oportunidades de negócios e promovendo o desenvolvimento econômico.
- Melhoria da Gestão de Dados: Os dados abertos podem ajudar as organizações governamentais a compreender e gerir melhor suas informações, resultando em processos mais eficientes e eficazes.

Esses benefícios são essenciais para promover a inovação, a participação cívica e o progresso social em uma sociedade cada vez mais orientada pela informação.

3. Método de pesquisa

O método de pesquisa adotado neste trabalho foi de origem qualitativa conforme Sampieri, Collado e Lucio (2006), com foco em um estudo de caso único, o município de Santo Antônio da Patrulha - Rio Grande do Sul, conforme Yin (2002). A pesquisa foi estruturada em três fases principais: planejamento, coleta de dados e análise de dados. A seguir, detalha-se cada uma dessas etapas:

1. **Planejamento:** A primeira fase consistiu em uma revisão sistemática da literatura, com o objetivo de identificar as categorias e conceitos relevantes para a elaboração do instrumento de pesquisa, utilizando a base de dados Web of Science e focando em artigos que abordavam IA, DAG e Inovação, com combinações de palavras-chave como "Artificial Intelligence", "Open Data", "Open Data Government" e "Innovation", além da aplicação de filtros para exclusão de artigos de revisão (Review Article) e periódicos Open Access. Como resultado, foram encontrados 269 documentos, publicados principalmente em 2023, o que permitiu

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

uma análise atualizada do tema, a partir da qual foram identificadas três categorias principais para análise: Qualidade dos Dados Abertos Governamentais (acesso, disponibilidade, legibilidade, representatividade, confiabilidade e transparência), Processamento de Dados com IA (triagem, análise, interpretação e tratamento de dados) e Inovação e Automação Governamental (portais de dados abertos, digitalização governamental, e-governo, serviços públicos automatizados), que serviram de base para a elaboração do roteiro de entrevista, validado por três mestrandos e um doutorando em Administração com experiência em DAG e IA.

2. **Coleta de Dados:** A segunda fase foi realizada por meio de duas estratégias principais, as quais foram: análise do portal de dados abertos do município de Santo Antônio da Patrulha e entrevistas semiestruturadas. No portal, foram avaliados critérios como acesso aos dados (facilidade de acesso e necessidade de login), disponibilidade (frequência de atualização e completude), legibilidade (formato e facilidade de compreensão), representatividade (abrangência em relação a setores e grupos populacionais), confiabilidade (precisão e fontes) e transparência (clareza e ausência de omissões). Já as entrevistas foram conduzidas com 08 gestores (05 da administração pública e 03 do setor privado), utilizando um roteiro dividido em três partes: conceitos e consentimento (explicação de DAG, IA e inovação, além da apresentação do Termo de Livre Esclarecimento e Consentimento - TLEC), perguntas sobre DAG e IA (11 questões sobre a percepção dos gestores quanto ao uso dessas tecnologias para inovação) e dados sociodemográficos (06 perguntas para caracterizar o perfil dos respondentes, como idade, gênero, nível de escolaridade, área de atuação, cargo e tempo de experiência). As entrevistas foram gravadas e transcritas com o auxílio de ferramentas de IA, como Tactiq (para entrevistas online) e Transcriby e TurboScribe (para entrevistas presenciais).

3. **Análise de Dados:** A terceira fase, dedicada à análise dos dados, foi realizada em duas etapas principais. Primeiramente, os dados coletados do Portal de Dados Abertos do Município de Santo Antônio da Patrulha e foram organizados e analisados em um quadro classificatório (localizado na seção 4.1.2 Análise classificatória do portal de dados abertos do município) que avaliou o atendimento aos critérios de qualidade dos Dados Abertos Governamentais. O quadro utilizou três status: “Atende totalmente” (critério plenamente atendido), “Atende parcialmente” (critério parcialmente atendido, mas com necessidade de melhorias) e “Não atende” (critério não atendido ou com deficiências críticas). Em seguida, as transcrições das entrevistas realizadas com 08 gestores (05 da administração pública e 03 do setor privado) foram analisadas com o auxílio do software Sphinx, que facilitou a codificação e categorização dos dados. Os trechos das entrevistas foram agrupados em códigos e categorias predefinidas na Revisão Sistemática da Literatura, como Qualidade dos DAG (fácil acesso, falta de divulgação, dificuldade de acesso), Processamento de Dados com IA (triagem, análise, interpretação, ética na gestão de informações e falta de capacidade técnica) e Inovação e Automação Governamental (serviços públicos automatizados, geração de novos empreendimentos, colaboração público-privada e auxílio na tomada de decisão). A análise permitiu identificar padrões e tendências nas respostas dos gestores, além de comparar os resultados com os conceitos teóricos da RSL. Para a análise de conteúdo, foi utilizado o método proposto por Bardin (2002), que consiste em três etapas principais: pré-análise (organização e leitura flutuante dos dados), exploração do material (codificação e categorização dos trechos das entrevistas) e interpretação dos resultados (identificação de insights e elaboração de conclusões). Essa abordagem metodológica garantiu uma análise robusta e detalhada, permitindo a extração de informações relevantes e a conexão entre os dados empíricos e o embasamento teórico.

Na seção 4 (Resultados), serão apresentados os resultados obtidos a partir da análise dos dados coletados, tanto da avaliação do Portal de Dados Abertos quanto das entrevistas realizadas com os gestores, destacando os principais insights relacionados à qualidade dos DAG, ao processamento de dados com IA e à inovação e automação governamental.

Para embasar essa discussão, a seção 3.1 (Descrição do Caso) trará um panorama detalhado do município em estudo (incluindo dados demográficos, econômicos e geográficos) e o contexto das organizações entrevistadas (setor privado e público), fundamentais para interpretar os resultados referente às particularidades locais.

3.1 Descrição do caso

O município de Santo Antônio da Patrulha possui 42.947 habitantes, Índice de Desenvolvimento Humano (IDH) de 0,717, renda per capita de R$ 38.723,81, área territorial de 1.049,583 km^2 e área urbanizada de 20,64 km^2, conforme dados do IBGE, que representam, respectivamente, os anos de 2022, 2010, 2021, 2022 e 2019.

O município encontra-se localizado a cerca de 75 km da capital gaúcha - Porto Alegre e 53,7 km do litoral, sendo atravessado pela BR-290 (Freeway), conforme Google Maps (2024). Diante da sua excelente localização e facilidade de acesso, a cidade está muito bem posicionada para atrair novas oportunidades de negócios.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Para compreender melhor o cenário local, foram realizadas entrevistas com gestores de empresas de grande porte do município que utilizam ferramentas de IA em suas operações, como empresa de telecomunicação, cooperativa de beneficiamento de sementes e instituição bancária, além de representantes estratégicos da administração pública.

4. Resultados

Neste capítulo, são apresentados os resultados da pesquisa, com a avaliação dos dados e informações disponibilizados no portal de dados abertos oficial de Santo Antônio da Patrulha, visando identificar a apresentação, o acesso e a utilização potencial dos DAG. Além disso, são apresentados os resultados das entrevistas com gestores públicos e privados nas quais foram divididas em três tabelas, onde foram denominadas como: "Tab. 1 - Comparativo da revisão sistemática da literatura sobre Qualidade dos DAG", "Tab. 2 - Comparativo da revisão sistemática da literatura sobre Processamento de dados com IA" e "Tab. 3 - Comparativo da revisão sistemática da literatura sobre Inovação e Automação governamental", explorando suas percepções sobre o uso desses dados em conjunto com a inteligência artificial para promover a inovação em suas organizações. Já na Tabela 4 são demonstrados os resultados obtidos através da análise do portal de dados abertos do município.

4.1 Análise classificatória das entrevistas

Com base em entrevistas semiestruturadas, esta análise busca classificar as respostas dos participantes em categorias relevantes, fornecendo uma compreensão aprofundada das diferentes visões e experiências relacionadas ao objeto de estudo.

Tab. 1 – Comparativo da revisão sistemática da literatura sobre Qualidade dos DAG.

Categoria	Descrição categórica	Código	Evidência	Frequência de códigos citados
Qualidade dos Dados Abertos Governamentais	Engloba um conjunto de atributos que determinam o valor e a utilidade dos dados disponibilizados pelo governo para o público. Ao avaliar a qualidade desses dados, busca-se garantir que eles sejam precisos, completos, acessíveis e utilizáveis para diversos fins.	Fácil acesso aos dados	E6 - [...] eu entendo que são bem acessíveis, o nosso portal da transparência da prefeitura inclusive já foi premiado pelo Tribunal de Contas, então eu os vejo acessíveis [...] E8 - [...] eu acredito que é fácil da população pesquisar [...]	3
		Falta de divulgação de DAG	E2 - [...] acredito que a dificuldade possa ser a falta de divulgação [...] E4 - [...] nunca vi divulgado em lugar algum [...] E8 - [...] as gestões dos governos poderiam melhorar, divulgar talvez mais dados além daquilo que a lei obriga [...]	3
		Dificuldade de acesso aos dados	E3 - [...] realmente não foi algo que a gente conseguiu ter um acesso tão facilitado porque teve algumas informações que eu por conhecer as pessoas e alguns conhecidos da prefeitura que a gente consegue ter um acesso diferente quanto algumas informações e elas não estavam todas disponibilizadas, e quando a gente acaba pegando um dado mais específico, ele não está no domínio da prefeitura [...]	3

Fonte: Elaborado pelos autores (2025).

A tabela 1 revela contradições significativas na implementação dos DAG. Enquanto alguns entrevistados destacam acessibilidade (como o portal premiado citado por E6), outros apontam três problemas principais: acesso desigual a informações específicas (E3), falta de divulgação eficaz (E2, E4, E8) e dificuldades técnicas persistentes.

Os dados expõem uma política de transparência que opera mais no cumprimento formal do que na efetiva abertura.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

A necessidade de "contatos internos" para certos dados (E3) e a crítica sobre divulgar "além do que a lei obriga" (E8) revelam uma abordagem burocrática, não cidadã. Apesar de portais tecnicamente avançados, persistem barreiras que limitam o uso prático das informações tanto por cidadãos quanto por gestores.

Esses achados sugerem que a qualidade dos DAG vai além da publicação técnica diante da Lei Complementar nº 101/2000, requer estratégias ativas de divulgação, design centrado no usuário e mecanismos contínuos de melhoria. A verdadeira abertura de dados exige superar a lógica do cumprimento mínimo para adotar uma cultura de transparência efetiva e inclusiva diante de (Calaça et al., 2022).

Tab. 2 - Comparativo da revisão sistemática da literatura sobre Processamento de dados com IA.

Categoria	Descrição categórica	Código	Evidência	Frequência de códigos citados
Processamento de dados com IA	Consiste em um conjunto de técnicas e ferramentas que utilizam a IA para coletar, organizar, analisar e interpretar grandes volumes de dados. Esse processo é fundamental para extrair insights, tomar decisões e automatizar tarefas.	Triagem dos dados	E2 - [...] o benefício que eu vejo é amplitude, porque ela vai filtrar melhor do que o humano. Então se tu quer ver onde está errado, tu vai filtrar para localizar o defeito e a inteligência artificial vai achar, ou até mesmo tu está procurando um defeito e tu não acha, ao usar a IA ela vai achar. Então eu acredito que nessa parte para melhoria e filtragem vai ser muito bom. Se sobressai sobre o ser humano. [...]	5
		Análise dos dados	E5 - [...] A partir da análise desses dados, você tem uma inovação [...]	6
		Interpretação dos dados	E8 - [...] a inteligência artificial, se tu alimentares, pedir para ela cruzar informações, ela já foi preparada para isso, ela vai ser mais ágil. O tempo utilizado para isso vai ser menor do que o ser humano que vai estar ali fazendo. E eu acredito que a propensão de risco de erro, margem de erro, seja menor [...]	6
		Falta de capacidade técnica	E7 - [...] a gente que não faz uso ainda em todas as áreas, eu acho quehoje nós não estamos preparados. Mas a gente vai ter que, de forma muito acelerada, se preparar [...]	5

Fonte: Elaborado pelos autores (2025).

A análise demonstra como o processamento de dados com IA, detalhado na tabela 2, funciona como alicerce tecnológico indispensável para as inovações governamentais apresentadas na tabela 3. A capacidade da IA em triar, analisar e interpretar grandes volumes de dados de forma rápida e precisa cria as condições necessárias para transformações profundas em ambas as administrações conforme Paschen, Pitt e Kietzmann (2020).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

A análise de dados com IA (6 citações) revela capacidade única para identificar padrões complexos invisíveis aos métodos tradicionais, enquanto a interpretação de dados (6 citações), como destacado por E8, permite cruzamentos ágeis de informações com menor margem de erro que processos manuais diante de Sandeep Ganesh (2022). Contudo, como alerta E7, a falta de capacidade técnica (5 citações) representa um obstáculo crítico, exigindo preparo acelerado das equipes para plena implementação dessas soluções.

Estas capacidades técnicas, quando aplicadas ao contexto governamental, viabilizam as inovações documentadas na tabela 3, a automação de serviços públicos, mencionada em 8 citações, depende diretamente da capacidade de processar rapidamente solicitações e dados dos cidadãos conforme Nitzberg e Zysman (2022). Da mesma forma, o apoio à tomada de decisão estratégica (também com 8 citações) só é possível graças à análise preditiva e à visualização de cenários complexos proporcionadas pela IA conforme (Wang et al., 2022).

Tab. 3 - Percepções sobre Inovação e Automação governamental.

Categoria	Descrição categórica	Código	Evidência	Frequência de códigos citados
Inovação e Automação Governamental	Conjunto de iniciativas que modernizam a gestão pública por meio de tecnologias digitais e automação, visando eficiência, transparência, qualidade dos serviços e inovação governamental.	Serviços públicos automatizados	E3 - [...] essa questão de a gente ter a possibilidade de aumentar a experiência, reduzir as falhas, reduzir prejuízo, conseguir ter estratégias mais assertivas, pode contribuir para formas de ser mais eficientes. E, para a inovação do município, a gente consegue realizar pesquisas mais aprofundadas, mais práticas, aumentar essa segurança digital e tentar contribuir de alguma forma com a produtividade [...]	8
		Processos automatizados no setor público	E1 - [...] um chatbot que eu possa direcionar perguntas e já ela já vai conseguir trazer um retorno automático até a própria câmara de vereadores, se precisar colocar alguma reclamação não precisa mais ter um humano para tratar isso, porque o chat consegue compilar todos os aspectos [...]	8
		Geração de novos empreendimentos locais	E5 - [...] a análise desses dados poderia focar em determinados setores. Por exemplo, uma realocação de recursos, possibilidade de novos empreendimentos [...]	7
		Colaboração público-privada	E8 - [...] uma parceria público-privado, sabendo utilizar tanto o público quanto o privado, essa ferramenta, usando os dados abertos governamentais, os dados privados também da empresa, isso pode vir a agilizar, tanto para a empresa, no sentido de uma análise interna da prefeitura, para concessão de um alvará, uma certidão que ela precise, quanto para a prefeitura [...]	8
		Auxílio na tomada de decisão	E7 - [...] entendo que vai facilitar nesse sentido para a tomada de decisão. Tanto do ponto de vista da gestão pública, mas também da iniciativa privada [...]	8

Fonte: Elaborado pelos autores (2025).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

As tabelas são compostas por quatro colunas. A primeira coluna, denominada "Categoria", apresenta os temas analisados no contexto do estudo. A segunda coluna, "Descrição da categoria", contém a explicação detalhada de cada tema listado anteriormente. Já a terceira coluna, intitulada "Código", reúne os códigos identificados tanto na literatura quanto durante as entrevistas realizadas. Na quarta coluna, "Evidência", são exibidos trechos das falas dos participantes, codificados com a letra "E" seguida de um número para manter o anonimato. Por fim, a última coluna, "Frequência de citações dos códigos", indica a quantidade de vezes que cada código foi mencionado ao longo das entrevistas. As informações obtidas foram organizadas e classificadas com o auxílio do software Sphinx, a fim de identificar padrões, semelhanças e tendências significativas.

A análise das entrevistas com gestores públicos e privados de Santo Antônio da Patrulha, organizada em formato de tabelas, revela percepções importantes sobre o uso de DAG e IA para a inovação. No que tange à categoria de qualidade dos DAG (Tab. 1), observa-se uma dualidade de percepções entre gestores: enquanto alguns gestores consideram os dados facilmente acessíveis (E6, E7 e E8), citando como exemplo o portal da transparência da prefeitura, outros relatam dificuldades no acesso (E2, E4 e E6) especialmente para informações mais específicas.

A falta de divulgação dos DAG citada novamente pelos gestores (E2, E4 e E8) emerge como um fator crítico, limitando o conhecimento sobre sua disponibilidade e potencial. A dificuldade de acesso aos dados que é apontada pelo gestor E3 é outro ponto de atenção, deve-se levar em conta a citação do E6 com o relato sobre a falta de familiaridade da população com os meios de busca e a ausência de dados mais detalhados nos canais oficiais.

Quanto à categoria de processamento de dados com IA (Tab. 2), os gestores E2, E4 e E5 reconhecem o potencial da tecnologia principalmente para fins de triagem automatizada, enquanto E1, E4 e E5 destacam sua utilidade para análise e interpretação de dados. Um ponto de convergência entre os respondentes é o reconhecimento da capacidade da IA de proporcionar maior eficiência, precisão e agilidade nos processos analíticos quando comparada aos métodos tradicionais, aspecto particularmente enfatizado pelo gestor E2.

Contudo, os entrevistados destacaram desafios significativos na implementação dessas tecnologias. A questão ética no gerenciamento de informações emergiu como uma preocupação unânime entre E1, E2, E3, E4 e E6, exigindo a implementação de mecanismos robustos de controle e fiscalização. Paralelamente, os gestores E1, E3, E4, E7 e E8 apontaram limitações técnicas na operacionalização dessas ferramentas, revelando uma carência de profissionais qualificados para lidar adequadamente com os sistemas de IA. Esses achados sugerem que, além dos evidentes benefícios operacionais, a adoção de IA no processamento de dados enfrenta obstáculos críticos que englobam tanto dimensões ético-governamentais quanto lacunas de competência técnica, fatores que demandam atenção especial no planejamento estratégico de implementação tecnológica. Os gestores entrevistados reconhecem o papel transformador da IA e dos DAG no âmbito da inovação e automação governamental (Tab. 3). De acordo com os respondentes E1, E3, E4, E5, E6, E7 e E8, essas tecnologias emergem como poderosos impulsionadores para a geração de novos empreendimentos, demonstrando seu potencial para fomentar o ecossistema de inovação. Além disso, todos os gestores entrevistados (E1 a E8) destacam a capacidade dessas ferramentas para aprimorar a tomada de decisão e promover a automação de serviços e processos governamentais, indicando um consenso sobre seu valor estratégico na modernização da administração pública.

Um aspecto particularmente relevante que emerge da análise é a ênfase unânime (E1 a E8) na colaboração público-privada como fator determinante para acelerar a inovação em ambas as administrações, tanto pública quanto privada. Essa percepção compartilhada pelos entrevistados sugere que, embora as tecnologias de IA e DAG ofereçam oportunidades significativas para transformação digital, sua implementação eficaz requer parcerias estratégicas entre governo e iniciativa privada. Esses resultados alinham-se às concepções contemporâneas sobre governança colaborativa e inovação aberta no município.

Apesar do reconhecimento do potencial dessas tecnologias, a falta de capacitação técnica é apontada como um obstáculo significativo para sua implementação. Conforme supracitado, a análise indica que os gestores de Santo Antônio da Patrulha percebem a combinação de DAG e IA como uma oportunidade para impulsionar a inovação e melhorar a gestão pública, mas a efetiva adoção dessas tecnologias ainda enfrenta desafios relacionados à qualidade, acessibilidade e divulgação dos dados, além da necessidade de capacitação técnica e da superação de barreiras como a resistência à mudança e a falta de familiaridade com as ferramentas de busca e análise.

4.1.2 Análise classificatória do portal de dados abertos do município

Essa seção se dedica à análise detalhada do portal de dados abertos do município de Santo Antônio da Patrulha, utilizando critérios para classificar sua conformidade com as melhores práticas de transparência, disponibilidade e qualidade da informação pública digital, expostos nas tabelas 1, 2 e 3.

Tab. 4 - Classificação do portal de dados abertos do município.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Critério	Status	Pontos Principais
Acesso aos Dados	Parcialmente	Acesso público, mas alguns documentos exigem login.
Disponibilidade dos Dados	Totalmente	Atualizações diárias (notícias) e mensais (financeiro). Informações atualizadas e contínuas.
Legibilidade	Parcialmente	Fácil compreensão, mas problemas de legibilidade após download em alguns formatos.
Representatividade	Não Atende	Não reflete a diversidade populacional e setorial. Exclui áreas rurais, segmentos sociais e econômicos. Limita o planejamento estratégico e a eficácia das políticas públicas.
Confiabilidade e Transparência	Parcialmente	Falta de transparência na origem e nos métodos de coleta dos dados, com lacunas que afetam sua confiabilidade e análise.
Triagem dos Dados	Parcialmente	Permite filtragem básica, mas sem funcionalidades avançadas.
Análise dos Dados	Não Atende	Falta de informações detalhadas impede a extração de insights. Prejudicando a tomada de decisões baseadas em evidências.
Interpretação dos Dados	Parcialmente	Apresentação clara, mas a falta de detalhes limita a aplicabilidade prática.
Tratamento dos Dados	Totalmente	Filtros internos auxiliam na organização e eliminam inconsistências. Melhora a experiência do usuário.
Incompletude dos Dados	Não Atende	Ponto Crítico: Lacunas importantes em informações sobre setores e grupos populacionais. Afeta a confiabilidade das análises.
Processamento de Dados	Não Atende	Problemas técnicos com formatos de dados e falta de detalhes dificultam a manipulação técnica.
Portais de Dados Abertos	Totalmente	Plataforma de acesso público com dados em formatos abertos. Promove transparência e acessibilidade.
Digitalização Governamental	Parcialmente	Apenas 10 tipos de serviços online, sendo 2 exclusivos para servidores públicos.
Processos e serviços automatizados no Setor Público	Parcialmente	Recursos automatizados escassos, aumentando a dependência de processos presenciais e manuais.

Fonte: Elaborado pelos autores (2025).

A análise do portal de dados abertos de Santo Antônio da Patrulha revela um desempenho misto em relação aos critérios avaliados. A disponibilidade dos dados e o tratamento dos mesmos são pontos em destaque, com atualizações regulares e ferramentas de organização eficientes (Janssen; Zuiderwijk, 2014). O portal eletrônico de dados abertos do município cumpre com as obrigações conforme o Ministério do Planejamento e Orçamento (2023) diante da Lei Complementar nº 101/2000, onde estabelece o requisito fundamental que entidades públicas, incluindo prefeituras, mantenham um portal oficial na internet. Esta disposição legal tem como propósito principal garantir a confiabilidade e a transparência ativa, exigindo a divulgação de informações de relevância coletiva, com ênfase especial na disponibilização de dados abertos governamentais. Tal previsão normativa representa um importante mecanismo para a efetivação dos princípios constitucionais de acesso à informação pública e de transparência administrativa, além de servir como alicerce para a política de dados abertos no âmbito da administração pública.

Conforme (Silva, 2022) a obrigatoriedade de manutenção de websites oficiais por parte dos entes públicos configura-se assim como instrumento essencial para: Promover a accountability governamental; facilitar o controle social; fomentar a participação cidadã; e permitir o reaproveitamento de informações públicas por parte da sociedade. Esta exigência legal reflete o entendimento contemporâneo de que a confiabilidade e a transparência ativa constituem o dever essencial do estado democrático, sendo a tecnologia digital ferramenta indispensável para sua concretização.

No entanto, áreas críticas como representatividade, análise e incompletude dos dados apresentam deficiências significativas. A falta de representatividade dos dados, que não contemplam a diversidade populacional e setorial do município, limita o planejamento estratégico e a formulação de políticas públicas eficazes. Como destacam

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Ruijer, Grimmelikhuijsen e Meijer (2017), a escassez de informações detalhadas prejudica análises robustas, limitando insights cruciais e comprometendo decisões baseadas em evidências. Quando os dados têm lacunas essenciais, a confiabilidade das conclusões se enfraquece, levando a políticas públicas com bases frágeis, um ciclo que distancia a gestão da eficácia e transparência ideais. Como observado e relatado pelo entrevistado E8 (gestor da administração pública municipal), "os dados que se tem hoje são aqueles exigidos por força da lei", situação que reflete uma cultura de transparência mínima e reativa. Essa restrição à divulgação apenas do estritamente obrigatório resulta em informações incompletas e superficiais, que comprometem a qualidade das análises e a confiabilidade das decisões baseadas nestes dados.

A falta de detalhamento e a presença de lacunas em informações essenciais impedem uma análise mais profunda e a extração de insights relevantes, perpetuando um ciclo de gestão pouco informada e pouco transparente. O próprio entrevistado E8 reconhece o potencial de melhoria, sugerindo que "as gestões dos governos poderiam melhorar, divulgar talvez mais dados além daquilo que a lei obriga", indicando a necessidade de superar a abordagem minimalista atual em prol de uma cultura de transparência ativa e abrangente.

A legibilidade, triagem, confiabilidade e transparência dos dados apresentam pontos que necessitam de melhorias Nikiforova, Aloqaily e Alsmirat (2021). Apesar de as informações serem geralmente de fácil compreensão (boa legibilidade), o relato do entrevistado E8 "[...] eles querem que seja publicado em Excel, PDF, Word, todas as formas, e alguns a gente ainda não consegue fazer em quatro formatações [...]" revela desafios práticos na disponibilização dos dados, especialmente após o download em diferentes formatos. Essa situação evidencia a necessidade urgente de padronização, conforme já apontado por Kalampokis et al. (2011), pois a falta de uniformidade nos formatos disponíveis pode comprometer a acessibilidade e utilidade dos dados para os cidadãos e organizações que dependem dessas informações. A falta de clareza sobre a origem e o método de coleta dos dados (confiabilidade) e a presença de lacunas em informações importantes (transparência) também são pontos de atenção. A triagem de dados, embora permita filtragens básicas, carece de funcionalidades avançadas para uma análise mais aprofundada.

Em relação à digitalização governamental e automação, o portal apresenta um estágio inicial de implementação. A oferta limitada de serviços online e a dependência de processos presenciais demonstram que há um longo caminho a percorrer para alcançar um modelo digital eficiente conforme já dito por (Janssen et al., 2022).

Em resumo, o portal de dados abertos de Santo Antônio da Patrulha demonstra potencial, mas enfrenta desafios consideráveis que limitam sua efetividade como ferramenta para a gestão pública e a promoção da inovação. Investimentos em representatividade, completude, análise e processamento de dados, além de melhorias na digitalização, e-governo e automação, são essenciais para que o portal atinja seu potencial máximo.

5. Discussão dos resultados

As entrevistas realizadas com gestores de Santo Antônio da Patrulha revelam um cenário complexo quanto ao uso de DAG e IA no município. Enquanto alguns gestores, como o E6, destacam a acessibilidade do portal de transparência, inclusive premiado pelo Tribunal de Contas, outros, como o E3, apontam a necessidade de recorrer a contatos pessoais na prefeitura para acessar informações mais específicas, não disponibilizadas publicamente. Essa disparidade de percepções, conforme discutido por Nikiforova, Aloqaily e Alsmirat (2021), evidencia como a acessibilidade efetiva varia significativamente conforme o perfil e as conexões institucionais de cada gestor.

No que diz respeito à IA, os desafios se mostram ainda mais pronunciados. O E1 chamou atenção para a escassez de profissionais qualificados na região, um obstáculo crítico que demanda investimentos em capacitação, como sugerem (Spalević et al., 2023). Contudo, mesmo reconhecendo essas limitações, gestores como o E8 enxergam na IA um potencial transformador para o processamento de dados municipais, destacando sua capacidade de analisar informações com maior agilidade e precisão do que métodos tradicionais, particularmente em análises populacionais e projeções estratégicas, conforme demonstrado por Gao, Janssen e Zhang (2020).

O contexto específico de Santo Antônio da Patrulha apresenta particularidades que merecem destaque. Por um lado, a existência de um portal de transparência reconhecido indica uma base promissora para o avanço na política de dados abertos. Por outro, persiste uma cultura de transparência mínima, onde a divulgação de informações muitas vezes se limita ao estritamente exigido por lei, como observado pelo E8, restringindo assim o potencial inovador desses dados. Além disso, a dependência de redes de contatos pessoais para acesso a certas informações, conforme relatado pelo E3, fragiliza os princípios de equidade e transparência.

As oportunidades, contudo, são significativas. Os dados locais disponíveis, como aqueles relativos ao perfil populacional, poderiam alimentar modelos preditivos para subsidiar políticas públicas mais eficazes, na linha do proposto por Karamanou, Kalampokis e Tarabanis (2022). Para tanto, será necessário superar desafios estruturais, começando por uma mudança cultural que transcenda a transparência meramente formal em direção a uma abertura proativa de dados. Investimentos em capacitação técnica, seja através da formação de talentos locais ou

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

de parcerias estratégicas, e a padronização dos dados disponibilizados serão igualmente cruciais para viabilizar análises automatizadas mais sofisticadas.

Em síntese, Santo Antônio da Patrulha se encontra em uma encruzilhada tecnológica. O município possui as condições iniciais necessárias para se tornar um caso exemplar de aplicação inovadora de DAG e IA em contexto municipal, mas precisa enfrentar decisivamente suas limitações culturais e estruturais para transformar esse potencial em realidade. O caminho a seguir exigirá não apenas recursos técnicos, mas sobretudo vontade política e visão estratégica para aproveitar as oportunidades que a era digital apresenta para a gestão pública local.

6. Considerações Finais

Este estudo investigou o potencial da integração entre DAG e IA para fomentar a inovação em Santo Antônio da Patrulha, sob a perspectiva de gestores públicos e privados. Os resultados apontam um cenário paradoxal: enquanto há amplo reconhecimento do valor estratégico dessas tecnologias, sua implementação efetiva esbarra em desafios estruturais.

A análise revelou que, embora o município disponibilize DAG, esses dados demonstram lacunas críticas e problemas técnicos que limitam sua reutilização. As entrevistas destacaram barreiras como a cultura de transparência mínima "apenas o exigido por lei", dependência de contatos pessoais para acesso a informações e carência de infraestrutura para análise avançada. Curiosamente, mesmo reconhecendo o potencial da IA para automação, redução de erros e geração de insights (como projeções populacionais), apenas dois gestores relataram uso efetivo, evidenciando um abismo entre percepção e prática.

6.1 Limitações e Fronteiras para Pesquisa Futura

Como estudo em contexto municipal, esta pesquisa enfrentou limitações metodológicas (amostra reduzida) e empíricas (dados incompletos). Tais restrições, contudo, apontam direções promissoras para investigações futuras:

- Interlocuções Críticas entre DAG e IA: Como diferentes formatos de abertura de dados (ex.: high-value e datasets) impactam a eficácia de algoritmos de IA? Quais são os limites éticos do uso de dados governamentais incompletos em sistemas automatizados?

- Governança Híbrida: Quais arranjos institucionais podem mediar as tensões entre demandas por inovação e limitações da administração pública (ex.: infraestrutura tecnológica)?

- Viés e Representatividade: Como desenvolver frameworks para auditar não apenas a qualidade técnica dos DAG, mas sua capacidade de representar grupos defeituosos em modelos preditivos?

Para além das recomendações práticas já destacadas (capacitação técnica, parcerias público-privadas), os achados sugerem uma agenda urgente pautada na necessidade de repensar políticas de dados abertos não como fins em si mesmas, mas como infraestruturas digitais para inovação responsável. Isso exigirá:

- Padrões de interoperabilidade que compatibilizem DAG com pipelines de IA (Kalampokis et al., 2011);

- Experimentos locais que testem modelos de cocriação entre governo, academia e setor privado, como living lab**s** focados em problemas municipais específicos (ex.: otimização de rotas de transporte público usando DAG e IA generativa).

Este trabalho não encerra, mas inaugura uma discussão crítica: em um cenário onde mesmo dados "abertos" podem ser estruturalmente excludentes, como garantir que a revolução da IA não amplifique assimetrias já existentes? A resposta exigirá não apenas tecnologia, mas novas formas de governança democrática dos dados.

Agradecimentos

- **Financiamento:** O presente trabalho foi realizado com o apoio da Fundação Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, CAPES - Brasil e da Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul - Fapergs, salientando o mérito ao projeto “Governança Pública Inteligente e Políticas Públicas: Uma Abordagem Integrativa de Boas Práticas Internacionais para Mitigar os Impactos Econômicos e Sociais de Eventos Climáticos Extremos”, nº **90870.861.15286.12112024**.

- **Declaração de Acesso a Dados/Software (se aplicável):** Os dados utilizados neste estudo foram obtidos publicamente por meio do Portal da Transparência do Município de Santo Antônio da Patrulha - RS,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

disponível em: https://www.santoantoniodapatrulha.rs.gov.br/portal-transparencia/. Esses dados incluem informações oficiais sobre receitas, despesas, licitações e outros registros administrativos disponibilizados pela prefeitura municipal.

- **Declaração de Contribuição*:** Autor 1 - Conceitualização, escrita, coleta de dados, análise dos dados, descrição e análise dos resultados obtidos; Autor 2 - Conceitualização, análise dos dados, revisão; Autor 3 - Conceitualização, revisão.
- **Uso de AI*:** Durante a elaboração deste trabalho, os autores usaram DeepSeek e ChatGPT para aprimorar a escrita, como para busca de sinônimos e ajustes ortográficos. Após o uso destas ferramentas, os autores revisaram, editaram e tornaram o conteúdo próprio, validando o resultado conforme necessário, e assumem total responsabilidade pelo conteúdo da publicação.
- **Conflito de Interesses (COI)*:** Não há conflito de interesse.

Referências

Attard, J., Orlandi, F., Scerri, S., & Auer, S. (2015). A systematic review of open government data initiatives. Government Information Quarterly, 32(4), 399–418. https://doi.org/10.1016/j.giq.2015.07.006

Wang, B., Li, Y., Zhang, J., & Liu, H. (2022). The impact of public opinion pressure on construction company green innovations: The mediating effect of leaders' environmental intention and the moderating effect of environmental regulation. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.936058

Wang, C., Teo, T. S. H., & Janssen, M. (2021). Public and private value creation using artificial intelligence: An empirical study of AI voice robot users in Chinese public sector. International Journal of Information Management, 61, 102401. https://doi.org/10.1016/j.ijinfomgt.2021.102401

Nitzberg, M., & Zysman, J. (2022). Algorithms, data, and platforms: The diverse challenges of governing AI. Journal of European Public Policy, 29(11), 1753–1778. https://doi-org.ez40.periodicos.capes.gov.br/10.1080/13501763.2022.2096668

Kawashita, I., Baptista, A. A., & Cunha, M. A. (2024). Open government data use: The Brazilian states and federal district cases. PLOS ONE, 19(3), e0298157. https://doi.org/10.1371/journal.pone.0298157

Bardin, L. (2002). Análise de conteúdo (70ª ed.). Lisboa: Edições 70.

Taylor, P. (2024, April 22). Crescimento de dados em todo o mundo 2010-2025. Statista. Recuperado em 22 de abril de 2024, de https://www.statista.com/statistics/871513/worldwide-data-created/#statisticContainer

Ghani, N. A., Hamid, S., Targio Hashem, I. A., & Ahmed, E. (2019). Social media big data analytics: A survey. Computers in Human Behavior, 101, 417–428. https://doi.org/10.1016/j.chb.2018.08.039

Mutascu, M. (2021). Artificial intelligence and unemployment: New insights. Economic Analysis and Policy, 69, 653–667. https://doi.org/10.1016/j.eap.2021.01.012

Sellitto, M. A. (2002). Inteligência artificial: Uma aplicação em uma indústria de processo contínuo. Gestão & Produção, 9(3), 363–376. https://doi.org/10.1590/S0104-530X2002000300010

Yigitcanlar, T., Degirmenci, K., & Inkinen, T. (2022). Drivers behind the public perception of artificial intelligence: Insights from major Australian cities. AI & Society. https://doi.org/10.1007/s00146-022-01566-0

Mak, K. K., & Pichika, M. R. (2019). Artificial intelligence in drug development: Present status and future prospects. Drug Discovery Today, 24(3), 773–780. DOI: 10.1016/j.drudis.2018.11.014

Yigitcanlar, T., & Cugurullo, F. (2020). The sustainability of artificial intelligence: An urbanistic viewpoint from the lens of smart and sustainable cities. Sustainability, 12(20), 8548. DOI: 10.3390/su12208548

Paschen, U., Pitt, C., & Kietzmann, J. (2020). Artificial intelligence: Building blocks and an innovation typology. Business Horizons, 63(2), 147–155. https://doi.org/10.1016/j.bushor.2019.10.004

Singh, S., Sharma, P. K., Yoon, B., Shojafar, M., Cho, G. H., & Ra, I.-H. (2020). Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city. Sustainable Cities and Society, 63, 102364.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://doi.org/10.1016/j.scs.2020.102364

Yigitcanlar, T., Kankanamge, N., & Vella, K. (2020). Can building "artificially intelligent cities" safeguard humanity from natural disasters, pandemics, and other catastrophes? Sensors, 20(10), 2988. https://doi.org/10.3390/s20102988

Alter, S. (2022). Understanding artificial intelligence in the context of usage: Contributions and smartness of algorithmic capabilities in work systems. International Journal of Information Management, 67, 102392. DOI: 10.1016/j.ijinfomgt.2022.102392

Barns, S. (2021). Out of the loop? On the radical and the routine in urban big data. Urban Studies, 58(15), 3203–3210. https://doi.org/10.1177/00420980211014026

Gao, Y., Janssen, M., & Zhang, C. (2020). Understanding the evolution of open government data research: Towards open data sustainability and smartness. Government Information Quarterly, 38(4), 101578. https://doi-org.ez40.periodicos.capes.gov.br/10.1177/002085232110099

Ganesh, S. (2022). Advancing health care via artificial intelligence: From concept to clinic. European Journal of Pharmacology, 934, 175320. https://doi.org/10.1016/j.ejphar.2022.175320

Nurakmal, M., Mustapha, M. Z., & Ahmad, M. N. (2022). Factors influencing open government data post-adoption in the public sector: The perspective of data providers. PLOS ONE, 17(11), e0276860. https://doi.org/10.1371/journal.pone.0276860

Calaça, O., Costa, A. P. C. S., & Moura, A. M. A. (2022). Tax evasion identification using open data and artificial intelligence. Revista de Administração Pública, 56(3), 426–440. https://doi.org/10.1590/0034-761220210256x

Pereira, G. V., Parycek, P., Falco, E., & Kleinhans, R. (2017). Delivering public value through open government data initiatives in a Smart City context. Information Systems Frontiers, 19(2), 213–229. https://doi.org/10.1007/s10796-016-9673-7

Janssen, M., & Zuiderwijk, A. (2014). Infomediary business models for connecting open data providers and users. Social Science Computer Review, 32(5), 694–711. https://doi.org/10.1177/0894439314525902

Lourenço, R. P. (2015). An analysis of open government portals: A perspective of transparency for accountability. Government Information Quarterly, 32(3), 323–332. https://doi.org/10.1016/j.giq.2015.05.006

Ruijer, E., Grimmelikhuijsen, S., & Meijer, A. (2017). Open data for democracy: Developing a theoretical framework for open data use. Government Information Quarterly, 34(1), 45–52. https://doi.org/10.1016/j.giq.2017.01.001

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data and open government. Information Systems Management, 29(4), 258–268. https://doi.org/10.1080/10580530.2012.716740

Karamanou, A., Kalampokis, E., & Tarabanis, K. (2022). Linked open government data to predict and explain house prices: The case of Scottish Statistics Portal. Big Data Research, 30, 100355. https://doi.org/10.1016/j.bdr.2022.100355

Alexopoulos, C., Zuiderwijk, A., Charapabidis, Y., Loukis, E., & Janssen, M. (2014). Designing a Second Generation of Open Data Platforms: Integrating Open Data and Social Media. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 8653 LNCS, 230–241. https://doi.org/10.1007/978-3-662-44426-9_19

Nikiforova, A., Aloqaily, M., & Alsmirat, M. (2021). Smarter open government data for society 5.0: Are your open data smart enough? Sensors, 21(15), 5204. https://doi.org/10.3390/s21155204

Mutambik, I., Almuqrin, A., Liu, Y. D., & Floos, A. (2023). Gulf Cooperation Council Countries and urbanisation: Are open government data portals helping? Sustainability, 15(17), 12823. https://doi.org/10.3390/su151712823

Karamanou, A., Kalampokis, E., & Tarabanis, K. (2022). Exploring the quality of dynamic open government data

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

using statistical and machine learning methods. Sensors, 22(24), 9684. https://doi.org/10.3390/s22249684

Spalević, Ž., Maksimović, M., & Vujović, M. (2023). Enhancing legally-based e-government services in education through artificial intelligence. International Journal of Cognitive Research in Science, Engineering and Education, 11(3), 511–518. https://doi.org/10.23947/2334-8496-2023-11-3-511-518

Kucera, J., & Chlapek, D. (2014). Benefits and risks of open government data. Journal of Systems Integration, 5(1), 30–41. DOI: 10.20470/jsi.v5i1.185

Instituto Brasileiro de Geografia e Estatística. (2024). Panorama: Santo Antônio da Patrulha, RS. https://cidades.ibge.gov.br/brasil/rs/santo-antonio-da-patrulha/panorama

Instituto Brasileiro de Geografia e Estatística. (2024, maio 28). Panorama: Santo Antônio da Patrulha, RS. https://cidades.ibge.gov.br/brasil/rs/santo-antonio-da-patrulha/panorama

Ministério do Planejamento e Orçamento. (2023). Dados abertos. Governo do Brasil. https://www.gov.br/planejamento/pt-br/acesso-a-informacao/dados-abertos/dados-abertos.pdf

Silva, W. (2022). Exceções legais ao direito de acesso à informação: Uma análise à luz da Lei de Acesso à Informação (Lei nº 12.527/2011). Arquivo Nacional. https://www.gov.br/arquivonacional/pt-br/servicos/publicacoes/execoes-legais-ao-direito-de-acesso_welder-silva.pdf

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 22: Digital Government Ecosystem Cases: Collaboration for enhancing transformative innovations and overcoming challenges

Track Description

This track aimed to explore real-world case studies showcasing how industry partners are facing challenges in digital government, highlighting the synergy between Industry 4.0 and the evolving concepts of Government 4.0 and 5.0. As public and private sectors increasingly collaborate in the digital transformation era, sharing experiences and lessons becomes necessary. The track aims to provide practical insights from industries that have successfully partnered with governments to implement transformative digital solutions. By showcasing these forward-thinking case studies, we aim to support the implementation of actionable solutions that align business goals with social impact, while fostering cross-sector collaboration in facing future challenges in the digital government landscape.

Track Chairs

C. Cappelli, University of Rio de Janeiro State, Brazil
V. Nunes, Inteli Leadership and Technology Institute, Brazil

Contents

Adapting Your Startup's Product for Public Sector Innovation Calls 1443
R. Chaves, G. Bairral, M. Moura, B. Albuquerque, J. Hwang, S. Rodrigues, and J. M. de Souza

Automation of the Planning and Management Instruments of the Unified Health System (SUS) 1451
I. C. De Meo, A. L. dos S. Teixeira, B. T. R. Suda, B. Martinelli, F. B. B. da Cunha, F. R. Pereira, F. B. T. de Aguiar, G. V. Dalenogare, K. T. Silva, L. G. M. Cruz, M. C. de M. Lavado, S. F. M. dos Santos, S. D. Di Benedetto, and E. N. R. dos Santos

BEPP-DS: Building Evidence-Based Public Policies with Data Science 1466
J. A. F. Macedo, R. M. de C. Andrade, R. P. Magalhães, L. A. Cruz, J. F. Q. Neto, S. B. Chaves, M. F. B. M. Filho, J. J. Escola, A. Sousa, P. A. M. Oliveira, D. S. Ribeiro, and P. V. A. Fabricio

Developing the Strategic and Master Plan for Information and Communication Technology at the IT Agency of the State of Tocantins 1476
V. T. Nunes, C. Cappelli, and C. Oliveira

Digital technologies and partnerships for Sustainable Development Goals: A document analysis 1484
B. V. L. de Albuquerque, S. W. M. Siqueira, and P. S. M. dos Santos

Drivers and Barriers in Libya's E-Government Implementation - A Case Study 1494
A. B. Shwehdy

From Trust Antecedents to Trust Frameworks: Co-Creating Multi-Actor Agreements for Data Sharing 1504
L. van der Peet, N. Bharosa, and M. Janssen

LiS - An AI for reviewing user service letters using plain language 1518
A. L. C. Felix and A. C. L. Pessoa

Reflections on Collaborative Design: Lessons from Creating a Digital Public Service App 1526
E. Venson, J. de Souza, S. Campos, R. Figueiredo, G. Marsicano, and W. P. Silva

Transformative Synergies: Partnership and Collaborative Governance for best Breast Cancer Patient Journey 1536
N. Andrade and D. Carneiro

Adapting Your Startup's Product for Public Sector Innovation Calls

Ramon Chaves[* ab], *Guilherme Bairral* [b], *Murilo Moura* [b], *Bianca Albuquerque* [b], *Jacson Hwang* [b], *Sérgio Rodrigues* [b], *Jano Moreira de Souza* [a]

[a] Systems Engineering and Computer Science Program (PESC/COPPE), Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

[b] Lemobs, Rio de Janeiro,Brazil

*Corresponding author: ramonchaves@cos.ufrj.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Recently, GovTech has gained prominence as a novel approach to fostering government-driven innovation by leveraging technology startups, academia, and innovators to develop digital public services. Although it promises more agile, user-centric, and cost-effective solutions, limited research explores how academic-based startups navigate public procurement models. This paper addresses that gap by presenting three cases of an academic-based Brazilian startup engaging in the public procurement process introduced by the Legal Framework for Startups (Marco Legal das Startups). The company proposed solutions adapted from its principal product for three public agencies: Tribunal de Contas da União (TCU), Correios, and Copasa, focusing on remote oversight of construction projects and building maintenance management. The lessons learned underscore the importance of predictable project scope and costs, emphasizing that unclear requirements can undermine competitiveness. Moreover, strong teams and reputable track records significantly enhance success prospects while balancing technological maturity with innovation, which remains critical for meeting specific public sector needs. Additionally, positioning a product at the technological frontier only proves beneficial when addressing actual government challenges. Effective communication, including well-crafted video pitches and presentations, further ensures evaluators grasp the solution's value. These insights aim to guide both aspiring and established academic entrepreneurs in bridging their research-based innovations with GovTech opportunities, ultimately strengthening collaboration between the public sector and academia.

Keywords. Govtech, Startup, Product Management, Innovation, Public Sector, Digital Transformation
Short case practical report, DOI: https://doi.org/10.59490/dgo.2025.1005

1. Introduction

Governments have long played a central role in fostering technological development by investing directly in research and development (R&D) and implementing policies encouraging private sector participation. Historically, these efforts have included financial incentives that stimulate private R&D investments, although their effectiveness varies depending on factors such as incentive type, industry characteristics, and policy design (Choi, 2022). In addition to direct funding, governments have shaped innovation ecosystems through intellectual property protection, tax credits, regulatory standards, and public procurement, all of which increase the potential returns on successful innovations (Nemet, 2009).

More recently, a new model for government-driven innovation has emerged with the rise of GovTech. This approach leverages technology startups, academia, and innovators to develop digital solutions for public services. GovTech initiatives aim to modernize government operations, drive economic development, and enhance service delivery efficiency (Silve and Moszoro, 2023). By fostering collaboration between the public and private sectors, GovTech represents a shift toward more agile, user-centric, and cost-effective solutions for digital governance (OECD, 2021). According to the OECD Digital Government Index (DGI) 2023, GovTech is becoming a widespread practice, with 70% of OECD countries implementing digital strategies to collaborate with the GovTech ecosystem, while 55% use it to foster innovation and experimentation. Additionally, 42% of OECD members employ GovTech to test and adopt emerging technologies such as artificial intelligence. Despite its potential, many countries still face challenges in fully leveraging GovTech, with only 40% having dedicated funding for collaborations and 24%

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

establishing procurement mechanisms to support partnerships. This highlights the need for further investment in digital public infrastructure and strategic frameworks to enable its full potential.

Hoekstra et al. (2023) present an explorative case study of GovTech ecosystems in the Netherlands and Lithuania. They observed differences in ecosystem structure, Lithuania's being more centralized compared to the Netherlands' more scattered setup, and identified success factors such as public-private collaboration, a clear vision and strategy, space for experimentation, and active knowledge-sharing networks. Similarly, Reichardt (2022) analyzes factors influencing GovTech development in Germany and France between 2017 and 2022, employing a realist review method to uncover how procurement frameworks, technical access to the state, and meetup opportunities between startups or SMEs and the public sector can either enable or impede GovTech growth. Nose (2023) investigates the potential of GovTech to improve budget processes and execution efficiency, noting that the introduction of digital budget payments and e-procurement can enhance budget transparency and widen social assistance coverage, particularly benefiting the bottom 50th percentile and female workers in emerging market and developing countries. The study also emphasizes that effective outcomes hinge on supportive policies, regulatory frameworks, robust digital infrastructure, and coordinated efforts facilitated by a dedicated GovTech institution. Meanwhile, Mortati et al. (2023) explore how design thinking can aid in establishing an EU GovTech ecosystem, describing a methodology synthesizing co-design and service design with experiential learning. They conclude that adopting and adapting design thinking principles helps align collaborative efforts and foster organizational learning, ultimately promoting a more cohesive and innovative GovTech environment.

Despite significant advancements in the field and academic efforts to understand the GovTech phenomenon, little research explores how startups from academia can leverage their products and navigate new public procurement models. Moreover, studies examining these challenges from the perspective of startups remain scarce.

This paper presents three cases that highlight key challenges and lessons learned. It examines how Lemobs, an academic-based startup in the Brazilian govtech sector, engaged in the public procurement process introduced by the Marco Legal das Startups (Legal Framework for Startups). Focusing on innovation, Lemobs proposed tailored solutions for three Brazilian agencies: Tribunal de Contas da União (TCU) - (the Federal Court of Accounts), Correios (Brazilian state-owned postal service), and Copasa (Brazilian sanitation company). In the TCU and Copasa calls, the focus was on remote oversight of construction projects, while in the Correios case, the objective was to develop a building maintenance management system for the organization's facilities. Leveraging its mature Sigelu platform, LEMOBS adapted its solution to meet the specific needs of these agencies. We hope these insights will inspire researchers who aspire to become entrepreneurs and, support those who already have a product derived from their academic work and seek to offer solutions to the public sector.

The remaining of text is organized as follows: section 2 provides the background with the necessary content to support this research. Section 3 presents the cases of TCU, Copasa, and Correios and some of the challenges faced. Section 4 presents the lessons learned by Lemobs, and conclusions are established in section 5.

2. Theoretical background

2.1 Marco Legal das Startups (Legal Framework for Startups)

The theme of governmental innovation is increasingly relevant as nations worldwide seek regulatory environments that foster private sector growth and entrepreneurship. Within this context, Brazilian Complementary Law No. 182/2021, the Legal Framework for Startups (Marco Legal das Startups), emerged as a flexible framework encompassing multiple innovation models, including public investment in science, technology, and innovation (de Almeida Veneziani and Vaz, 2023). By aligning with global trends in innovation policy, the law addresses the need for governments to act as catalysts for development, ensuring that technological advancement and public service innovation coexist.

Startups have become indispensable players in the global economy, significantly contributing to job creation and revenue (Anunciação and Fernandes, 2021). Worldwide, multiple governments are revising their legislative structures and cultural perceptions to incentivize emerging entrepreneurs (The World Bank, 2019). This trend is particularly salient among BRICS nations, where high-potential ventures correlate with increased domestic R&D and the rise of formidable unicorns (CB Insights, 2020). The rapid pace of technological change requires an agile regulatory stance, which the Marco Legal das Startups aims to provide by balancing entrepreneurial freedom and state oversight.

The new law fosters startup participation through the Contrato Público para Solução Inovadora (CPSI) - (Public Contract for Innovative Solution)- and regulatory sandboxes. As outlined, CPSI enables startups to collaborate with public entities by proposing innovative solutions to governmental challenges, thus harnessing state purchasing power for technological and economic progress (Batista, 2022). Overall, the Marco Legal das Startups places Brazil

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

within a global trend that recognizes the impact of innovative enterprises on economic development. Comparable legislative measures have been adopted in Argentina and Chile, highlighting the regional importance of thriving startup ecosystems (Anunciação and Fernandes, 2021).

2.2 Lemobs

Lemobs is a technology startup established by researchers holding master's and doctoral degrees in Systems Engineering and Computer Science from the Federal University of Rio de Janeiro (UFRJ). Its work centers on developing innovative solutions for the public sector. The Lemobs's team comprises 60 professionals, two-thirds specializing in technology, and approximately 44% hold advanced degrees such as MBAs, master's, or doctoral qualifications. This strong background in systems engineering, computing, and knowledge management underpins its drive toward research and innovation.

Operating as a GovTech, Lemobs focuses on creating tools that help cities become more efficient and responsive. Its flagship platform, Sigelu, exemplifies this approach by providing web, mobile, map-based, and business intelligence features that automate and enhance various governmental processes. With over 300,000 development hours and a user base of around 2,400 individuals across more than ten public institutions, Sigelu covers tasks ranging from planning and monitoring public works to inventory control, urban maintenance, and oversight of city operations. Its integrated dashboards and analytics offer decision-makers actionable insights based on real-time data.

Lemobs has also earned notable recognition within the public domain. It was awarded Brazil's first Public Contract for an Innovative Solution (CPSI) by Petrobras, receiving the highest scores for innovation, execution capability, and maturity of its platform. In 2020, it was acknowledged by the Municipal Strategy for Science, Technology, and Innovation of Maricá City for its contributions at the municipal level. Under the Software as a Service (SaaS) model, Lemobs provides licensing, training, support, and software customization. Maintaining a strong commitment to research and development, it continuously refines its product offerings, exploring new methods and technologies to enhance public-sector operations and contribute to the broader field of digital transformation in governance.

3. Cases

The three cases discussed were proposals submitted by Lemobs for calls under the CPSI modality. The solutions described represent the technological tools that would be developed if Lemobs were chosen. It should be noted that in the TCU call, Lemobs was not selected, placing fourth, while three winners were chosen. However, in the calls from Correios and Copasa, Lemobs was selected, though at the time of writing this article, no contracts had been signed, and, in keeping with the CPSI bidding process, the project scope will still be negotiated with these public entities. As a result, the proposed projects and the main challenges encountered in adapting the current Sigelu version to meet the specific demands of these calls are as follows.

3.1 Tribunal de Contas da União (TCU)

The Tribunal de Contas da União (TCU) is the Federal Court of Accounts - the Brazilian supreme audit institution - responsible for overseeing the proper use of public funds and ensuring transparency and accountability in government projects. TCU's main challenge is gathering evidence of public works' execution and progress without requiring an on-site visit. This process involves comparing non-geolocated project and execution data published in various government systems with current realities in often remote municipalities. The objective is to detect potential irregularities cost-effectively and promptly present them on a risk dashboard and in detailed reports, allowing TCU auditors to focus on critical issues without incurring high travel expenses.

We presented Sigelu as a crowdsourcing-based solution with two core components: a cloud-based software platform and comprehensive services covering recruitment, training, and ongoing support, as seen in Figure 1. The software aspect begins by integrating directly with TransfereGov through an API, automatically retrieving key information on public works. This data is then used to plan evidence collection, with artificial intelligence and geoprocessing tools helping TCU technicians identify strategic sampling areas for inspection. Once those areas are defined, a diverse group of collaborators, including roadwork specialists, technical professionals such as architects, engineers, and even laypeople, receives task recommendations via a system that applies different crowdsourcing methods.

In the mobile crowdsourcing approach, individuals with smartphones can capture local evidence in real time. In contrast, drone crowdsourcing employs civilian-operated drones to gather aerial data, reducing the need for costly or cumbersome inspections by TCU staff. The Public Participation Geographic Information System (PPGIS) approach integrates local communities directly into the data collection and decision-making process, enhancing

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

transparency and inclusivity by allowing residents to contribute spatial information relevant to the projects in their regions. Once participants collect these images, videos, and other forms of evidence, Sigelu processes the material to validate reliability and compare it against official project requirements. Artificial intelligence further refines this process by detecting inconsistencies or anomalies in the collected evidence.

After successful validation, Sigelu authorizes payment to the crowdsourced collaborators and incorporates information on potential noncompliance into a risk management workflow, accessible via reports and data visualization dashboards. These outputs enable TCU auditors to quickly pinpoint areas of concern and determine the level of scrutiny needed. Beyond software, Sigelu also provides services for recruiting the required pool of collaborators, training them on best practices for collecting evidence, and ensuring TCU technicians know how to use the system to optimize their oversight activities. The innovative approach blends the efficiency gains offered by artificial intelligence with the collective expertise of on-the-ground contributors, yielding more context-rich data while refining AI models through domain-specific training. It also pioneers a novel business model in the public sector by compensating citizens and professionals for auditing tasks that were once solely the responsibility of government officials. By integrating technology, human collaboration, and ongoing support services, Sigelu represents a forward-looking solution poised to enhance TCU's capacity to monitor works across vast and varied locations, ultimately improving transparency and accountability in public expenditures.

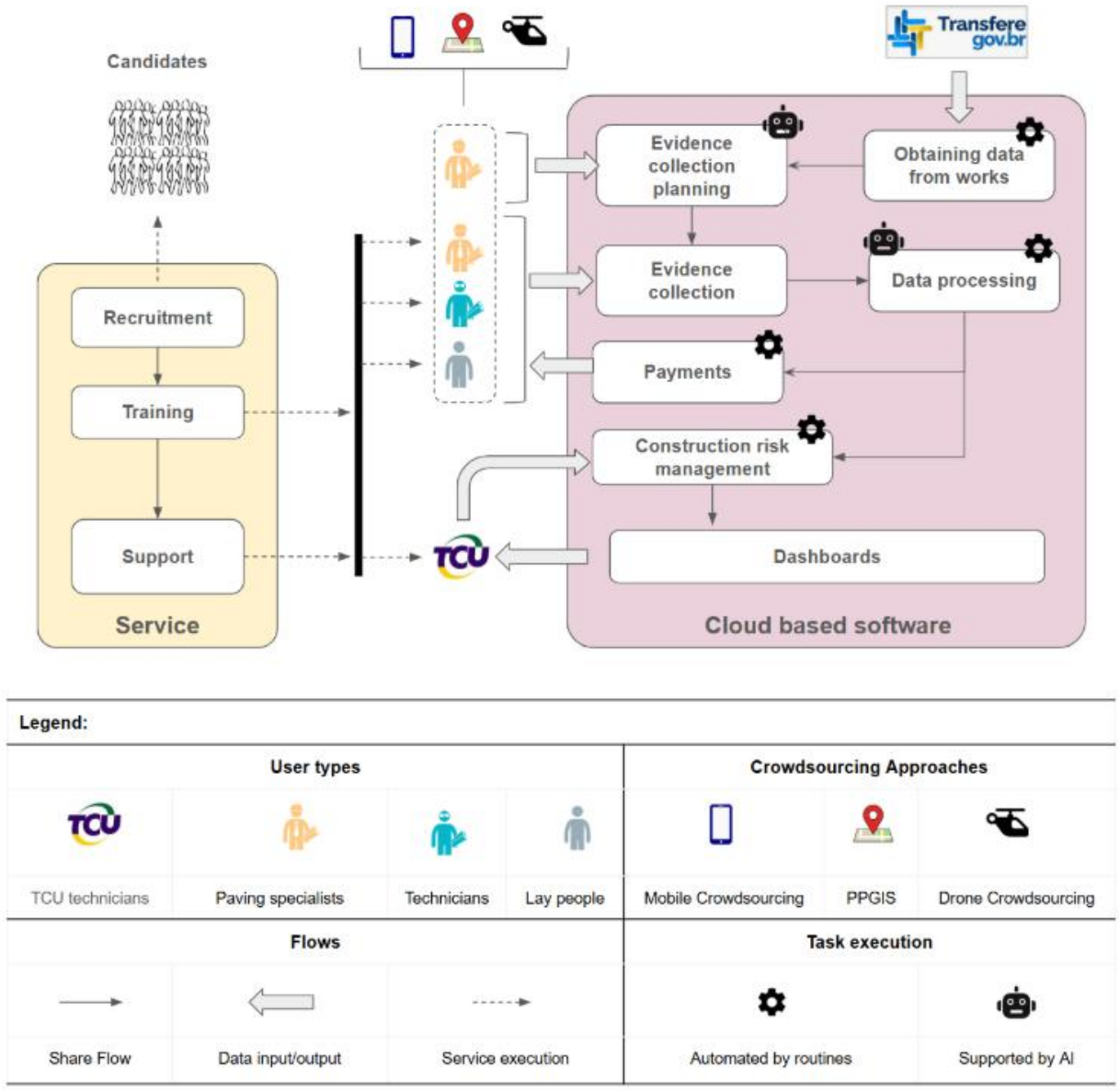


Fig. 1. General Solution Architecture proposed for TCU.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In this project proposal, the main challenges revolved around two primary aspects: first, how to ensure timely evidence collection across Brazil through a crowdsourcing approach, given that some worksites are located in extremely remote areas far from major centers, and second, how to establish predictable costs for paying inspection fees, particularly if multiple inspections become necessary due to substandard task execution. In response to the first concern, the proposed solution involved strategies for recruiting and training inspectors nationwide and providing financial incentives to encourage participation in inspections far from major hubs, thereby compensating for any lack of initial interest. As for the second challenge, the system was envisioned to include functionalities controlling the monthly financial resources allocated to inspections, ensuring cost predictability. However, while this approach might resolve financial forecasting issues, it does not necessarily guarantee the minimum number of high-quality inspections required to maintain consistent standards.

3.2 Correios

Correios is Brazil's state-owned postal service, providing logistics and correspondence solutions nationwide. Within this vast organization, the Regional Engineering Management area is part of the broader support macro process, overseeing building and equipment maintenance, construction and renovation projects, and the upkeep of key systems. As outlined in Correios's 2023–2027 strategic plan, "Digital Transformation" stands as a critical priority. This initiative emerged in response to numerous operational hurdles: multiple non-integrated systems (both internal and external), a reliance on tedious manual routines, fragmented data scattered across varied sources, delays resulting from document processing (including invoices and official records), and limited capabilities for analyzing usage or consumption patterns. These factors create vulnerabilities such as missed deadlines, administrative bottlenecks, and inconsistencies in preventive, predictive, and corrective maintenance tasks. By deploying innovative technological solutions, Correios aims to modernize and streamline engineering processes in light of these challenges. The goal is to consolidate information, reduce human error, expedite service management, and ultimately fortify the reliability of building and system maintenance. By doing so, Correios hopes to strengthen operational efficiency and elevate the quality of services, paving the way for smoother, more cohesive engineering workflows across its extensive network of facilities and equipment.

Sigelu, proposed by Lemobs, was presented as a robust software platform designed to handle the full spectrum of Correios maintenance workflows, from initial request creation to post-service analysis and payment. When a maintenance need arises, whether it involves plumbing, lighting, generators, elevators, or specialized equipment, users can register a request through a mobile application or a web-based interface. This flexibility suits diverse operational scenarios, allowing on-site staff or remote personnel to initiate new tasks, attach supporting documents and images, and even set up recurring maintenance schedules. Once requests enter the system, they appear on customizable dashboards that organize them by priority, location, or type of service. Administrators can then triage, assigning tasks based on team expertise, workload, or geographic proximity. The mobile app assists technicians by displaying request details, offering integrated map views for route optimization, and enabling real-time progress updates, even in areas with limited connectivity, which are later synced when the device regains network access.

A dedicated inspection feature allows managers or external auditors to create separate verification requests, ensuring that completed services meet quality standards. If discrepancies are identified, they can be documented and automatically sent back to technicians for review or correction. In parallel, Sigelu supports contract management and payment workflows by consolidating all relevant records, such as costs, service dates, and performance metrics, into a unified environment. This integration ensures a clear audit trail, simplifies invoice validation in the ERP system, and reduces the risk of inconsistencies or delayed payments. Across the entire maintenance lifecycle, Sigelu's analytical capabilities provide insights through visual dashboards and performance indicators, helping decision-makers identify trends, allocate resources more efficiently, and address recurring issues proactively. By merging powerful field tools with seamless back-office processes, Sigelu delivers a comprehensive solution that advances Correios's digital transformation goals and empowers the engineering division to manage complex maintenance operations with greater agility and transparency.

In this project proposal, the primary challenge lies in determining how Sigelu would be integrated with the numerous applications already in use by Correios. We observed that Sigelu could replace many existing systems by functioning as a central platform while allowing integration with other tools. The features included in this project demonstrate a high level of technological maturity and flexibility, as they have been successfully employed in both urban and building maintenance contexts. Due to its high technological maturity and its ability to support a wide range of operational processes, Sigelu gave us the confidence to present it as a viable alternative to the technological patchwork developed by Correios over the years.

3.3 Copasa

Copasa is a Brazilian sanitation company responsible for expanding and maintaining water supply and sewage systems across more than 640 municipalities in the State of Minas Gerais. Its current investment program, valued

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

at approximately R$1.67 billion in 2024, drives the construction and enhancement of pipelines, water and sewage treatment facilities, and associated infrastructure. These projects can be highly diverse: some are linear, like pipelines laid in densely populated urban areas or remote forests, while others involve the erection or refurbishment of large-scale treatment stations. Because the work is spread over wide geographical areas, Copasa faces logistical hurdles in delivering timely and detailed oversight. Engineers and technicians cannot always be present on-site, so there is a risk of undetected irregularities, such as delays, subpar materials, noncompliant safety measures, and poorly executed construction techniques. As Copasa seeks to meet its universal sanitation goals and ensure its contractual commitments, it aims to integrate advanced technologies that enable remote tracking, monitoring, and analysis of the progress of these simultaneous works.

Sigelu was presented as a smart, data-driven platform designed to centralize Copasa's project oversight while enabling remote and automated inspections. The solution begins by streamlining the registration and management of ongoing projects within an integrated environment that uses georeferencing to locate each work site. A unified dashboard organizes daily logs, comments, and documents, linking them to a Gantt chart that displays timelines, milestones, and deadlines. By importing schedules directly from MS Project, Sigelu creates a coherent list of deliverables and tasks, all updated in real-time whenever field data is recorded during inspections. Whether images and videos are gathered via smartphones, 360-degree cameras, or drones, the system continuously populates its database with fresh visual evidence. It generates time-lapse sequences of particular work sites to document progress over days or weeks.

Sigelu applies artificial intelligence from these data sets to analyze inconsistencies or highlight potential risks. The AI system draws upon Copasa's historical records to refine its model through supervised machine learning. Comparing current imagery to baseline plans can detect deviations from proposed designs, estimate earthwork volumes, calculate distances, and measure surface areas. All these insights contribute to creating a live picture of the works' development, allowing Copasa's engineers and auditors to make decisions based on near real-time data without sending personnel to each location. If issues arise, such as inadequate safety compliance, Sigelu provides instant notifications to help teams address them quickly.

In addition to the technical components, Sigelu supports remote inspections through video calls, geolocation services, and other collaborative tools. Engineers can schedule virtual site visits, specify inspection parameters, and rely on the platform's AI to suggest priority checks based on risk indicators. By collecting and processing information efficiently, Sigelu generates comprehensive reports detailing each project's quality and safety and adherence to schedule and budget. These findings are visualized in interactive management panels that synthesize performance metrics across multiple works. Through this intelligent approach, Copasa can ensure greater oversight and accountability in its construction activities, maximizing the value of its investments and strengthening the reliability of its services for communities throughout Minas Gerais.

In this project proposal, the main challenges involve adapting three essential features within Sigelu. First, the system must support synchronous remote inspections through videoconferencing, for which we plan to provide mobile data packages as part of the contract, as well as offline functionality for emergency scenarios that lack full connectivity. Second, integrating multiple inspection methods, drones, fixed cameras, and smartphones into a cohesive workflow is critical. For example, orthophotos generated from drone images can detect earth movements; fixed cameras at the construction site can capture occupational safety anomalies; and smartphone-based records collected by the supervising engineer can provide detailed information on work progress. Finally, the third element centers on generative AI to consolidate notes recorded during remote inspections. This AI-generated report organizes the data by key managerial concerns such as workplace safety, the quality of executed services, and overall project progression according to the established schedule.

4. Lessons Learned

Predictability is essential in public-sector sales processes, providing clear expectations regarding outcomes and costs. One of our key insights from participating in the TCU CPSI bidding process is that the absence of predictable parameters can negatively impact how advantageous a proposal appears to public managers. Although CPSI contracts are designed to test market-based solutions for public-sector issues, thereby sharing risks, unpredictability can make a project appear less competitive than other proposals.

Building strong teams and a solid reputation is another critical factor. Originating in academia, Lemobs boasts a highly qualified technical staff with experience in both industry and government. Over time, we have earned multiple awards in the govtech and smart cities sectors and worked with major national clients. Such credentials and demonstrated market experience have consistently placed Lemobs among the top-rated companies in CPSI calls, influencing our successful selection by Correios and Copasa. For startups, it is advisable to strengthen teams

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

with qualified personnel and establish a continuous process of gaining credentials, such as certifications, awards, intellectual property, and reputable clients, to enhance credibility.

Balancing the introduction of new functionalities with leveraging existing strengths is another lesson learned. CPSI calls often consider a solution's technological maturity and innovative potential to address the presented challenge. In practice, the public-sector issue rarely aligns perfectly with an existing solution, resulting in a gap between the agency's needs and the startup's current offerings. When a proposal emphasizes many new features that deviate significantly from existing functionalities, it may gain points for innovation but risk losing points for technological maturity. Thus, an optimal balance is needed to demonstrate that the startup has a sufficiently mature solution while accommodating the organization specific requirements.

Positioning a product at the technological frontier can be equally important, particularly when the public sector explicitly seeks solutions involving cloud computing, artificial intelligence, machine learning, the Internet of Things, blockchain, etc. However, incorporating the latest technologies does not guarantee success; the chosen technology should genuinely address a pain point for the client. In other words, integrating cutting-edge tools must clearly deliver value to the public agency.

Finally, every CPSI call we have participated in has required a video pitch of the solution, followed by a live presentation. Developing a concise, easily understandable presentation highlighting the solution's core aspects is relevant. Evaluators often review dozens of proposals, and while they may have notes or specific questions, they may still struggle to grasp the fundamental points of a project when it is time for the live presentation. It can be frustrating for the solution developers, who may have well-thought-out answers for various detailed aspects. As a result, clear communication is key to ensuring that the agency fully appreciates the merits of the proposed solution.

5. Conclusion

In this study, we examined the participation of Lemobs, an academic-based startup in the Brazilian govtech sector, in the CPSI public procurement process established by the *Marco Legal das Startups*. Through three cases, we analyzed the challenges encountered and the lessons learned as Lemobs proposed innovative solutions for three public agencies: the Tribunal de Contas da União (TCU), Correios, and Copasa. Each case provided insights into how startups emerging from academia can adapt their solutions to public-sector demands while navigating the complexities of government procurement processes. This research underscores the growing role of govtech companies in fostering digital transformation within public administration and highlights the strategic approaches required for startups to engage with government clients effectively.

From our findings, several key lessons emerged. First, predictability in project scope and costs is crucial in public procurement, as the lack of clear expectations can hinder competitiveness. Second, building strong teams and a credible reputation significantly enhances a startup's chances of success, as demonstrated by Lemobs' high ratings in CPSI calls due to its academic expertise, industry experience, and prior achievements. Third, balancing technological maturity with innovation is essential, startups must bridge the gap between their existing solutions and the specific needs of public agencies without compromising reliability. Additionally, positioning a product at the technological frontier is valuable, but only when the selected technologies genuinely address government challenges. Finally, effective communication is critical, particularly in CPSI processes that require video pitches and live presentations. A well-structured presentation ensures that evaluators fully understand the solution's value, preventing misinterpretation and strengthening the proposal's competitiveness.

These contributions are intended to support researchers who seek to transition into entrepreneurship and those who already have a product derived from their academic research and wish to engage with the public sector. A key limitation of this study is the limited discussion on how the specific adaptations of Sigelu were presented in each proposal, as word constraints prevented a deeper exploration of these details. Future research will incorporate feedback from CPSI evaluators, providing insights into how they perceive the main challenges faced by startups and identifying strategies that could enhance their competitiveness in public procurement calls under the *Marco Legal das Startups*.

Acknowledgement

- **Funding or Grant:** Coordenação de Aperfeiçoamento de Pessoal de Nível Superior,001,001.
- **Contributor Statement**: Ramon Chaves: Conceptualization, Data Curation, Investigation, Methodology, Project Administration, Visualization, Writing – Original Draft, Writing – Review & Editing; Guilherme Bairral: Validation, Project Administration; Murilo Moura: Software; Bianca Albuquerque: Software;

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Jacson Hwang: Software; Sérgio Rodrigues: Funding Acquisition, Resources; Jano Moreira de Souza: Supervision

- **Use of AI**: During the preparation of this work, the authors used ChatGPT in order to support text processing tasks such as translation and rewriting to improve clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Anunciação, I. I. M., & Fernandes, G. A. (2021). As startups no ordenamento jurídico: uma leitura comparada dos ecossistemas de startups na Argentina, no Chile e no Brasil. Cadernos de Ciências Sociais Aplicadas, 240-255.

Batista, H. R. (2022). MARCO LEGAL DAS STARTUPS: Uma análise da Lei Complementar n. 182/2021. Revista de Iniciação Científica e Extensão da Faculdade de Direito de Franca, 7(1).

Business, D. (2019). Training for reform. Washington DC: The World Bank.

Choi, J. (2022). Do government incentives to promote R&D increase private R&D investment?. The World Bank Research Observer, 37(2), 204-228.

de Almeida Veneziani, J. R., & Vaz, J. C. (2023). O Impacto do Marco Legal das Startups na Promoção da Inovação e do Empreendedorismo no Brasil.

Hoekstra, M., Van Veenstra, A. F., & Bharosa, N. (2023, July). Success Factors and Barriers of GovTech Ecosystems: A case study of GovTech ecosystems in the Netherlands and Lithuania. In Proceedings of the 24th Annual International Conference on Digital Government Research (pp. 280-288).

Insights, C. B. (2021). The complete list of unicorn companies. CB Insight: New York, NY, USA.

Mortati, M., Mariani, I., & Rizzo, F. (2023). How Design Thinking can support the establishment of an EU GovTech ecosystem.

Nemet, G. F. (2009). Demand-pull, technology-push, and government-led incentives for non-incremental technical change. Research policy, 38(5), 700-709.

Nose, M. (2023). Inclusive GovTech: Enhancing Efficiency and Equity Through Public Service Digitalization.

OECD (2024), Enabling Digital Innovation in Government: The OECD GovTech Policy Framework, OECD Digital Government Studies, OECD Publishing, Paris, https://doi.org/10.1787/a51eb9b2-en

Prefeitura Municipal de Maricá. (2020). Estratégia municipal de ciência, tecnologia e inovação de Maricá: Cidade humana, inteligente e sustentável (ICTIM). Maricá, RJ, Brasil.

Reichardt, N. (2022). Factors influencing the development of GovTech in France and Germany: a realist review

Silve, A., & Moszoro, M. (2023). The Political Economy of GovTech. International Monetary Fund.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Automation of the Planning and Management Instruments of the Unified Health System (SUS)

Ilka Correa de Meo [a*], *André Luiz dos Santos Teixeira* [b*], *Bianca Tomi Rocha Suda* [c*], *Bruno Martinelli* [d*], *Felipe Barbugian Borges da Cunha* [e], *Felipe Ribeiro Pereira* [f*], *Fernanda Braz Tobias de Aguiar* [g*], *Gianlucca Vergian Dalenogare* [h*], *Karina Teixeira Silva* [i*], *Luiz Gustavo Machado Cruz* [j*], *Miriam Carvalho de Moraes Lavado* [k*], *Sandra Fernandes Maciel dos Santos* [l*], *Suellen Decario Di Benedetto* [m], *Estevão Nicolau Rabbi dos Santos* [n*].

[a] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. planejasaude@prefeitura.sp.gov.br

[b] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. ateixeira@prefeitura.sp.gov.br.

[c] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil . btrsuda @prefeitura.sp.gov.br.

[d] São Paulo Public Innovation Lab, São Paulo Municipal School of Public Administration, Municipal Secretariat of Management, São Paulo City Hall, São Paulo, Brazil. bmartinelli @prefeitura.sp.gov.br.

[e] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil.

[f] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. feliperibeiro @prefeitura.sp.gov.br.

[g] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. fernandaaguiar @prefeitura.sp.gov.br.

[h] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. gianluccavergian @prefeitura.sp.gov.br.

[i] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. karinateixeira @prefeitura.sp.gov.br.

[j] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. luizgmcruz @prefeitura.sp.gov.br.

[k] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. mlavado @prefeitura.sp.gov.br.

[l] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. sfmaciel @prefeitura.sp.gov.br.

[m] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil.

[n] Planning Advisory Office of the São Paulo City Health Secretariat, São Paulo, Brazil. enrsantos @prefeitura.sp.gov.br.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Practical report, DOI: https://doi.org/10.59490/dgo.2025.1046

Abstract. This paper aimed to develop a solution using digital technological resources to overcome operational obstacles and improve efficiency in the process of developing and monitoring the Planning and Management Instruments of the Unified Health System (IGSUS). The IGSUS instruments include: the Municipal Health Plan (PMS), the Annual Health Programming (PAS), the Detailed Report of the Previous Quarter (RDQA), and the Annual Management Report (RAG). These instruments result from the collaboration of multiple stakeholders and are essential for organizing actions that address the health needs of the population. Reports from the team itself, corroborated by an initial mapping of the process, indicated that there was significant repetition of operational tasks and rework in the creation of data collection files, sending emails to technical areas, reviewing the information entered by respondents, consolidating spreadsheet files, and preparing the consolidated text file. The mapping and automation of the processes for developing and monitoring the IGSUS followed methodologies for project management, process management, and agile methods, focusing on a collaborative, governed approach inclined toward innovation and improvement in the delivery of public services. This work led to the establishment of standardized data collection forms, Python scripts that automated these tasks, and a platform for sharing spreadsheets, reducing the hours spent on these tasks and enabling better support

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

for the planning process with the technical areas of the Municipal Health Department of São Paulo.

Keywords. Digital Health; Public Sector; Digital Transformation; Innovation

1. Introduction

The planning function is one of the four administrative functions that make up the administrative process, along with organization, direction, and control, and its scope is to define objectives to be achieved, as well as the resources and tasks to accomplish them. Modern planning concepts go beyond the idea of planning as a mere projection based on past information and reflect the paradigm of complexity, in which multiple elements interrelate and transform, creating new scenarios. Therefore, planning that aims to be sensitive to these changes must be structured to consider the perspectives of the affected actors and the historical and social contexts in which they are embedded. According to Matus (1991), the proponent of the Situational Strategic Planning method, planning is a continuous action, adapted to circumstances, with specified analytical factors and that considers the asymmetries between the stakeholders. Thus, its use allows for a more dynamic understanding of the analyzed scenario and the limits of governance over the challenges it aims to address. This perspective proves most advantageous for planning health actions, because, as expressed by Giovanella, L., citing Testa (1989), health planning is directed toward social change and is designed as an action that seeks direct intervention in history.

According to Consolidation Ordinance GM/MS No. 01/17 (Ministério da Saúde da República Federativa do Brasil, 2017), which systematizes the planning guidelines of the SUS, planning is an individual responsibility of each of the three federative entities, to be developed continuously, articulated, and integrated (Art. 94, Item I). The Planning and Management Instruments of the SUS, known by the acronym IGSUS, consist of the Municipal Health Plan (PMS), the Annual Health Programming (PAS), the Detailed Report of the Previous Quarter (RDQA), and the Annual Management Report (RAS). These instruments relate to budgetary documents that compose governmental planning and must reflect the health needs of the population and the actions and resources required for its care. It is important to emphasize that these instruments are mandatory and continuous, and their timely delivery is a condition for intergovernmental transfers of resources. Decree No. 1,651 of 1995 (Presidência da República Federativa do Brasil, 1995) and Complementary Law No. 141 of 2012 (Presidência da República Federativa do Brasil, 2012) regulate audits and budget and financial accountability through SUS management instruments, as well as the temporal relationship between budget planning and the annual health program (PAS). Decree No. 7,508 of 2011 (Presidência da República Federativa do Brasil, 2011) explains the mandatory nature of health planning. Finally, Resolution No. 459 of 2012 (Conselho Nacional de Saúde, 2012) standardizes the structure of the Detailed Report for the Previous Quarter (RDQA). Respect for the rites established for the preparation and publication of the IGSUS is therefore of paramount importance for compliance and transparency in the implementation of public policies and is a requirement for the continued transfer of federal funds.

Within the São Paulo Municipal Health Department, the support for the planning process is within the responsibilities of the Planning Advisory Office (ASPLAN). The Planning Advisory Office of the São Paulo Municipal Health Department (SMS/SP) is a unit that provides direct assistance to the Municipal Health Secretary regarding strategic planning and the decision-making process. Among its responsibilities outlined in Article 16 of Municipal Decree No. 59,685 of 2020 (Prefeitura Municipal de São Paulo, 2020), Item III, the office is tasked with disseminating and developing planning, monitoring, and evaluation methodologies for processes, projects, and strategic programs to support SMS/SP management, coordinating related areas within the Executive Secretariats. In order to enhance this process, ASPLAN has integrated digital tools into its workflow, encouraging the team to train and propose solutions using these resources, particularly those stemming from accessible digital transformations

Many public and private health organizations are using digital technologies to enhance organizational performance and create innovative solutions to improve healthcare delivery, generating innovation in the form of new processes, tools, therapies, medical procedures, or innovative approaches to education, training, management, and procurement (World Health Organization, 2021; Stoumpos et al., 2023). The process of digital transformation and the adoption of innovative tools directly impact a wide range of work processes, especially the automation of routine and repetitive tasks. When considering this transformation within the public sector, Terlizzi (2021) notes that digitization as a tool contributes to achieving a more efficient government, which aligns with the view of Jonathan, G.M. (2020), who sees digital transformation as a value-adding element for citizens by reducing operational costs and increasing the productivity of the public sector.

The author also discusses the differing expectations regarding digital transformation, which can be divided into optimists who view it as a definitive improvement for all domains, pessimists who see it as compromising the decision-making process due to the simplifications it requires for data modeling, and those who view it with a balanced perspective, recognizing the importance of digital transformation but understanding that other necessary conditions, when combined, make it effective.

In relation to the public sector, the digital transformation presents challenges, such as 1) regulatory hurdles; 2) data integration issues; 3) ICT infrastructure gaps; 4) limited digital literacy; 5) bureaucratic culture; 6) ethical considerations with AI; and 7) privacy and security concerns (Latupeirissa et al., 2024). Adamczyk, W.B. (2020) points out that insufficient incorporation of innovations in automation within public sector planning can lag behind the private sector's productivity, resulting in direct and indirect impacts on the operations of agencies and facilities, generating inefficiency and low problem resolution for service users. Asgarkhani (2005) argues that such transformations are driven in the private sector by competition, with competitive needs setting higher service standards involving digital tools. This contrast highlights the urgency for the public sector to address structural and cultural barriers in order to keep pace with evolving service expectations. As pointed out by Jonathan, G.M. (2020), one of the main factors for the successful implementation of digital transformation in an institution is its organizational culture, since cultures that are flexible toward innovation influence leaders and employees to invest the necessary effort in related deliverables. In a broader context, Gkrimpizi, T. et al. (2023) consider that digital transformation goes beyond technological innovation itself and also encompasses cultural changes that ensure its operability and continuity.

Despite the challenges and barriers to radical and timely digital transformation, incremental changes that qualify processes and work, supported by the automation of certain tasks to overcome significant bottlenecks, remain feasible. This perspective is even more timely when considering the efficiency gains that such applications can bring to improving the quality of services for SUS-dependent health needs. This point is particularly relevant when considering the determinants and conditions influencing the increased demand for the system, such as population aging, increased informality in the labor market, and the prevalence of chronic diseases, with a high concentration of preventable deaths in the most vulnerable population segments. Therefore, promoting the development of strategies based on digital transformations in SUS is providing responses that can contribute to the qualification and efficiency of care for an increasingly growing and diverse demand.

From the perspective of incremental change, the Planning Advisory team (ASPLAN) of SMS/SP, responsible for monitoring more than 250 goals in the Municipal Health Plan, which involves 40 technical areas of the Department, developed an automation solution for handling spreadsheets containing information about these goals using Python scripts. Since standardizing and streamlining processes is an indispensable requirement for automating tasks, a BPM (Business Process Management) approach was adopted to map the processes to be automated. With the incorporation of this improvement into the workflow, it was possible to simplify data collection, processing, and monitoring of goal-related information, yielding gains in the available hours of the team, impacting overall productivity, and allowing the team to focus on enhancing analysis of goal achievement and action execution.

2. Methodology

The mapping and automation of the processes for the development and monitoring of IGSUS followed project management methodologies, process management, and agile methods, focusing on a collaborative, governed approach inclined towards innovation and improving the delivery of public services.

A project management methodology was used to increase commitment to objectives and results, integration between the involved areas, availability of information for decision-making, improve the quality of project results, optimize human and material resources, and minimize project risks and issues.

The practice of tailoring, which aims to adapt and customize processes, methods, tools, and project management practices to meet the specific needs of each project and organization, was utilized. Thus, the process management method used was a hybrid form of recommendations from the PMBOK Guide (Project Management Institute, 2017) and agile methodologies, aiming to offer the success guarantees that a management methodology can provide, aligning the company's desired objectives with the available resources and time. The following stages were then followed:

1. **Initiation:** where the project was defined and authorized. The Project Charter was proposed, and the

project team was defined.

2. **Planning:** the project's scope, schedule, and resources were defined, along with the project's work breakdown structure.
3. **Execution:** the project plan was executed.
4. **Monitoring and Control:** the project's progress and performance were monitored and controlled.
5. **Closure:** the project's stages were finalized and documented.

During the execution phase, the developed solutions followed agile methodology steps with prototyping and testing to define the final solution product. This choice was due to the fact that this type of methodology provides feedback from end-users in short iterations, allowing for the development of faster solutions, directed at process users, and with better quality.

The processes related to IGSUS were then mapped using process management methodology according to BPM (Business Process Management) standards. An adapted BPM cycle from the CMBOK 4.0 Guide (ABPMP International, 2020) was used, consisting of planning, analysis, design, implementation, and monitoring. As an initial step, project planning was carried out, reviewing objectives and teams, as well as providing documents related to the processes to be mapped. The objective was defined as the development of solutions that make the analyzed processes and process flows more efficient. Next, an analysis was conducted to identify and evaluate how the processes were occurring. Through meetings and interviews with the team involved, it was possible to identify the key elements of a business process: Supplier, Input, Process, Output, and Customer (SIPOC). Thus, activities, tasks, and their responsible parties, the stages to which each task was related, and the estimated time in hours of work for their completion could be differentiated. As a result of this stage, a flowchart of the initial state of the process (AS-IS) was developed following business process management notation (BPMN).

After completing this stage, the process analysis phase began, in which repetitive activities and tasks that generated rework were identified, listing the development of data collection forms – Excel spreadsheets – and the treatment of collected data as tasks to be developed for improvement solutions.

In the process design phase, after identifying the activities targeted for improvement, the development of solutions began, consisting of three phases: prototyping, which involved the creation of initial solutions, testing these solutions, and the actual development of those that best met the proposed objective. Optimizations and reorganization of stages were agreed upon, and automations of repetitive and routine tasks were proposed and developed. Thus, a new process design (TO-BE) that incorporated the solutions was validated.

The final stage was the implementation of the developed tools. For data collection, the use of standardized collection forms in Excel documents for each of the goals was proposed. Additionally, Python code routines were developed to automate the creation of the forms, processing of collected data, and generation of a Word document with the IGSUS goals information. The more than 250 forms required the addition of new fields, locking and unlocking of cells, and occasionally specific formulas and formatting. To support the Word document, a database was created with the information collected from the forms, a task that was also automated. To facilitate the sharing of forms and instructional information about the process, a web page was developed and implemented using Microsoft's SharePoint tool. Focal points from each area had permission to access only their forms, avoiding the step of sending emails to each area with their folders and preventing unauthorized access to the forms. Additionally, this tool enabled the centralization of the sharing of instructional information for technical areas.

After developing these solutions, the routines were migrated according to the defined schedule, and the solutions entered a continuous improvement cycle. During the application period of the redesigned stages, the time spent by the team on activities and the return time of the completed forms were monitored to be compared to the time identified for the AS-IS process.

3. Results

The mapping of the processes involved was done according to the BPM notation. First, the process was mapped as it was executed (AS IS). Then, in an effort to evaluate and agree jointly between the actors involved in the tasks, improvements and optimizations were defined in the flow of activities. After validating these

improvements, the version to be implemented was designed (TO BE). This standardization made it possible to automate repetitive and laborious tasks, implementing more efficient and rational flows.

To illustrate the improvements made, Appendix A and Appendix B show, respectively, the AS IS version and the TO BE version of the monitoring and publication of the annex to the RDQA. As you can see, the original flow involved 4 macro-steps and 5 activities that are labor-intensive and have potential for optimization. The TO BE version, on the other hand, consists of 3 macro-steps and 4 activities that present significant improvements and optimizations. This redesign therefore resulted in the exclusion of 5 labor-intensive and time-consuming activities, as can be seen in the figures below.

Based on the mapping of the involved processes, Python scripts were developed that enabled the automation of digital stages for editing tables in Excel, creating and updating a database, and generating Word documents. These scripts utilize libraries such as pandas and openpyxl for data analysis, and python-docx and docxcompose for document manipulation. Additionally, tkinter is used to create user-friendly interfaces for data input and message display.

These stages were part of actions aimed at consolidating data, adjusting the forms to be sent to technical areas, and producing the final Word document for the publication of the IGSUS. The automation process is divided into three main steps: preparation for data collection, monitoring and filling, and data consolidation for publication.

1. Preparation for Data Collection: Scripts create specific fields for information input, with data validation to ensure accuracy. They also manage cell locking and unlocking to facilitate standard field filling.
2. Monitoring and Filling: A daily script monitors the completion of specific fields, updating a control spreadsheet that tracks progress goal by goal.
3. Data Consolidation: Scripts generate an Excel database, which is then used to create formatted sheets with information and images for each goal, ready for final publication.

With a tool that provided a more intuitive interface for shared filling with technical areas, the speed of information collection allowed for timely actions to qualify the Planning Advisory team's support in goal monitoring. This included proposing activities for goal analysis and providing the necessary methodological support for this task.

The entire workflow for the creation of the instruments was compiled in SharePoint, a Microsoft platform that allows for the creation of collaborative portals and web interfaces. Beyond serving as a documentation space, compiling the workflow and forms on this platform aimed to provide a single address that facilitated sharing them for completion, avoiding the need to send attachments via email to all relevant areas within the SMS/SP. This strategy also had the advantage of indirectly training the actors involved in the planning instruments on the new workflow and tools used. It is estimated that over 100 employees involved in monitoring goals were exposed to the developed content, and their work was impacted by this action.

The automation of the processes resulted in an annual gain of 1,240 hours related to form production, plus an additional 60 hours for sending customized emails per area, totaling a 1,300-hour saving for the team. This result pertains to the time saved from the work of two team members. In addition to efficiency gains, this reduction in time spent on repetitive tasks has allowed for a greater focus on improving the planning of actions and the analysis of results in the IGSUS, promoting reflection on the part of the actors who implement public policies to improve their results. In this way, process mapping and the automation of tasks have been configured as a relevant innovation in the context of public health policy management, contributing to qualitative gains in its execution and thus generating social value that translates into the improvement of actions and services offered to citizens.

The table below summarizes the deliverables from the automation project promoted by the Planning Advisory team of SMS/SP:

Tab. 1 - Main deliverables of the project.

Deliverables

1	New tool for registering information and monitoring IGSUS goals
2	Document with mapping of the new process
3	Python codes documented on GitHub
4	Gain of 1,300 technical hours annually
5	Training of over 100 professionals in the use of the new form
6	Platform with work flows and form sharing

4. Final Considerations

This initiative represented a successful case of digital transformation applied to a key process, where solutions using automation for routine and repetitive tasks impacted the overall reduction in time to complete the filling of the SUS Management Instruments. It enabled better qualification of analysis and monitoring processes and contributed to the creation of an intuitive, secure, and agile interface for data collection with technical areas. The qualification and development of the team during the process also stands out, as it incorporated new knowledge and skills into their technical repertoire. The increased efficiency derived from these improvements allowed the team's efforts to focus on enhancing the planning of stakeholders from the territory and technical areas within SMS, contributing to the greater efficiency, effectiveness, and impact of policies, as well as reducing health inequities.

This experience marked the initial step towards the automation of tasks that are beneficial to both the administration and the workers directly involved, adding value to the management and planning process. However, efforts are still required to disseminate the competencies involved, document, and standardize processes to institutionalize the benefits and improvements achieved. In this regard, additional efforts are being made to deepen mapping actions, optimization, and continuous improvement in the IGSUS processes, aiming to expand and sustain the benefits obtained.

Acknowledgement

- **Funding or Grant**: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
- **Data/Software Access Statement:** The data involved in this study consisted of goal-related data exchanged between departments during the traditional work process (monitoring goal progress). Data automation and processing were performed using Microsoft Excel, Microsoft Word, and VS Code (version 1.86) running Python (version 3.13), along with relevant Python packages.
- **Contributor Statement:**

  - Ilka Corrêa De Meo: Conceived the study and methodology. Supervised the development of scripts and the use of technologies. Wrote and reviewed the article. Contributed ideas for process improvement.

  - André Luiz dos Santos Teixeira: Catalogued references. Led the writing and review of the work.

  - Bianca Tomi Rocha Suda: Conceived the study and methodology. Contributed ideas for process improvement and validated the results.

  - Bruno Martinelli: Conceived the study and methodology. Participated in the development of automated steps. Reviewed the article and contributed ideas for process improvement.

  - Felipe Barbugian Borges da Cunha: Developed automated steps (scripts, SharePoint construction). Contributed ideas for process improvement.

  - Felipe Ribeiro Pereira: Developed automated steps (scripts). Assisted in process mapping. Wrote and reviewed the article. Reviewed flowcharts.

  - Fernanda Braz Tobias de Aguiar: Supervised the study. Contributed ideas for process

improvement and work conduction. Validated the results.

- Gianlucca Vergian Dalenogare: Reformulated process mapping. Wrote and reviewed the article. Developed flowcharts.
- Karina Teixeira Silva: Supported the construction and maintenance of SharePoint. Reviewed information and contributed ideas for process improvement.
- Luiz Gustavo Machado Cruz: Contributed ideas for process improvement. Validated scripts.
- Miriam Carvalho de Moraes Lavado: Supervised the study. Contributed ideas for process improvement and work conduction. Validated the results.
- Sandra Fernandes Maciel dos Santos: Supported the construction and maintenance of SharePoint. Reviewed information and contributed ideas for process improvement.
- Suellen Decario Di Benedetto: Conceived the study and methodology. Contributed ideas for process improvement and validated the results.
- Estevão Nicolau Rabbi dos Santos: Supervised the study. Contributed ideas for work conduction and validated the results.

- **Use of AI:** During the preparation of this work, the authors used ChatGPT (OpenAI) and Copilot (Microsoft) to support the development of Python code for data processing, edit text documents, and create system interfaces. Additionally, AI was utilized to assist in reviewing and improving the clarity, structure, and academic tone of the English text. After using this tool, the authors critically reviewed, edited, and validated all content, and take full responsibility for the final version of the publication.
- **Conflict of Interest:** There is no conflict of interest.

References

ABPMP International. (2020). Guide to the Business Process Management Body of Knowledge (BPM CBOK®) Version 4.0. ABPMP International. Retrieved from https://www.abpmp.org/page/guide_BPM_CBOK

Asgarkhani, M. (2005). The effectiveness of e-service in local government: A case study. The Electronic Journal of e-Government, 3(4), 157-166. Available online at https://www.ejeg.com

Conselho Nacional de Saúde. (2012). Resolução nº 459, de 10 de outubro de 2012. Aprova o modelo padronizado de relatório quadrimestral de prestação de contas para os estados e municípios. Retrieved from https://bvsms.saude.gov.br/bvs/saudelegis/cns/2012/res0459_10_10_2012.html

Giovanella, L. (1990). Planejamento estratégico em saúde: Uma discussão da abordagem de Mário Testa. Cadernos De Saúde Pública, 6(2), 129–153. https://doi.org/10.1590/s0102-311x1990000200003

Gkrimpizi, T., Peristeras, V., & Magnisalis, I. (2023). Classification of barriers to digital transformation in higher education institutions: Systematic literature review. Education Sciences, 13(7), 746. https://doi.org/10.3390/educsci13070746

Haug, N., Dan, S., & Mergel, I. (2023). Digitally-induced change in the public sector: A systematic review and research agenda. Public Management Review, 26(7), 1963–1987. https://doi.org/10.1080/14719037.2023.2234917

Jonathan, G. M. (2020). Digital transformation in the public sector: Identifying critical success factors. In M. Themistocleous & M. Papadaki (Eds.), Information Systems. EMCIS 2019. Lecture Notes in Business Information Processing (Vol. 381, pp. 189-199). Cham: Springer. https://doi.org/10.1007/978-3-030-44322-1_17

Latupeirissa, J., et al. (2024). Transforming public service delivery: A comprehensive review of digitization initiatives. Sustainability, 16(7), 2818.

Matus, C. (1991). O plano como aposta. Tradução de Frank Roy Cintra Ferreira. São Paulo em Perspectivas, 5(4), 28-42.

Ministério da Saúde da República Federativa do Brasil. (2017). Portaria de Consolidação nº 01/17. Retrieved from https://portalsinan.saude.gov.br/images/documentos/Legislacoes/Portaria_Consolidacao_1_28_SETEMBRO_2017.pdf

Prefeitura Municipal de São Paulo. (2020). Decreto nº 59.685. Retrieved from https://legislacao.prefeitura.sp.gov.br/leis/decreto-59685-de-13-de-agosto-de-2020

Presidência da República Federativa do Brasil. (1995). Decreto nº 1.651, de 28 de setembro de 1995. Regulamenta o Sistema Nacional de Auditoria no âmbito do Sistema Único de Saúde. Retrieved from https://www.planalto.gov.br/ccivil_03/decreto/1995/d1651.htm

Presidência da República Federativa do Brasil. (2011). Decreto nº 7.508, de 28 de junho de 2011. Regulamenta a Lei nº 8.080, de 19 de setembro de 1990, para dispor sobre a organização do Sistema Único de Saúde - SUS, o planejamento da saúde, a assistência à saúde e a articulação interfederativa. Retrieved from https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2011/decreto/d7508.htm

Presidência da República Federativa do Brasil. (2012). Lei Complementar nº 141, de 13 de janeiro de 2012. Regulamenta o § 3º do art. 198 da Constituição Federal para dispor sobre os valores mínimos a serem aplicados anualmente pela União, Estados, Distrito Federal e Municípios em ações e serviços públicos de saúde. Retrieved from https://www.planalto.gov.br/ccivil_03/leis/lcp/lcp141.htm

Project Management Institute. (2017). A guide to the project management body of knowledge (PMBOK® guide) (6th ed.). Project Management Institute.

Shankarmani, R., Pawar, R., Mantha, S., & Babu, V. (2012). Agile methodology adoption: Benefits and constraints. International Journal of Computer Applications, 58(15), 31-37. https://doi.org/10.5120/9361-3698

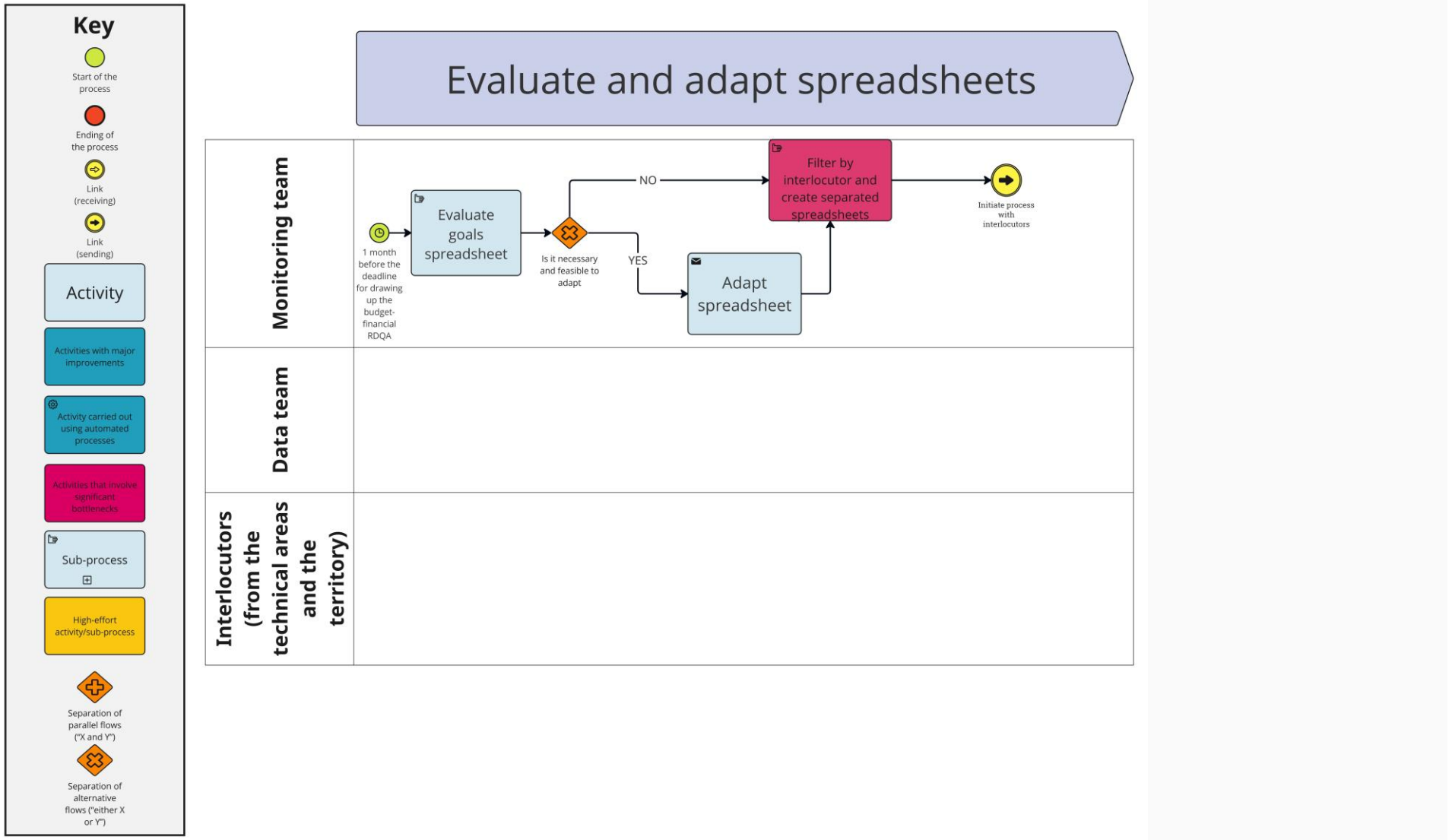
Stoumpos, A. I., Kitsios, F., & Talias, M. A. (2023). Digital transformation in healthcare: Technology acceptance and its applications. International Journal of Environmental Research and Public Health, 20(4).

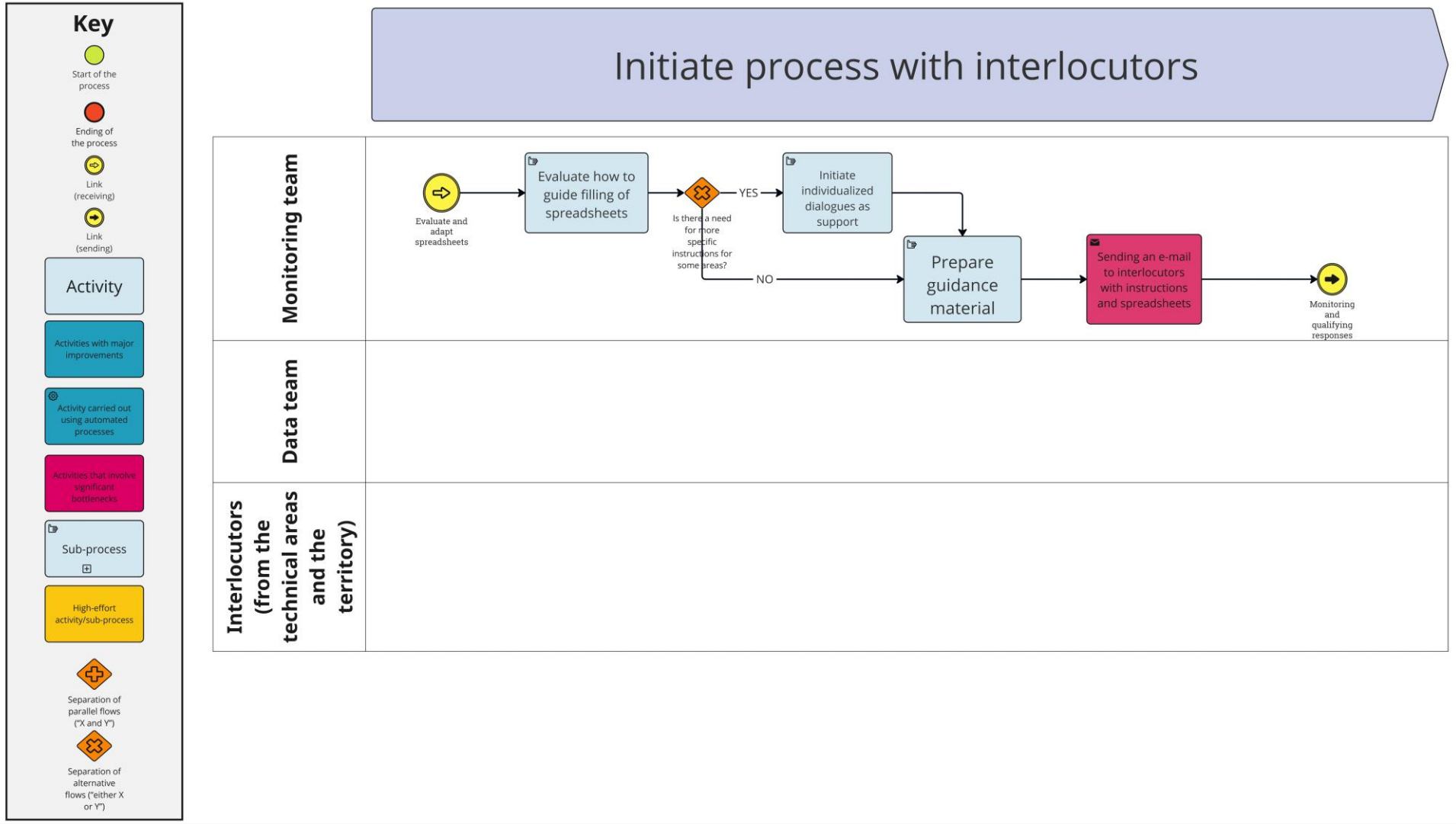
Terlizzi, A. (2021). The digitalization of the public sector: A systematic literature review. Rivista Italiana di Politiche Pubbliche, 1, 1-27. https://doi.org/10.1483/100372

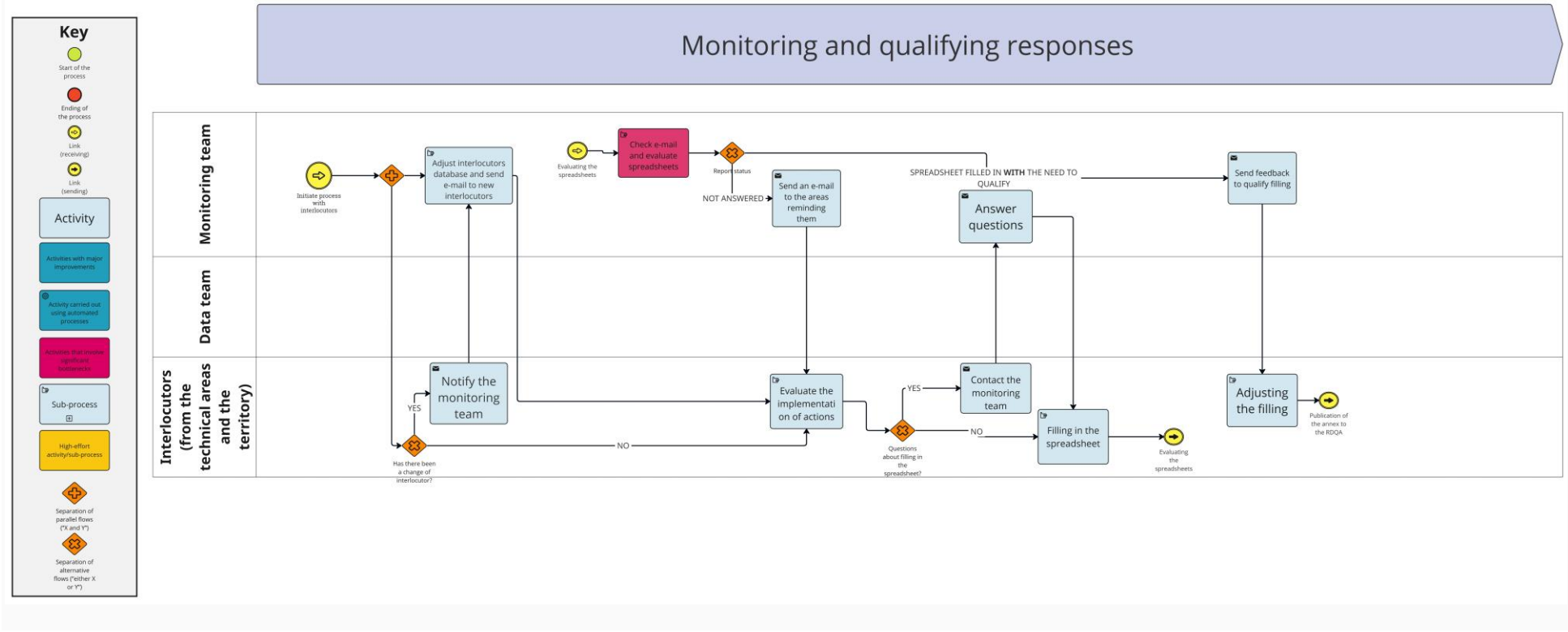
Whitaker, S. (2014). The benefits of tailoring: Making a project management methodology fit. Project Management Institute. Retrieved from https://www.pmi.org/learning/library/tailoring-benefits-project-management-methodology-11133

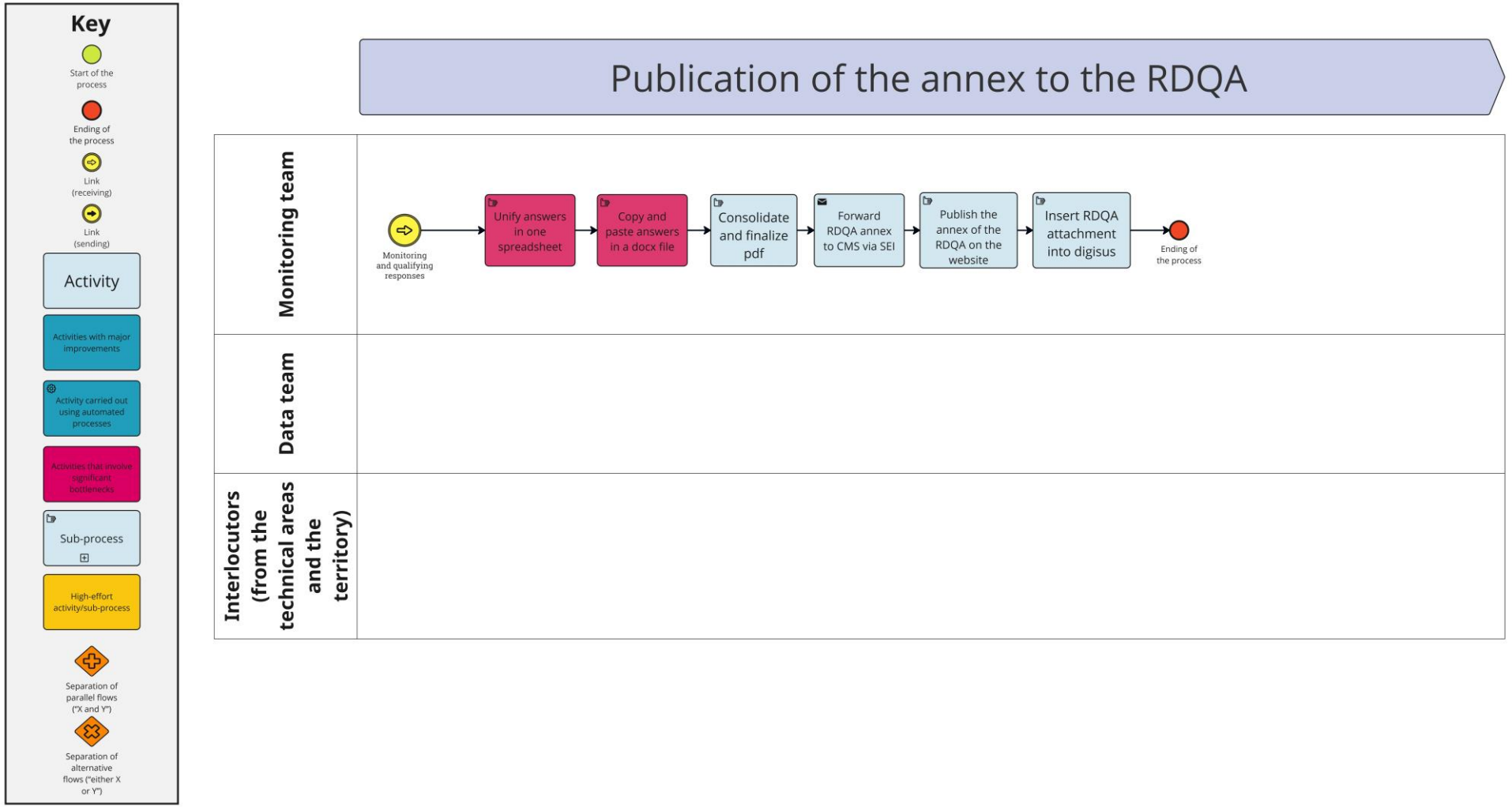
World Health Organization. (2021). Global strategy on digital health 2020-2025. Geneva: Licence: CC BY-NC-SA 3.0 IGO. Retrieved from https://www.who.int/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf

Appendix A

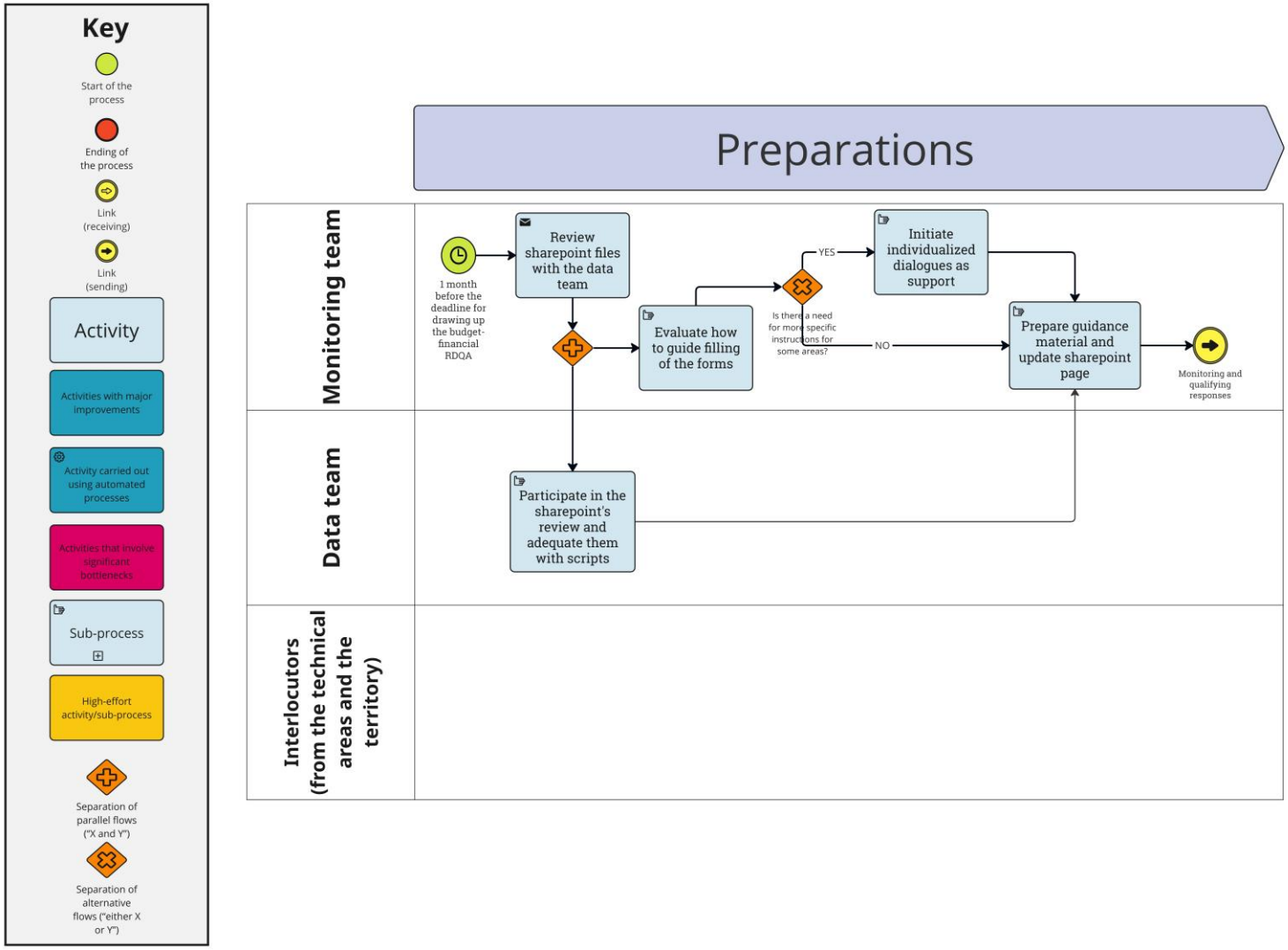

Key
Start of the process
Ending of the process
Link (receiving)
Link (sending)
Activity
Activities with major improvements
Activity carried out using automated processes
Activities that involve significant bottlenecks
Sub-process
High-effort activity/sub-process
Separation of parallel flows ("X and Y")
Separation of alternative flows ("either X or Y")
Evaluate and adapt spreadsheets
Monitoring team
Data team
Interlocutors (from the technical areas and the territory)
1 month before the deadline for drawing up the budget-financial RDQA
Evaluate goals spreadsheet
Is it necessary and feasible to adapt
NO
YES
Filter by interlocutor and create separated spreadsheets
Adapt spreadsheet
Initiate process with interlocutors

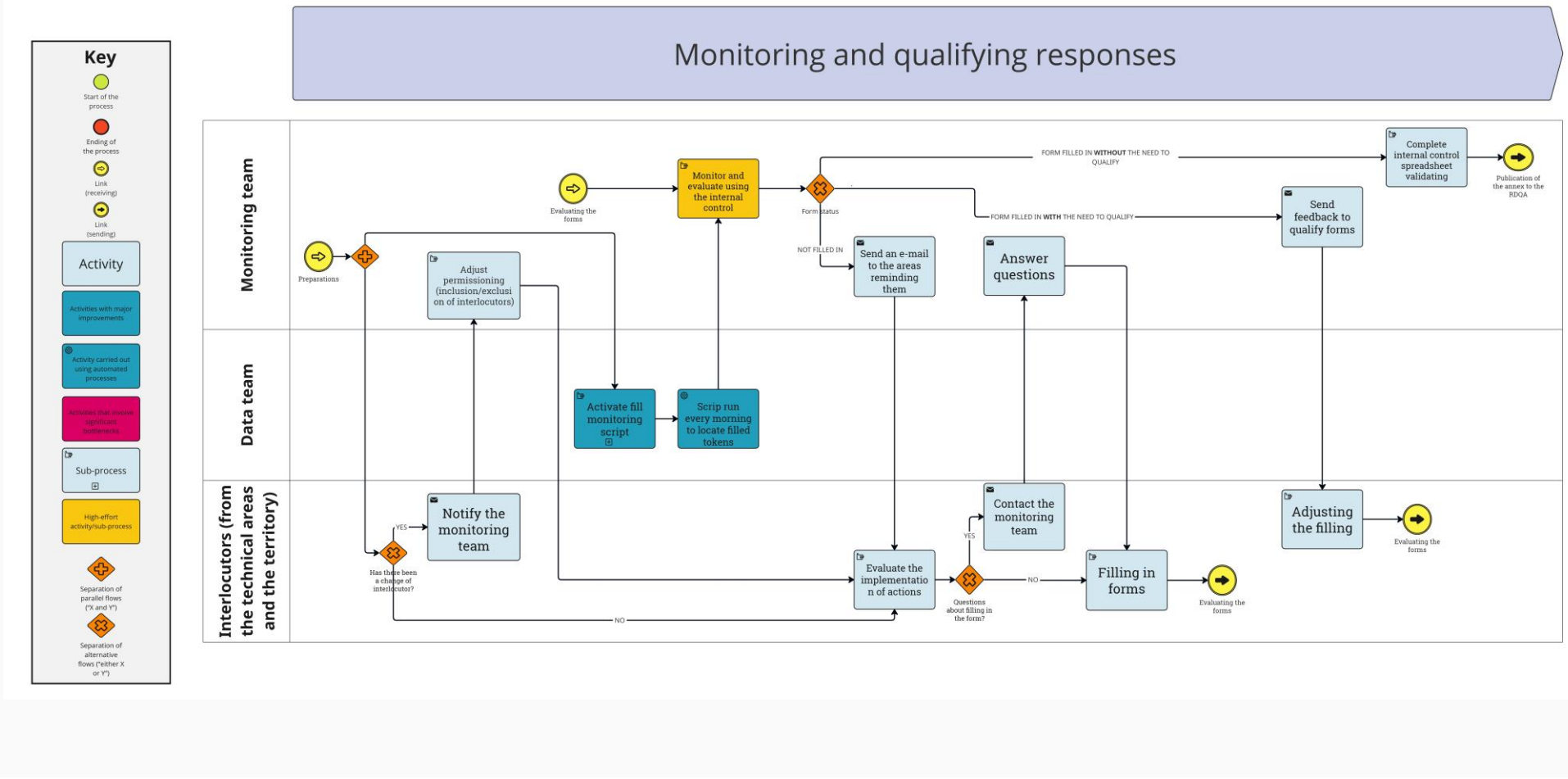

Key
Start of the process
Ending of the process
Link (receiving)
Link (sending)
Activity
Activities with major improvements
Activity carried out using automated processes
Activities that involve significant bottlenecks
Sub-process
High-effort activity/sub-process
Separation of parallel flows ("X and Y")
Separation of alternative flows ("either X or Y")
Initiate process with interlocutors
Monitoring team
Data team
Interlocutors (from the technical areas and the territory)
Evaluate and adapt spreadsheets
Evaluate how to guide filling of spreadsheets
Is there a need for more specific instructions for some areas?
YES
Initiate individualized dialogues as support
NO
Prepare guidance material
Sending an e-mail to interlocutors with instructions and spreadsheets
Monitoring and qualifying responses

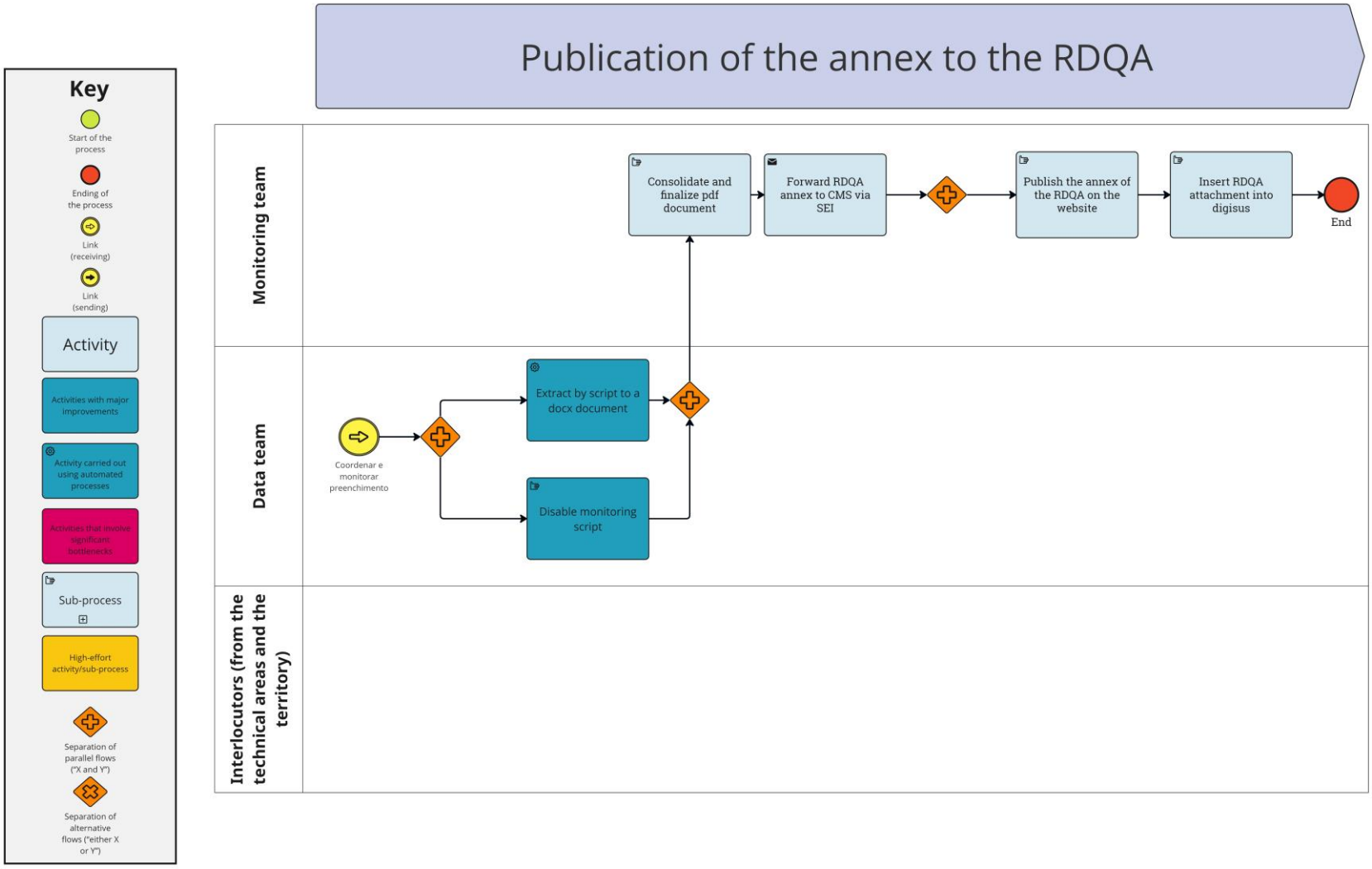

Key
Start of the process
Ending of the process
Link (receiving)
Link (sending)
Activity
Activities with major improvements
Activity carried out using automated processes
Activities that involve significant bottlenecks
Sub-process
High-effort activity/sub-process
Separation of parallel flows ("X and Y")
Separation of alternative flows ("either X or Y")
Monitoring and qualifying responses
Monitoring team
Data team
Interlocutors (from the technical areas and the territory)
Initiate process with interlocutors
Adjust interlocutors database and send e-mail to new interlocutors
Evaluating the spreadsheets
Check e-mail and evaluate spreadsheets
Report status
NOT ANSWERED
Send an e-mail to the areas reminding them
SPREADSHEET FILLED IN WITH THE NEED TO QUALIFY
Answer questions
Send feedback to qualify filling
Notify the monitoring team
YES
Has there been a change of interlocutor?
NO
Evaluate the implementation of actions
Questions about filling in the spreadsheet?
YES
Contact the monitoring team
NO
Filling in the spreadsheet
Evaluating the spreadsheets
Adjusting the filling
Publication of the annex to the RDQA


Key
Start of the process
Ending of the process
Link (receiving)
Link (sending)
Activity
Activities with major improvements
Activity carried out using automated processes
Activities that involve significant bottlenecks
Sub-process
High-effort activity/sub-process
Separation of parallel flows ("X and Y")
Separation of alternative flows ("either X or Y")
Publication of the annex to the RDQA
Monitoring team
Data team
Interlocutors (from the technical areas and the territory)
Monitoring and qualifying responses
Unify answers in one spreadsheet
Copy and paste answers in a docx file
Consolidate and finalize pdf
Forward RDQA annex to CMS via SEI
Publish the annex of the RDQA on the website
Insert RDQA attachment into digisus
Ending of the process

Appendix B


Key
Start of the process
Ending of the process
Link (receiving)
Link (sending)
Activity
Activities with major improvements
Activity carried out using automated processes
Activities that involve significant bottlenecks
Sub-process
High-effort activity/sub-process
Separation of parallel flows ("X and Y")
Separation of alternative flows ("either X or Y")
Preparations
Monitoring team
Data team
Interlocutors (from the technical areas and the territory)
1 month before the deadline for drawing up the budget-financial RDQA
Review sharepoint files with the data team
Evaluate how to guide filling of the forms
Is there a need for more specific instructions for some areas?
YES
NO
Initiate individualized dialogues as support
Prepare guidance material and update sharepoint page
Monitoring and qualifying responses
Participate in the sharepoint's review and adequate them with scripts


Key
Start of the process
Ending of the process
Link (receiving)
Link (sending)
Activity
Activities with major improvements
Activity carried out using automated processes
Activities that involve significant bottlenecks
Sub-process
High-effort activity/sub-process
Separation of parallel flows ("X and Y")
Separation of alternative flows ("either X or Y")
Monitoring and qualifying responses
Monitoring team
Data team
Interlocutors (from the technical areas and the territory)
Preparations
Adjust permissioning (inclusion/exclusion of interlocutors)
Evaluating the forms
Monitor and evaluate using the internal control
Form status
FORM FILLED IN WITHOUT THE NEED TO QUALIFY
Complete internal control spreadsheet validating
Publication of the annex to the RDQA
FORM FILLED IN WITH THE NEED TO QUALIFY
Send feedback to qualify forms
NOT FILLED IN
Send an e-mail to the areas reminding them
Answer questions
Activate fill monitoring script
Scrip run every morning to locate filled tokens
YES
Notify the monitoring team
Has there been a change of interlocutor?
NO
Evaluate the implementation of actions
Contact the monitoring team
YES
Questions about filling in the form?
NO
Filling in forms
Evaluating the forms
Adjusting the filling
Evaluating the forms


Key
Start of the process
Ending of the process
Link (receiving)
Link (sending)
Activity
Activities with major improvements
Activity carried out using automated processes
Activities that involve significant bottlenecks
Sub-process
High-effort activity/sub-process
Separation of parallel flows ("X and Y")
Separation of alternative flows ("either X or Y")
Publication of the annex to the RDQA
Monitoring team
Data team
Interlocutors (from the technical areas and the territory)
Consolidate and finalize pdf document
Forward RDQA annex to CMS via SEI
Publish the annex of the RDQA on the website
Insert RDQA attachment into digisus
End
Extract by script to a docx document
Coordenar e monitorar preenchimento
Disable monitoring script

BEPP-DS: Building Evidence-Based Public Policies with Data Science

José Antonio F. Macedo[a], *Rossana Maria de Castro Andrade*[b], *Regis P. Magalhães*[a], *Lívia A. Cruz*[a], *José Florêncio Q. Neto*[a], *Samir B. Chaves*[a], *Mauricio Feijo B. M. Filho*[c], *Joaquim José Escola*[d], *Amanda Sousa*[b], *Pedro Almir M. Oliveira*[b,e], *Davyson S. Ribeiro*[b], *Paulo V. A. Fabrício*[b]

[a] Insight Lab, Federal University of Ceará, Brazil
jose.macedo@insightlab.ufc.br, ORCID: 0000-0002-0661-2978.

[b] Group of Computer Networks, Software Engineering and Systems (GREat), Federal University of Ceará, Brazil,
rossana@ufc.br, ORCID: 0000-0002-0186-2994.

[c] Federal University of Ceará, Brazil,
mauricio.benevides@ufc.br, ORCID: 0000-0002-8652-4328

[d] Trás-os-Montes and Alto Douro University, Portugal,
jescola@utad.pt ORCID: 0000-0002-6676-6928.

[e] Laboratory of Innovation and Scientific Computing (LICC), Federal Institute of Maranhão, Pedreiras, Brazil,
pedro.oliveira@ifma.edu.br, ORCID: 0000-0002-3067-3076.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. The exponential growth of data and the advancement of computational tools have made Data Science (DS) an essential discipline for addressing complex societal challenges. In the public sector, Evidence-Based Public Policies (EBPP) leverage data-driven insights to enhance governance transparency, efficiency, and effectiveness. However, the integration of Data Science into policymaking presents challenges, including data quality, interdisciplinary collaboration, and institutional resistance. This paper introduces BEPP-DS, a structured methodology for developing EBPP using DS principles, emphasizing transparency, reproducibility, and scalability. The methodology is informed by real-world applications such as Big Data Social and Big Data Fortaleza, which illustrate how data-driven strategies improve policy design, implementation, and monitoring. BEPP-DS defines a structured framework, from problem identification to policy evaluation, ensuring data-driven decision-making in governance. The methodology provides a replicable model for governments seeking to harness Data Science in policy formulation. Future work includes expanding AI-driven analytics and strengthening citizen engagement in data governance.

Keywords. Data Science, Evidence-Based Public Policies, E-Government, Public Administration, Big Data, Policy Analytics, Digital Governance, Decision Support Systems
Practical report, DOI: https://doi.org/10.59490/dgo.2025.1045

1. Introduction

The exponential growth of data and developments in computational tools made Data Science (DS) a key field to tackle multidimensional societal challenges (Silva et al., 2022). Helping to derive actionable insights from data, DS has established itself as a vital force in many fields, such as medicine, education, and urban administration (Santos et al., 2023). Lately, applications of DS in governance have been exemplary, especially in the framing and implementation of Evidence-Based Public Policies (EBPP) (Anderson et al., 2005).

There is an increasing need for governments worldwide to make policies effective, equitable, and more transparent, with full involvement of relevant stakeholders (Saltelli et al., 2020). Evidence-based approaches allow

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the systematic use of data within policy-making to ensure decisions are evidence-based, as opposed to intuition or tradition. However, for developing DS into public policy-making, there are related challenges –issues of data availability and quality, an interdisciplinary way of collaboration, and ethical, systematic methodologies guiding how knowledge is extracted within the government institutions' peculiarities (MacArthur et al., 2022).

Such is the demand for data-driven solutions in Brazil, whose socio-economic setting has also entrenched regional disparities. Despite all challenges, there is an emerging consensus on the need to structure and formalize DS use in government to work toward more effective public policies ultimately. This work describes a methodology for constructing EBPP using DS based on principles of transparency and non-discrimination.

Given this context, the question that guides this research is: how to structure a replicable methodology for building evidence-based public policies, using Data Science principles, that is applicable in different governmental contexts and capable of promoting more informed and effective decisions?

This paper describes the methodology that profited from the lessons learned while implementing large-scale data platforms such as Big Data Social (Sucupira Furtado et al., 2023a) and Big Data Fortaleza (Batista et al., 2024). Both examples give evidence of the potential of Data Science for developing governance that is efficient in processes, reproducible in decisions, and scalable in policies.

The rest of the paper is organized as follows: Section 2 gives an overview of the theoretical underpinning of Evidence-Based Public Policies and Data Science, showing their meeting point in governance. Section 3 reviews the related methodologies and pinpoints the literature gaps. Section 4 describes the proposed methodology, core components, and activities in depth. Section 5 demonstrates how the methodology works in real applications and discusses its impact. Finally, Sections 6, 7 and 8 discuss lessons learned and future opportunities, especially integrating Artificial Intelligence into data-driven policy-making.

2. Background

This section provides the basics necessary to understand the conjunction of Evidence-based Public Policies and Data Science, considering e-government. Understanding these domains allows us to comprehend better the opportunities and challenges of leveraging data science into governance practices, particularly in a context such as Brazil.

2.1. Evidence-based Public Policies

Evidence-based Public Policies are strategies and interventions designed and implemented based on empirical data and scientific research (Anderson et al., 2005). This approach ensures that rigorous evidence, rather than intuition or tradition, is the primary determinant of whether a policy is effective, efficient, and equitable. It is based on the central premise that structured methodologies that critically appraise and synthesize sound data substantially aid public decision-making and thus enable governments to handle societal challenges systematically and transparently.

EBPP adoption is rapidly expanding as the data and analytical tools base improve. Globally, the call for governments to account for their actions and deliver increased public service has grown. However, embedding evidence in policy faces several challenges: problems related to the quality of the data, resistance at the institutional level, and requirements for collaboration across disciplines. These hurdles notwithstanding, with increased calls for transparency and accountability, EBPP has become an indispensable framework for modern governance.

2.2. Data Science For Governments

Data Science (DS) is an interdisciplinary field that deals with methods and processes for extracting meaningful insights from data, combining statistical analysis, computational techniques, and domain expertise (Van Der Aalst and van der Aalst, 2016). It is pivotal in addressing complex societal challenges; it offers tools and methodologies to help uncover patterns, predict outcomes, and support decision-making processes.

The data science life cycle consists of five phases: data collection, cleaning, analysis, interpretation, and dissemination (Rahul and Banyal, 2020). Data collection involves aggregating information from diverse sources, while preprocessing ensures the data is clean and structured. In the analysis phase, analytical techniques like machine learning and statistical modeling are applied to derive actionable insights. These insights are then interpreted in the context of the problem domain and disseminated to stakeholders to inform decisions. This iterative cycle allows continuous improvement and adaptation, particularly suited for dynamic environments like governance.

2.3. e-Government in Brazil

e-Government is the use of digital technologies to improve the delivery of government services, enhance citizen engagement, and streamline administrative processes (Silcock, 2001). In Brazil, e-Government initiatives represent a unique opportunity to reduce persistent regional disparities and enhance public sector efficiency (Musafir, 2018). With more than 200 million people and a growing internet penetration rate, Brazil has the potential to use digital platforms to expand access to public services and enhance transparency.

However, adopting e-Government in Brazil is still dogged by various factors: deficiencies in rural digital infrastructure, socioeconomic disparities, and bureaucratic resistance. Nevertheless, projects like "Big Data Fortaleza" (Batista et al., 2024) and "Big Data Social"(Sucupira Furtado et al., 2023a) represent the transformational use of data science integrated into governance. These projects show how data-driven strategies could improve decision-making, resource allocation, and citizen outcomes.

3. Related Works

This section presents the related works studied to understand models and their respective results presented by Evidence-Based Public Policies and Data Science. Understanding these works allows us to better understand the challenges of leveraging data science in governance practices, especially in social contexts present in Brazil.

(Sucupira Furtado et al., 2023b) demonstrated how Ceará's digital transformation integrated technological innovation into public policy cycles to address social challenges and promote sustainable development. Tools like big data platforms and mobile apps enabled data-driven policymaking, improving efficiency, transparency, and responsiveness. Collaboration among public, academic, and private sectors (e.g., the IRIS Lab) enhanced institutional capacity and policy legitimacy. Focus on vulnerable populations aligned with SDGs, reducing inequalities through targeted interventions.

(Pereira et al., 2021) highlighted the role of standardized information structures in creating efficient and accessible policies. Interoperability between government systems improved evidence-based decision-making and digital inclusion by simplifying access to services. Standardized taxonomies enabled better policy monitoring and evaluation, ensuring adaptive and inclusive governance.

(Furtado et al., 2023) presented the importance of integrating data and advanced analytics to support the creation of more effective and targeted public policies. By consolidating information on social vulnerabilities, such as income, housing, and nutrition, the system made it possible to identify populations at greatest risk and prioritize government actions in a well-founded manner. This approach demonstrates how digital tools can strengthen the diagnosis of social problems, offering an empirical basis for the formulation of policies that are more aligned with the real needs of the population. A central feature of this work is its ability to personalize public policy recommendations based on detailed analyses of specific conditions. Through interactive dashboards, public managers can access solutions adapted to meet particular demands, such as the provision of financial aid, housing policies, or access to government programs to support society. This personalization reflects a more human and strategic approach to policymaking, by focusing on practical results and immediate impacts for the most vulnerable populations, maximizing the efficiency and social impact of government interventions.

(Schröer et al., 2021) presents CRISP-DM (Cross-Industry Standard Process for Data Mining) highlighting its relevance as a methodological framework capable of guiding the creation of evidence-based public policies. Divided into six phases – business understanding, data understanding, data preparation, modeling, evaluation,

and implementation –, this model offers a systematic approach to analyze large volumes of data, transform information into useful knowledge, and translate analytical insights into concrete actions. This methodology has a strong potential for application in the public sector, where data analysis can improve the formulation of policies aimed at complex social problems. The initial phase of business understanding is essential to align the data analysis objectives with public policy priorities. It allows managers to identify critical issues, such as social inequality or low coverage of health services, and define clear goals for interventions. By establishing these connections between data and objectives, the model enables the creation of more strategic policies aligned with the real needs of the population. This approach highlights how structuring data in analytical projects can improve the diagnosis of problems and direct resources to areas of greatest impact. The data preparation and modeling phases are equally important to the policymaking process, as they ensure the quality and usability of the analyzed data. By consolidating information from different sources, such as government databases or sectoral statistics, CRISP-DM helps to create a comprehensive overview of the challenges faced by society. In addition, the analytical models developed at this stage allow for scenario simulations and predictions of the effects of policies before their implementation, reducing uncertainty and optimizing expected results. This is especially relevant in contexts such as health, education and public safety, where well-planned interventions can generate significant transformations.

The analysis of the presented studies reveals a convergence around the strategic use of digital technologies and structured methodologies to strengthen the process of creating and implementing public policies. However, they also highlight significant gaps that need to be addressed to ensure a comprehensive and sustainable implementation. These studies underscore both the central role of technology in modernizing public governance and the challenges associated with inter-institutional integration, data privacy, continuous monitoring, and social participation.

The use of structured frameworks demonstrates the importance of well-defined analytical processes to guide data-driven decision-making. This approach allows for the identification of critical problems, the definition of clear goals, and the evaluation of the potential impact of policies before their implementation. However, inter-institutional integration, necessary to consolidate data and promote a holistic view of social demands, still faces challenges such as standardizing information and defining responsibilities among government agencies. Overcoming these challenges is crucial to maximize the effectiveness of public interventions.

Furthermore, the application of digital transformation in specific contexts reinforces the need to align technology and governance with strategic planning that prioritizes inclusion, sustainability, and data privacy protection. However, the studies leave open questions about how to ensure the financial and operational sustainability of these solutions and how to balance the use of data with guarantees of security and ethical treatment. They also highlight gaps in post-implementation monitoring. Time is needed to assess the long-term impacts of these strategies derived from public policies. These studies emphasize that achieving modern and sustainable public governance requires the integration of technology, ethics, inter-institutional collaboration, and citizen participation. This integration is essential to ensure efficiency, equity, and significant social impact.

4. BEEP-DS

Given our experience in government Big Data projects, it was possible to observe and extract good practices to compose a methodology for Building Evidence-Based Public Policies from Data Science (BEEP-DS). The construction of the BEPP-DS methodology followed a set of guiding requirements, derived from the analysis of real cases and the limitations observed in previous projects. The main requirements include: (i) clarity and traceability of decisions; (ii) minimization of rework and data reprocessing; (iii) integration of different professional profiles with defined roles; (iv) feasibility of replication in different institutional contexts; and (v) support for impact assessment. Based on these requirements, it was possible to design the workflow represented in Figure 1.

Based on the experiences of the Federal University of Ceará and the resources provided by the Fundo Nacional de Desenvolvimento da Educação (FNDE), the data product creation process is structured into six main roles: the requester, the data scientist, the business analyst, the data engineer, the developer, and the data manager.

The requester is the FNDE representative responsible for submitting a data product request. They present a strategic question already approved by FNDE, meaning that the business need has been previously analyzed

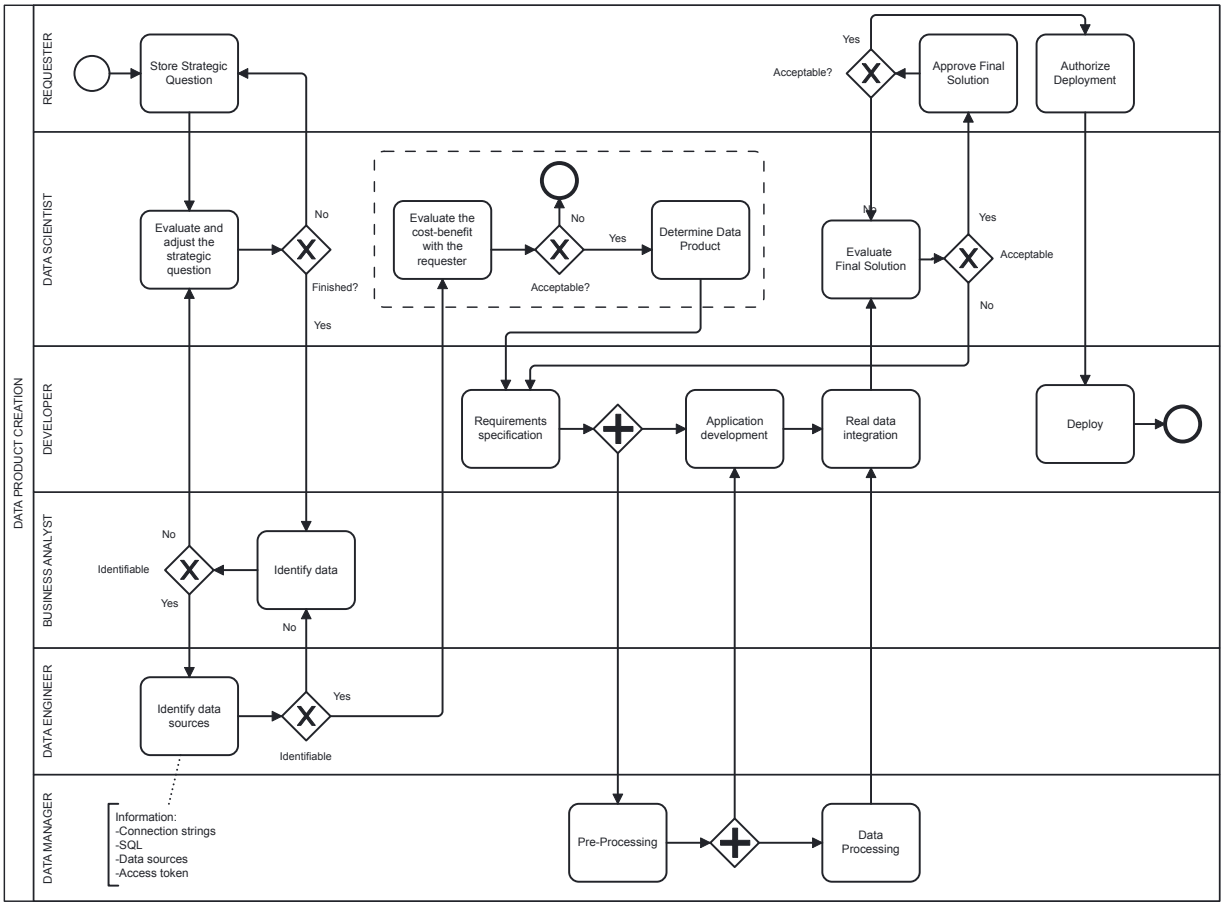


Fig. 1 – BPM Diagram for data product creation.

before the process has been started. Consequently, the submitted question would be structured and ready to be addressed.

The data scientist, in charge of the next step, is an information technology professional experienced in data analysis. Their role is to assess whether the strategic question meets essential criteria such as objectivity, well-defined scope, and feasibility within a reasonable timeframe. If necessary, the data scientist collaborates with the requester to refine the question. The data scientist is also supposed to accompany the whole data product creation process, trying to keep the efforts aligned with the goals of the requester. Once the question is sufficiently clear and viable, it is passed on to the business analyst. At this point, the process aligns with Business Understanding in CRISP-DM (Figure 2), where the objectives are identified, and the success criteria are established. Although the analysis of predictions is carried out by the data scientist, it will be clear that decisions about the development of data products for public policies require a broader vision. The technique envisaged, although essential, may not fully capture the social or strategic value of an initiative. Therefore, it is proposed that this stage evolve into a collegiate assessment, also involving experts from the business area and representatives of public management, allowing for the consideration of not only computational or technical effort aspects, but also the potential impact of the policy to be strengthened — for example, in terms of urgency, population coverage or mitigation of social risks.

The business analyst identifies data sources needed to address the strategic question, leveraging institutional knowledge. If data is unavailable or costly, they return the request with feedback; otherwise, they forward it (with documentation) to the data engineer. This aligns with CRISP-DM's Data Understanding phase. The data engineer handles technical infrastructure (connection strings, queries, access tokens). If obstacles arise (e.g., external data ownership), they escalate to the analyst and data scientist. Successfully sourced data is documented, mirroring CRISP-DM's Data Preparation.

The data scientist then evaluates feasibility (strategic fit, technical viability, cost-benefit) with the requester. If



Fig. 2 – Phases of the CRISP-DM Process Model for Data Mining

approved, they jointly define the product (dashboard, chart, etc.), initiating development (Modeling in CRISP-DM). The developer builds the product using a sample dataset (provided by the data manager), while the manager prepares the final dataset. The data scientist validates the product with real data, requesting adjustments if needed (Evaluation phase).

Finally, the requester reviews the product. If approved, the team deploys it, and the data manager catalogs it for use (Deployment in CRISP-DM). Rejection triggers reevaluation by the data scientist.

5. Usage Scenarios

This section describes two projects in which we obtained the necessary experiences to propose the method discussed in this paper. Big Data Social and Big Data Fortaleza are platforms built to help public managers make decisions based on analytical data. Although created in different scenarios, both faced challenges, such as the lack of a data culture in government sectors and the absence of processes to ensure the continuity of the platforms based on the management of the construction of new analytics.

5.1. Big Data Social

Big Data Social platform is a centralized hub for consolidating, managing, and analyzing diverse government databases related to low-income families enrolled in the “Mais Infância” welfare program. By integrating multiple sources, the system improves governance by generating key indicators and highlighting the social policies that directly benefit these families. These households are a priority for state agencies, as they often face significant socioeconomic hardships, predominantly living in rural areas and including one child under six.

To build the database, a state-led survey was conducted, gathering data from more than 150,000 families on topics such as food security, health, child welfare, housing conditions, income, and education. The Big Data Social platform not only stores this vast dataset but also provides advanced tools for data analysis, including analytics, data mining, and interactive dashboards. The platform maps the geographic locations of these families, providing decision-makers with valuable insights into how current policies impact families’ quality of life.

The execution of this project gave us experience with the challenges inherent in constructing evidence-based public policies. Although several data science processes can be applied to address such challenges, the lessons learned in this type of project are valuable for avoiding future mistakes and optimizing the results achieved.

5.2. Big Data Fortaleza

The Big Data Fortaleza platform was designed to create a robust data ecosystem that supports evidence-based public policy formulation, implementation, and monitoring. By centralizing and processing large volumes of

data from diverse governmental and institutional sources, the platform enables in-depth analysis and pattern recognition, optimizing public management. Its methodology is grounded in Data Science principles tailored for the public sector, with a strong emphasis on the BEPP-DS framework.

Aligned with e-Government initiatives and international data-driven policy standards, the platform adopts a modular approach encompassing data collection, preprocessing, exploratory analysis, predictive modeling, and interactive visualization. Machine learning and artificial intelligence enhance its capabilities, allowing for scenario forecasting and strategic recommendations that improve resource allocation and impact assessment. Built with interoperability and data governance best practices, the platform facilitates seamless integration across agencies, preventing data silos and promoting collaboration.

Validation across key public administration areas—such as urban mobility, health, education, and security—demonstrated the platform's effectiveness in integrating and cross-referencing previously fragmented databases, offering a comprehensive view of urban and social challenges. However, implementation faced hurdles, including institutional resistance to data technologies, the need for technical upskilling among public managers, and constraints in data quality and availability. To overcome these challenges, a participatory approach was adopted, engaging stakeholders and fostering a data-driven governance culture. The application of BEPP-DS proved instrumental in standardizing processes for extracting actionable insights from heterogeneous data sources, ensuring reliable and replicable outcomes.

The platform's deployment significantly enhanced municipal analytical capabilities, leading to optimized resource allocation, reduced administrative redundancies, and stronger policy monitoring and evaluation mechanisms. Interactive dashboards and automated reports improved data accessibility for both public managers and civil society, while increased transparency allowed citizens to track government actions more closely, promoting accountability. These advancements reinforced the shift toward responsive, data-informed governance.

The insights derived from Big Data Fortaleza contributed to refining the BEPP-DS methodology, establishing best practices for data science in public policy. The project highlighted the importance of robust data governance, including standardized processes, clear institutional responsibilities, and continuous data validation. As the methodology evolved, the platform incorporated advanced predictive models and expanded interoperability with national and international databases. Equally critical was the emphasis on continuous training for public officials, ensuring effective tool utilization to drive tangible societal benefits.

Looking ahead, Big Data Fortaleza aims to broaden its impact by leveraging open data and artificial intelligence to refine public policy formulation on a national scale, further cementing its role as a catalyst for data-driven governance.

6. Discussion

The BEPP-DS methodology was designed to address gaps observed in applying traditional data science frameworks to public policy contexts. While CRISP-DM is widely recognized for its six-phase structure—from business understanding to deployment—its direct application in government settings can be challenging due to insufficient emphasis on public-sector specifics, such as institutional complexity and the need for transparency and accountability. In comparison, BEPP-DS adapts and expands CRISP-DM principles by incorporating stages tailored to public-sector realities. For instance, while CRISP-DM focuses on business understanding, BEPP-DS emphasizes strategic questions aligned with political and social priorities. Additionally, BEPP-DS introduces a data governance framework addressing privacy, ethics, and responsible data use—aspects often overlooked in more generalized frameworks.

Although it has been applied in projects like Big Data Social and Big Data Fortaleza, a systematic evaluation of its effectiveness and adaptability across different government contexts is still needed. This includes further case studies, comparative analyses with other methodologies, and performance metrics to demonstrate its benefits and limitations. Moreover, implementing BEPP-DS requires significant institutional maturity and technical capacity. Public organizations with less developed structures may struggle with full adoption. Therefore, adaptations and ongoing support are crucial to ensure long-term effectiveness and sustainability.

BEPP-DS represents progress in integrating data science into public policy, offering a more contextualized and

sensitive approach to public-sector needs. However, its consolidation as a standard methodology will depend on further validation, adaptations to diverse institutional realities, and strengthening the technical capabilities of involved organizations.

7. Lessons Learned

Based on the BEPP-DS and the usage scenarios described in section 5, it was possible to systematize a set of lessons learned. This section discusses these lessons using the following structure: Each lesson has a title, a description of the context, the challenge faced, and the actions taken to overcome it.

Identifying the Real Problems of Each Institution: Understanding the unique challenges institutions face is crucial to implementing data-driven solutions effectively. In many cases, institutions can not clearly understand their operational hurdles, leading to poorly defined goals and misallocated resources. To address this, it is recommended that in-depth diagnostic assessments be conducted before initiating any project. These assessments should focus on understanding institutional workflows, key performance indicators, and stakeholder expectations.

Collaboratively Constructing Strategic Questions to Be Addressed: One of the most significant challenges in evidence-based policy-making is defining actionable and strategic questions. These questions must be relevant, measurable, and aligned with the institution's goals. A collaborative approach involving all stakeholders, including policymakers, data scientists, and end-users, ensures that the questions address real needs. Facilitation workshops and iterative refinement processes are recommended to align these diverse perspectives.

Establishing a Pilot to Validate the Methodology Quickly: Large-scale projects often face risks associated with untested methodologies. Pilots serve as controlled environments to test assumptions, refine processes, and gather feedback. By implementing a pilot phase, organizations can identify potential bottlenecks or risks. It is advised to select a small, representative sample for the pilot to maximize its relevance and scalability.

Systematizing the Recording of New Strategic Questions: In dynamic environments, new challenges and opportunities continuously emerge. Without a systematic approach, these new strategic needs might go unnoticed or be poorly documented. Implementing a structured repository or a formal process for capturing and reviewing new strategic questions ensures that the organization can adapt its policies and strategies effectively over time.

Creating Automated Flows to Keep Data Products Updated: Data products often lose relevance if not updated regularly. Many institutions rely on manual processes, which are prone to delays and errors. Automating data Extraction, Transformation, and Loading (ETL) processes ensures that data products remain current and accurate. Institutions should invest in robust automation tools and ensure adequate training for their technical teams.

Promoting a Data Culture Within Institutions: Adopting data-driven methodologies requires more than technical tools; it demands a cultural shift. Many public institutions encounter resistance to change due to their lack of familiarity with data practices. Building a data culture involves continuous education, transparent communication, and promoting data-driven decision-making at all organizational levels.

Establishing Standards for System Integration: Fragmented systems often lead to inefficiencies and missed opportunities for holistic insights. Integration challenges are particularly acute in multi-agency environments where data interoperability is essential. Developing and enforcing standards for system integration can address these challenges. Such standards should include data formats, APIs, and security protocols to ensure seamless collaboration.

Defining Data Architectures Independent of Business Domains: Rigid architectures tied to specific business domains often limit scalability and adaptability. Designing modular and domain-agnostic data architectures enables institutions to reuse data and infrastructure for various applications. This approach facilitates integration with external systems and future-proofing against evolving organizational needs.

8. Final Remarks

The BEPP-DS methodology introduced in this paper integrates Data Science into creating Evidence-Based Public Policies, focusing on transparency, scalability, and efficiency. Drawing from real-world initiatives like Big Data Social and Big Data Fortaleza, the methodology tackles the distinct challenges of implementing data-driven solutions within the public sector. It provides a structured framework that guides every stage of developing data products—from identifying key strategic questions to delivering actionable insights—helping improve decision-making in governance.

The study's findings underscore the importance of collaborative problem definition, systematic testing through pilot projects, and embedding data-driven practices within institutions. Applying the BEPP-DS methodology demonstrated its effectiveness in overcoming common challenges public organizations face, such as fragmented data, limited data culture, and a lack of automated processes. It also enabled policymakers to prioritize and implement targeted interventions, promoting evidence-based solutions to address critical societal issues.

Future work should aim to enhance the BEPP-DS methodology by incorporating Artificial Intelligence and Machine Learning for predictive analytics and real-time decision-making. Another valuable direction is developing approaches to increase citizen participation, enabling stakeholders to contribute to data collection, validation, and policy evaluation. Additionally, efforts must address ethical and privacy concerns to ensure that data-driven governance adheres to fairness, accountability, and inclusive principles.

Acknowledgement

- **Funding or Grant**: This work was supported by the National Fund for Educational Development (FNDE) in partnership with the Federal University of Ceará (UFC).
- **Data/Software Access Statement**: The datasets used in this study were derived from government sources and are not publicly available due to privacy and confidentiality concerns. However, processed results and methodological insights can be requested from the corresponding author.
- **Contributor Statement**: Conceptualization and Methodology: José Antônio F. Macedo, Rossana Maria de Castro Andrade; Data Curation and Analysis: Regis P. Magalhães, Lívia A. Cruz, José Florêncio Q. Neto, Samir B. Chaves; Software Development: Davyson S. Ribeiro, Paulo V. A. Fabrício; Writing - Original Draft: Pedro Almir M. Oliveira, José Florêncio Q. Neto, Samir B. Chaves, Davyson S. Ribeiro; Writing - Review and Editing: Mauricio Feijo B. M. Filho, Joaquim José Escola, Amanda Sousa, Paulo V. A. Fabricio.
- **Use of AI**: During the preparation of this work, the authors used ChatGPT and Copilot to assist in drafting and refining some textual sections. After using these tools, the authors reviewed, edited, and validated the content to ensure accuracy and originality, taking full responsibility for the final publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest to declare.

References

Anderson, L. M., Brownson, R. C., Fullilove, M. T., Teutsch, S. M., Novick, L. F., Fielding, J., & Land, G. H. (2005). Evidence-based public health policy and practice: Promises and limits. *American journal of preventive medicine*, *28*(5), 226–230.

Batista, É., Andrade, R. M., Santos, I. S., Nogueira, T. P., Oliveira, P. A., Lelli, V., & Oliveira, V. T. (2024). Fortaleza city hall strategic planning based on data analysis and forecasting. *Congresso Ibero-Americano em Engenharia de Software (CIbSE)*, 433–436.

Furtado, L. S., Moura, G., Vasconcelos, D. J., Fernandes, G. S., Cruz, L. A., Magalhães, R. P., & Coelho da Silva, T. L. (2023). An analytical citizen relation management system (czrm) for social vulnerability mapping and policy recommendation in brazil. *Decision Support Systems*, *172*, 113995. DOI: https://doi.org/https://doi.org/10.1016/j.dss.2023.113995.

MacArthur, B. D., Dorobantu, C. L., & Margetts, H. Z. (2022). Resilient government requires data science reform. *Nature Human Behaviour*, *6*(8), 1035–1037.

Musafir, V. E. N. (2018). Brazilian e-government policy and implementation. *International E-Government Development: Policy, Implementation and Best Practice*, 155–186.

Pereira, G., Monteiro, I., Vasconcelos, D., Braz, L., & Silva, C. (2021). Classificação taxonômica de categorias de serviços públicos para aplicações digitais. *Anais do IX Workshop de Computação Aplicada em Governo Eletrônico*, 119–130. DOI: https://doi.org/10.5753/wcge.2021.15982.

Rahul, K., & Banyal, R. K. (2020). Data life cycle management in big data analytics. *Procedia Computer Science*, *173*, 364–371.

Saltelli, A., Bammer, G., Bruno, I., Charters, E., Di Fiore, M., Didier, E., Nelson Espeland, W., Kay, J., Lo Piano, S., Mayo, D., Pielke Jr, R., Portaluri, T., Porter, T. M., Puy, A., Rafols, I., Ravetz, J. R., Reinert, E., Sarewitz, D., Stark, P. B., … Vineis, P. (2020). Five ways to ensure that models serve society: A manifesto. *Nature*, *582*(7813), 482–484. DOI: https://doi.org/10.1038/d41586-020-01812-9.

Santos, I. S., Oliveira, P. A. M., Oliveira, V. T., Nogueira, T. P., Dantas, A. B. O., Menescal, L. M., Batista, É., & Andrade, R. M. C. (2023). Big Data Fortaleza: Plataforma Inteligente para Políticas Públicas Baseadas em Evidências. *Workshop de Computação Aplicada em Governo Eletrônico (WCGE)*, 200–211. DOI: https://doi.org/10.5753/wcge.2023.230796.

Schröer, C., Kruse, F., & Gómez, J. M. (2021). A systematic literature review on applying crisp-dm process model [CENTERIS 2020 - International Conference on ENTERprise Information Systems / ProjMAN 2020 - International Conference on Project MANagement / HCist 2020 - International Conference on Health and Social Care Information Systems and Technologies 2020, CENTERIS/ProjMAN/HCist 2020]. *Procedia Computer Science*, *181*, 526–534. DOI: https://doi.org/https://doi.org/10.1016/j.procs.2021.01.199.

Silcock, R. (2001). What is e-government. *Parliamentary affairs*, *54*(1), 88–101.

Silva, W. C. P., Macedo, J. A. F. D., & De Queiroz Neto, J. F. (2022). Usando um modelo de classificação para a adequada implantação do patrulhamento policial para o enfrentamento à assaltos a bancos no nordeste do Brasil. *Revista Brasileira de Ciências Policiais*, *13*(9), 185–205. DOI: https://doi.org/10.31412/rbcp.v13i9.845.

Sucupira Furtado, L., Da Silva, T. L. C., Ferreira, M. G. F., De Macedo, J. A. F., & De Melo Lima Cavalcanti Moreira, J. K. (2023a). A framework for Digital Transformation towards Smart Governance: Using big data tools to target SDGs in Ceará, Brazil. *Journal of Urban Management*, *12*(1), 74–87. DOI: https://doi.org/10.1016/j.jum.2023.01.003.

Sucupira Furtado, L., da Silva, T. L. C., Ferreira, M. G. F., de Macedo, J. A. F., & de Melo Lima Cavalcanti Moreira, J. K. (2023b). A framework for digital transformation towards smart governance: Using big data tools to target sdgs in ceará, brazil [Digital Technologies in Urban Planning and Urban Management]. *Journal of Urban Management*, *12*(1), 74–87. DOI: https://doi.org/https://doi.org/10.1016/j.jum.2023.01.003.

Van Der Aalst, W., & van der Aalst, W. (2016). *Data science in action*. Springer.

Developing the Strategic and Master Plan for Information and Communication Technology at the IT Agency of the State of Tocantins

Vanessa Tavares Nunes [a*], *Claudia* Cappelli [b], *Cristiane* Oliveira[c]

[a] Institute of Technology and Leadership (Inteli), São Paulo, Brazil, vanunes@gmail.com, 0000-0002-5043-0207.

[b] State University of Rio de Janeiro, Rio de Janeiro,-Brazil, claudia.cappelli@gmail.com , 0000-0003-1699-3492

[c]Information Technology Agency of the State of Tocantins (ATI/TO), Palmas, Brazil, crpoliveira@gmail.com, 0009-0005-8611-3093.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. The rapid evolution of digital governance necessitates strategic planning to ensure efficiency, transparency, and adaptability in public service delivery. This paper presents the development of the Strategic and Master Plan for Information and Communication Technology (PEDTIC) at the Tocantins State Information Technology Agency (ATI/TO), a pivotal initiative aimed at strengthening digital transformation efforts in Tocantins, Brazil. The PEDTIC was built upon three foundational diagnostic assessments: the Governance of ICT, the Strategic IT Plan (PDTI), and the ABEP-TIC Index evaluation. These diagnostics provided a comprehensive analysis of ATI/TO's digital service capabilities, governance structures, and alignment with state objectives. The methodological approach combined situational assessments, regulatory reviews, management interviews, and benchmarking against national best practices. The findings highlighted gaps in IT governance, data integration, and digital service effectiveness. By aligning ATI/TO's strategic vision with the broader objectives of the Tocantins government, the PEDTIC establishes a framework that prioritizes structured governance, risk management, and the enhancement of public digital services. This study discusses the lessons learned from the diagnostic phase, emphasizing the importance of clear communication, cross-department collaboration, and proactive risk management in digital transformation. The PEDTIC provides a structured action plan with clearly defined objectives, performance indicators, and accountability mechanisms to ensure continuous improvement and adaptation. The results of this initiative have already led to a significant improvement in ATI/TO's ranking in the ABEP-TIC Index, demonstrating tangible progress in digital governance. Additionally, this paper explores the implications of ATI/TO's transformation towards a more strategic operational model, shifting from purely technical functions to a leadership role in state digital governance. The conclusions drawn highlight the critical need for structured digital strategies, ongoing capacity-building initiatives, and stakeholder engagement to sustain long-term advancements in public digital services. The PEDTIC serves as a case study for other government institutions aiming to implement structured and scalable digital transformation initiatives.

Keywords. Digital Governance, IT Strategic Planning, Government Digital Transformation, Public Sector Innovation, ICT Governance, PEDTIC, ABEP-TIC Index.
Short case practical report, DOI: https://doi.org/10.59490/dgo.2025.1066

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1. Introduction

In the face of rapid technological advancements, the public sector must undergo significant digital transformation to meet the evolving expectations of citizens. This transformation is critical for embracing public and digital governance (Kitsios et al., 2023), where efficiency, transparency, and accessibility are paramount. The Tocantins State Information Technology Agency (ATI/TO) plays a crucial role in this transformation within the state of Tocantins, Brazil. The agency's efforts culminated in the development of the Strategic and Master Plan for Information and Communication Technology (PEDTIC), which serves as a comprehensive framework to guide the agency's digital initiatives.

The foundation for the PEDTIC was established through three diagnostic documents: the Governance of ICT, the Strategic IT Plan (PDTI), and the assessment of the ABEP-TIC Index. These documents provided a detailed analysis of ATI/TO's current state regarding digital transformation, IT governance, and alignment with the state's strategic objectives. The diagnostics involved a thorough review of existing regulations, interviews with management, and benchmarking against best practices from other states, highlighting both the strengths and areas needing improvement in the agency's digital service delivery.

The project aimed to identify the needs, challenges, and opportunities for ATI/TO, ultimately leading to the creation of a robust action plan to enhance its digital capabilities. The results from the diagnostic assessments revealed critical gaps in service delivery, integration of digital solutions, and data governance practices, which are essential for enhancing public service efficiency. Furthermore, by analysing the agency's performance against the ABEP-TIC Index, the diagnostics pinpointed specific areas for growth and improvement.

The lessons learned from this comprehensive diagnostic process are invaluable, providing insights into effective strategies for navigating the complexities of digital transformation in the public sector. The PEDTIC outlines clear actions, goals, and responsibilities, positioning ATI/TO to adapt and thrive in an increasingly digital landscape.

This introduction frames the importance of digital transformation in public governance, sets the context for the challenges faced by ATI/TO, and underscores the significance of the PEDTIC as a strategic response to these challenges. The subsequent sections will delve into the specific methodologies employed in the diagnostics, the findings that informed the PEDTIC, and the actionable strategies that will guide ATI/TO in achieving its digital transformation goals.

2. Context

In this section, we outline the methodology that was employed to assess the Tocantins State Information Technology Agency (ATI/TO) and develop the Strategic and Master Plan for Information and Communication Technology (PEDTIC).

The approach consisted of four key steps presented in the following four sections: the first (Section 3.1) focuses on a situational assessment of digital service delivery at ATI/TO, highlighting strengths, weaknesses, and areas for improvement. The second (Section 3.2) evaluates the existing IT governance practices, emphasizing the need for enhanced frameworks to align IT strategies with the state's broader objectives. Section 3.1 benchmarks ATI/TO against best practices from other states and organizations, providing insights into successful digital transformation strategies. Finally, Section 3.4 details the development of the PEDTIC, which presents a comprehensive action plan with defined goals and responsibilities aimed at guiding ATI/TO in its digital transformation efforts. Together, these sections provide a cohesive view of the main assessment processes and the strategic planning necessary for effective public sector digital transformation.

The methodology and findings presented in the subsequent sections align closely with the seven dimensions of ICT readiness assessment proposed in Alghamdi et. al. (2011), providing a structured approach to evaluating and enhancing ATI/TO's digital transformation efforts. In this paper, the authors define organizational requirements that are necessary for the adoption of e-government to resolve the delay of ICT readiness in public sector organizations in developing countries.

The situational assessment of digital service delivery (Section 3.1) corresponds to the user access and ICT infrastructure dimensions, as it evaluates the agency's ability to deliver accessible and efficient digital services while identifying gaps in technological capabilities. The assessment of IT governance practices (Section 3.2) addresses the e-government organizational ICT strategy and business process and information systems dimensions, emphasizing the need for alignment between IT strategies and state objectives, as well as the importance of process reengineering and interdepartmental collaboration. The benchmarking against best practices (Section 3.3) reflects the e-government program dimension, ensuring that ATI/TO adopts proven strategies for digital transformation. Finally, the development of the PEDTIC (Section 3.4) integrates all seven dimensions by providing a strategic roadmap that encompasses ICT architecture, human resources, and risk

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

management, in a holistic approach to achieving organizational ICT readiness.

3. Approach

In this section, we outline the methodology that was employed to assess the Tocantins State Information Technology Agency (ATI/TO) and develop the Strategic and Master Plan for Information and Communication Technology (PEDTIC).

The approach consisted of four key steps presented in the following four sections: the first (Section 3.1) focuses on a situational assessment of digital service delivery at ATI/TO, highlighting strengths, weaknesses, and areas for improvement. The second (Section 3.2) evaluates the existing IT governance practices, emphasizing the need for enhanced frameworks to align IT strategies with the state's broader objectives. Section 3.1 benchmarks ATI/TO against best practices from other states and organizations, providing insights into successful digital transformation strategies. Finally, Section 3.4 details the development of the PEDTIC, which presents a comprehensive action plan with defined goals and responsibilities aimed at guiding ATI/TO in its digital transformation efforts. Together, these sections provide a cohesive view of the main assessment processes and the strategic planning necessary for effective public sector digital transformation.

The methodology and findings presented in the subsequent sections align closely with the seven dimensions of ICT readiness assessment proposed in Alghamdi et. al. (2011), providing a structured approach to evaluating and enhancing ATI/TO's digital transformation efforts. In this paper, the authors define organizational requirements that are necessary for the adoption of e-government to resolve the delay of ICT readiness in public sector organizations in developing countries.

The situational assessment of digital service delivery (Section 3.1) corresponds to the user access and ICT infrastructure dimensions, as it evaluates the agency's ability to deliver accessible and efficient digital services while identifying gaps in technological capabilities. The assessment of IT governance practices (Section 3.2) addresses the e-government organizational ICT strategy and business process and information systems dimensions, emphasizing the need for alignment between IT strategies and state objectives, as well as the importance of process reengineering and interdepartmental collaboration. The benchmarking against best practices (Section 3.3) reflects the e-government program dimension, ensuring that ATI/TO adopts proven strategies for digital transformation. Finally, the development of the PEDTIC (Section 3.4) integrates all seven dimensions by providing a strategic roadmap that encompasses ICT architecture, human resources, and risk management, in a holistic approach to achieving organizational ICT readiness.

3.1 Diagnosis - Situational Assessment of Digital Service Delivery at ATI/TO

The Situational Assessment of Digital Service Delivery at ATI/TO (in Portuguese: "Diagnóstico Situacional sobre Índice ABEP-TIC na ATI/TO") evaluates the current state of digital services offered by the Tocantins State Information Technology Agency (ATI/TO) as assessed by the ABEP-TIC Index (https://abep-tic.org.br/pesquisa-indice-abep-tic/). This diagnostic, applicable to all Brazilian states, focuses on the agency's capabilities in delivering digital public services and highlights key strengths and weaknesses in its operations.

Structured around the ABEP-TIC Index methodology, which consists of 35 criteria divided into three dimensions—Digital Service Offering Capabilities, Digital Service Delivery, and Regulatory Framework for Modernization—this assessment identified the effectiveness and efficiency of services provided. Following improvement actions between annual assessments, Tocantins State improved its ranking from 19th in 2023 to 9th in 2024.

Key findings indicate significant gaps in the implementation of digital services, which hinder the agency's ability to meet growing citizen demands for accessible public services. The assessment also underscores the need for better integration among various digital platforms to enhance user experience.

This assessment was important for aligning ATI/TO's strategies with the state's digital transformation objectives, serving as a foundational document for developing targeted strategies to enhance the agency's performance and service quality.

3.2 Diagnosis - Situational Assessment for the Development of the PEDTIC at ATI/TO

The Situational Assessment for the Development of the PEDTIC at ATI/TO (in Portuguese: "Diagnóstico Situacional para Elaboração do PDTIC da ATI/TO") analyzed current IT practices and governance frameworks within the agency. This assessment identified strengths, weaknesses, and opportunities, including benchmarking against other states to adopt successful strategies.

The evaluation emphasized the alignment of ATI/TO's IT practices with state objectives and the need for a cohesive

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

technology management approach. Key insights reveal that while a foundation for IT governance exists, improvements are necessary in communication and collaboration among departments, as silos limit information sharing and efficiency. Enhancing interdepartmental communication can facilitate a more integrated approach to service delivery and ensure that all teams are aligned with the agency's strategic objectives.

The assessment also highlighted the need for a structured framework for performance measurement and accountability, recommending the implementation of robust Key Performance Indicators (KPIs) for better tracking and decision-making. Ongoing training and capacity-building initiatives are essential for staff to adapt to rapidly changing technologies. Establishing a continuous professional development program may empower employees, enhance their competencies, and therefore improve the agency's ability to respond to the demands of digital transformation.

This assessment goes directly into the need for the development of the PEDTIC, providing a framework for actionable strategies to strengthen governance and enhance the agency's effectiveness in supporting digital transformation objectives. An Action Plan was formulated to address identified improvements, serving as a roadmap for necessary changes in digital service delivery and IT governance. Each objective within the plan is accompanied by specific actions, timelines, and assigned responsibilities to ensure accountability and facilitate effective progress tracking.

3.3 Diagnosis - Situational Assessment for IT Governance and Digital Government Strategy at ATI/TO

The Situational Assessment for IT Governance and Digital Government Strategy at ATI/TO (in Portuguese: "Diagnóstico Situacional para Governança de TI e a Estratégia de Governo Digital da ATI/TO") analyzed the current IT governance practices and strategic framework for digital government within the agency. This assessment identified strengths, weaknesses, and opportunities related to governance and alignment with broader digital transformation objectives.

The evaluation highlighted the importance of a robust governance structure to support digital initiatives. It examined current governance mechanisms, decision-making processes, and policies promoting transparency and efficiency. Key findings indicate that while progress has been made, improvements are needed in defining roles and enhancing stakeholder collaboration, which complies with the previous two Diagnostics.

The assessment also emphasized the need for a comprehensive risk management approach and compliance with regulations. Establishing a structured risk management framework will help ATI/TO proactively address challenges, ensuring alignment with state and federal guidelines. Fostering a culture of innovation and continuous improvement is also determinant for success, with ongoing training enhancing staff adaptability and skills.

This assessment serves as an important input for developing a cohesive IT governance framework and digital government strategy. It offered actionable insights and recommendations to strengthen governance practices and align digital initiatives with state objectives.

3.4 PEDTIC Development

The Strategic and Master Plan for Information and Communication Technology (PEDTIC) at ATI/TO is a framework that synthesizes the insights gained from the three situational assessments conducted. These diagnostics have highlighted the agency's strengths, weaknesses, and opportunities in the realms of digital service delivery, IT governance, and digital government strategy. By leveraging the findings from these assessments, the PEDTIC aims to create a comprehensive roadmap that aligns with the strategic objectives of the state and enhances the effectiveness of digital public services.

Creating a PEDTIC, as opposed to a traditional PDTI (Plano Diretor de Tecnologia da Informação), was chosen for several reasons. Firstly, the PEDTIC emphasizes a strategic approach that integrates both the operational and strategic dimensions of ICT, ensuring that technology initiatives are closely aligned with the overall goals of the organization and the needs of citizens. A comprehensive strategic plan like the PEDTIC facilitates a more proactive approach to technology management, enabling organizations to effectively anticipate future challenges and opportunities. Secondly, the PEDTIC encompasses a broader scope, addressing not only the technical aspects of IT governance but also the organizational, cultural, and societal dimensions of digital transformation. This holistic perspective highlights the importance of understanding the interplay between technology, people, and processes within the context of public service delivery.

ATI/TO PEDTIC is organized into sections, each designed to provide a comprehensive understanding of the agency's strategic direction and initiatives.

Strategic Diagnosis: It provides a comprehensive analysis of the current state of the Tocantins State Information

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Technology Agency (ATI/TO). This analysis includes a SWOT analysis, generated based on the three previous Diagnostics, allowing the agency to understand its strategic positioning. The diagnosis reveals critical areas needing improvement, such as the integration of digital services and communication between departments. Additionally, it identifies strategic objectives that ATI/TO should pursue and offers practical recommendations to strengthen governance and enhance the delivery of digital services to citizens.

Strategic References: It establishes the guidelines that will direct ATI/TO in its initiatives and objectives. This section defines the agency's mission, which is to modernize public services through information technology, and its vision, which describes its aspiration to become a leader in digital governance. Furthermore, it presents the core values that will guide the agency's operations, such as transparency and innovation. The framework also includes strategic guidelines to ensure that all decisions and actions of ATI/TO are aligned with its mission and vision, promoting a collaborative and results-oriented work environment.

Strategic Objectives: It outlines the key goals that ATI/TO aims to achieve as part of its strategic planning. These objectives were designed to enhance the agency's capacity to deliver effective digital services and improve overall governance. Each objective is aligned with the findings from the situational assessments and emphasizes critical areas such as digital service modernization, data security, and stakeholder engagement. The section provides a clear framework for prioritizing initiatives that will drive the agency's digital transformation efforts, ensuring that all actions taken are focused on meeting the needs of citizens and enhancing public service delivery. We used the Balanced Scorecard methodology, but we adapted for public organizations.

Action Plan, Goals, and Responsibilities: It details the specific initiatives and actions that ATI/TO will undertake to achieve its strategic objectives. This section outlines measurable goals for each initiative, providing timelines and assigning responsibilities to ensure accountability (see an example in Figure 1). It emphasizes the importance of cross-departmental collaboration and sets forth a roadmap for implementing changes that will enhance digital service delivery and governance practices. By clearly defining actions, timelines, and responsible parties, this section ensures that the agency can effectively track progress and make data-driven decisions to adapt its strategies as needed, ultimately improving the quality of services offered to the citizens of Tocantins.

6.2.3. Systems Integration

KEY OUTCOME

- Make 100% of services available in the interoperability solution within 4 years..

FORMULA FOR CALCULATING THE KEY OUTCOME

- (Quantity of services available in the interoperability solution) / (Quantity of services that can be interoperated) * 100

SOURCE OF INFORMATION

- It is necessary to inventory the number of services that can be interoperated.

STRATEGIC ACTION	RESPONSIBLE	GOALS			
		Year 1	Year 2	Year 3	Year o 4
Update the inventory of government systems	Directorate of Training and System Implementation	80%	20%	-	-
Define eligible systems and information domain areas for integration	Directorate of Training and System Implementation	50%	30%	20%	-
Conduct a survey of interoperability requirements	Directorate of Information Systems	30%	70%	-	-
Implement the interoperability solution	Directorate of Information Systems	10%	30%	30%	30%

Fig. 1 - BSC Internal Processes - Systems Integration.

Risk Management Plan: It outlines the strategies and processes that ATI/TO will implement to identify, assess, and mitigate potential risks associated with its digital initiatives and operations. It begins by identifying various types of risks, including operational, technical, and compliance-related risks, and assesses their potential impact and likelihood of occurrence (see Figure 2 and Figure 3). It emphasizes the importance of establishing a structured risk management framework that enables continuous monitoring and evaluation of risks. The plan includes specific mitigation strategies for each identified risk, detailing the actions that will be taken to minimize their

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

impact. Additionally, it assigns responsibilities for risk management tasks to appropriate personnel within the agency, ensuring accountability and effective oversight. By implementing this Risk Management Plan, ATI/TO aims to foster a culture of risk awareness and resilience, enhancing its ability to achieve its strategic objectives and deliver high-quality public services to citizens.

Risk Probability and Impact Matrix		IMPACT			
		Very High	High	Medium	Low
PROBABILITY	Possível	***HIGH RISK*** - Occurrence of a large-scale cyber attack that results in the interruption of systems and services	**MODERATE RISK** - Inadequate or insufficient technological infrastructure - Ineffective strategic planning	***MODERATE RISK*** - Acquisitions or procurements not completed in a timely manner	***LOW RISK*** - Ineffectiveness in communication with other areas and other agencies
	Improvável	**MODERATE RISK** - Unavailability of services due to the use of outdated technology	***MODERATE RISK***	***LOW RISK***	***LOW RISK***

Fig. 2 - Risk matrix.

7.2.8 Risk: Occurrence of a large-scale cyber attack that results in the interruption of systems and services

Risk Probability: Possible

Risk Impact: Very High

Mitigation Plan:

- Acquisition and procurement of security equipment and services
- Conducting penetration tests periodically
- Raising awareness among staff in the use of the corporate environment

Fig. 3 - Risk Description.

Monitoring and Evaluation Plan: It outlines the framework that ATI/TO will use to assess the effectiveness and impact of its initiatives and strategies outlined in the PEDTIC. This plan is important for ensuring that the agency remains accountable and can adapt its actions based on performance data and feedback. It establishes clear metrics and key performance indicators (KPIs) that will be used to evaluate progress toward achieving the strategic objectives. It details the processes for regular monitoring, including the frequency of evaluations and the methods that will be employed to collect data. It emphasizes the importance of involving stakeholders in the evaluation process to gather diverse perspectives and insights. Additionally, the plan outlines how the findings from monitoring activities will be communicated to relevant parties, ensuring transparency and fostering a culture of continuous improvement.

By implementing this Monitoring and Evaluation Plan, ATI/TO aims to create a dynamic feedback loop that informs decision-making, enhances operational effectiveness, and ultimately improves the quality of digital services provided to the citizens of Tocantins. This proactive approach allows the agency to make necessary adjustments to its strategies in response to changing needs and circumstances, ensuring that it remains aligned with its mission and objectives.

4. Results and Lessons Learned

The initiatives developed under the PEDTIC framework have significantly increased visibility regarding the necessary demands within the agency, fostering a deeper understanding among all stakeholders involved. By providing a clear and organized path forward, the PEDTIC has laid the groundwork for transitioning ATI/TO from operational tasks to a more strategic focus. This shift is fundamental for discussing the transformation of ATI/TO into a public enterprise, which is expected to enhance the dynamism and efficiency in executing necessary actions

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and initiatives. Furthermore, positioning itself strategically allows ATI/TO to be perceived differently within the State, among peer institutions, and in relation to the State Government. These early results demonstrate the potential for more streamlined processes and improved governance, setting the stage for future advancements in digital service delivery.

Additionally, by aligning its initiatives with themes related to Digital Transformation, by including challenges and opportunities in the public sector, ATI/TO is strategically positioned to foster future participation as a key entity in the long-term, medium-term, and short-term Government Plans. This alignment not only enhances the agency's relevance but also ensures that it plays a critical role in shaping policies and initiatives that drive technological advancement and improve public service delivery.

In approaching the seven dimensions proposed by Alghamdi et al. (2011), the methodology for assessing ATI/TO and developing the PEDTIC was designed to address both technical and human factors. The "e-government organizational ICT strategy" was evaluated through the situational assessments, which identified gaps in IT governance and the need for alignment with state objectives, leading to the formulation of a cohesive strategic framework in the PEDTIC. "User access" was analyzed in the ABEP-TIC Index assessment, which highlighted the need for better integration of digital platforms to enhance service delivery and user experience. The "e-government program" dimension was addressed by benchmarking ATI/TO against best practices from other states, ensuring that the agency's initiatives align with successful digital transformation strategies. "ICT architecture" was considered through the evaluation of existing IT infrastructure and the recommendation of scalable, interoperable solutions in the PEDTIC. "Business process and information systems" were examined in the situational assessments, which emphasized the need for process reengineering and improved interdepartmental collaboration. "ICT infrastructure" was a focal point in the PEDTIC, with specific recommendations for enhancing hardware, software, and connectivity to support digital services. Finally, the "human resources" dimension was addressed through the identification of training needs and capacity-building initiatives to ensure that staff are equipped to support the agency's digital transformation efforts.

Although the implementation of the PEDTIC is still in progress, some important lessons have already emerged. First, the importance of clear communication and collaboration among departments has been underscored, as breaking down silos is essential for fostering a cohesive working environment. Establishing regular interdepartmental meetings and communication channels will be vital in maintaining this collaborative spirit moving forward. Second, the need for adaptability has become increasingly evident. As ATI/TO navigates the complexities of digital transformation, remaining flexible and responsive to new challenges will be essential. Continuous training and capacity-building initiatives for staff will be necessary to equip employees with the skills needed to embrace these changes effectively.

Lastly, engaging stakeholders, including citizens and other governmental entities, has proven determinant for the success of digital initiatives. Actively seeking feedback and involving stakeholders in the decision-making process will enhance the relevance and effectiveness of the services provided.

5. Conclusion

The implementation of the PEDTIC framework represents a significant step forward for ATI/TO in its journey towards enhanced digital transformation and IT strategic governance. The early outcomes have demonstrated the agency's ability to increase visibility regarding necessary demands, foster collaboration among stakeholders, and establish a clear path for transitioning from operational tasks to a more strategic focus.

There is a clear necessity to implement the recommendations outlined in the diagnostics, which emphasize the development and application of a comprehensive digital government strategy, improvement in the ABEP-TIC Index results, and the effective execution of the PEDTIC. By addressing these key aspects, ATI/TO aims not only to rectify existing gaps but also to establish a resilient and agile framework capable of responding to future challenges in the digital landscape.

As ATI/TO positions itself as a key player in the public sector, aligning its initiatives with themes of Digital Transformation will not only enhance its relevance but also enable it to participate actively in shaping future Government Plans. The insights gained from this process underscore the importance of clear communication, adaptability, and stakeholder engagement, which are essential for navigating the complexities of digital advancement.

Moving forward, ATI/TO is well-equipped to leverage these lessons learned to foster continuous improvement in its service delivery and governance practices. By maintaining a proactive approach and embracing the opportunities presented by digital transformation, ATI/TO can significantly enhance its contributions to the State of Tocantins, ultimately benefiting its citizens and ensuring a more efficient and effective public service. With this vision and political openness, PEDTIC has been approved in its totality and its implementation is programmed to

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

already fully start in 2025.

Contributor Statement

All of the authors were professionals that developed this project.

Use of AI

During the preparation of this work, the authors used chatgpt and Claude to proofread in order to ensure the readability of the text. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest

References

Alghamdi, I.A., Goodwin, R. & Rampersad, G. (2011). E-Government Readiness Assessment for Government Organizations in Developing Countries. *Computer and Information Science*, 4(3).

Kitsios, F., Kamariotou, M., & Mavromatis, A. (2023). Drivers and Outcomes of Digital Transformation: The Case of Public Sector Services. *Information*, 14, 43. https://doi.org/10.3390/info14010043

Sharma, A. (2011). IT in Governance in the 21st Century. IT Prof., 13, 7-9.

Wu, S.P-J., Straub, D.W., & Liang, L-P. (2015). How Information Technology Governance Mechanisms and Strategic Alignment Influence Organizational Performance. *MIS Quarterly*, 39(2), 497-512.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital technologies and partnerships for Sustainable Development Goals: A document analysis.

Beatriz Ventorini Lins de Albuquerque [a*], *Sean* Wolfgand Matsui Siqueira [b], *Paulo Sérgio* Medeiros dos Santos [c].

[a] Programa de Pós-graduação em Informática, Universidade Federal do Estado do Rio de Janeiro e Petrobras, Rio de Janeiro, Brasil. beatriz.ventorini@edu.unirio.br, ORCID 0009-0009-9245-2234.

[b] Programa de Pós-graduação em Informática, Universidade Federal do Estado do Rio de Janeiro, Rio de Janeiro, Brasil, sean@uniriotec.br, ORCID 0000-0002-0864-2396.

[c] Programa de Pós-graduação em Informática, Universidade Federal do Estado do Rio de Janeiro, Rio de Janeiro, Brasil, pasemes@uniriotec.br, ORCID 0000-0001-9502-1362.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Digital governance is a central concern in global efforts to achieve the Sustainable Development Goals (SDGs). The United Nations (UN) emphasizes the potential of digital technologies and technological partnerships to address global challenges, while governments struggle to develop technology governance policies at a pace that keeps up with technological advancements. Problem: despite growing recognition of digital technologies and technological partnerships as key enablers of sustainable development, there is limited understanding of how they could be more effectively leveraged by governmental and non-governmental organizations to advance the SDGs. Approach: This study examines how the UN envisions the role of digital technologies and technological partnerships in advancing the SDGs and analyses these findings through the lens of Social Innovation Ecosystems (SIEs). Methods: A qualitative document analysis was conducted on six official UN documents (2022–2024) addressing digital technologies and technological partnerships in the SDGs context. Thematic and reflexive analysis was applied with iterative coding. Main results: Findings highlight priority issues such as AI regulation for child protection, ethical and inclusive AI governance, counterterrorism, and efforts to reduce digital inequality. Four thematic categories were generated, and analysis also reveals a dual focus: centralized governance and stringent regulation of emerging technologies — particularly AI — alongside a call for international cooperation, ecosystem-like partnerships, public digital goods, and open models. Conclusions: Some UN priorities present tensions, as strict governance structures may hinder the agility required for open collaboration, and vice versa. SIEs approach may offer a potential balance, enabling governments, corporations, academia, and civil society to co-create solutions, share resources, and scale social innovations while ensuring technological development and adoption aligns with human rights, digital equity, and the SDGs.

Keywords. United Nations, Sustainable Development Goals, Digital Technologies, Technological Partnerships, Governmental Partnerships, Social Innovation Ecosystems, Document Analysis.
Short case practical report, DOI: https://doi.org/10.59490/dgo.2025.1004

1. Introduction

On September 22, 2024, during the United Nations Summit of the Future, global leaders endorsed the Pact for the Future — a comprehensive agreement emphasizing digital governance as critical to tackling global challenges. A core element of this pact, the Global Digital Compact, underscores the strategic role of technology in fostering international cooperation and represents a commitment to digital governance and equitable, ethical digital development that benefits the whole society. The Pact recognizes science, technology, and innovation as key drivers of progress toward the Sustainable Development Goals (SDGs), stressing the need for cross-sector

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

partnerships to shape an inclusive, equitable, and sustainable future (United Nations, 2024). High innovation performance is essential for solving complex social problems and accelerating sustainable development (Lu & Wang, 2024). Social Innovation Ecosystems (SIEs) offer a promising model for organizing multi-actor collaboration (Ho & Yoon, 2022; Bucio-Mendoza & Solis-Navarrete, 2024). Digital technologies serve as enablers of innovation (Chueri et al., 2020; Soni et al., 2021; Ho & Yoon, 2022; Hu, Phillips & Wu, 2024), helping organizations scale solutions effectively. Given resource constraints across sectors, technological partnerships between governments, businesses, academia, and civil society are essential for knowledge sharing and resource mobilization (Parthasarathy, Dey & Gupta, 2021; Pinheiro, Chueri & Santos, 2021; Slitine, 2024). SIEs offer a structured yet adaptable environment well-suited to this collaborative approach (Lyulyoy et al., 2024).

Although digital technologies and partnerships are increasingly seen as essential to sustainable development, their effective use by public and private organizations to advance the SDGs remains underexplored. In November 2024, we conducted a systematic mapping study (Albuquerque & Siqueira, 2025) to examine the use of digital technologies in SIEs and compare them to the UN's technological priorities. Few studies offered detailed empirical insights, and most indicated low adoption, reinforcing the need to better understand how to design, integrate, and scale digital solutions in SIEs. Building on these findings, this study investigates how the UN approaches digital technologies and partnerships within the SDG context, exploring the alignment between governance, innovation strategies, and social impact. Such understanding may offer strategic guidance to strengthen cross-sector collaboration and ensure that technological progress supports global sustainable development.

The general objective is to investigate the UN's approach to the use of digital technologies and the formation of governmental and non-governmental technological partnerships to advance the SDGs. The specific objectives are:

- Identify UN's documents that address digital technologies or technological partnerships in SDGs context;
- Extract and analyze excerpts from these documents that mention the development, adoption, and/or use of digital technologies and/or technological partnerships;
- Characterize the UN's approach to digital technologies and technological partnerships;
- Identify priority and/or sensitive topics for the development, adoption, and/or use of digital technologies and/or for technological partnership articulation in the SDGs context;
- Analize the results in light of the Social Innovation Ecosystems approach.

To achieve the proposed objectives, the research questions (RQs) presented in Table 1 were defined.

Tab. 1 – Research questions.

ID	Question	Topic
RQ1	What is the UN's approach to the development, adoption, and/or use of digital technologies in the SDGs context?	The UN's approach to digital technologies in the SDGs context
RQ2	What is the UN's approach to governmental and/or non-governmental technological partnerships in the SDGs context?	The UN's approach to technological partnerships in the SDGs context
RQ3	What topics are presented as priority and/or sensitive issues for accelerating progress toward the SDGs?	Priority and sensitive topics

No studies were found that directly address the topics proposed in the RQs. However, some works explore indirectly related topics. For example, Chueri et al. (2020) conducted an in-depth study on real social innovation ecosystems in Brazil, examining digital platforms for coordination and collaboration, addressing economic and social aspects, though without explicit reference to the SDGs. Chaudhuri et al. (2024) investigated the role of Industry 4.0 technologies in fostering data-driven organizational culture and improving performance and innovation. However, their focus lies on competitive advantage in traditional organizations rather than social innovation. Wamba et al. (2021) conducted a literature review on artificial intelligence (AI) for social goals, exploring how AI research can support technology-driven social change and the creation of a "good AI society." Still, their scope is limited to AI, excluding partnerships or other technologies. These studies offer valuable insights but do not address the specific gap targeted in this research.

1.1 Conceptual foundations

The SDGs comprise 17 objectives outlined in the 2030 Agenda (United Nations, 2015), a plan of action adopted by the UN in 2015 as a universal call to eradicate poverty, protect the planet, and ensure peace and prosperity for all by 2030. Their implementation is driven by a Global Partnership for Sustainable Development, emphasizing solidarity and prioritizing the needs of the most vulnerable, with the engagement of all countries, stakeholders, and individuals. The interconnected and integrated nature of the SDGs is essential for achieving the Agenda's goals. According to the UN, fulfilling the SDGs requires effective use of technology and strong national innovation

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

capacities. This involves enhancing technological capabilities in developing countries and coordinating actors engaged in social innovation (United Nations, 2024). The United Nations Trade and Development (UNCTAD), the UN's focal point for Science, Technology, and Innovation (STI), aims to boost STI capacities in developing countries and support their integration into national development strategies. This helps countries leverage STI for progress, job creation, and sustainable development (United Nations Economic and Social Council, 2024; United Nations Trade and Development, 2023). UNCTAD emphasizes the potential of frontier technologies — emerging technologies with high impact and growth potential that benefit from digitalization and connectivity. While these technologies can accelerate sustainable development, they also pose risks such as rising inequality, job displacement, and ethical concerns (United Nations Trade and Development, 2023). UNCTAD's reports recommend actions to maximize benefits and mitigate risks, and stress the importance of international cooperation to treat such technologies as global public goods. Its latest Innovation and Technology Report (United Nations Trade and Development, 2023) highlights 17 frontier technologies essential for achieving the SDGs, including eight digital ones: AI, internet of things (IoT), big data, blockchain, 5G, 3D printing, robotics, and drones. UNCTAD notes that many of these are still largely inaccessible in developing regions, reinforcing its mission to strengthen their technological capacities (United Nations, 2024).

Social innovation could be defined as a novel process or solution that addresses a social issue more effectively, efficiently, sustainably, or equitably than existing alternatives, delivering value primarily to society rather than individuals (Phills Jr. et al., 2008; Beckman et al., 2023). The concept of Social Innovation Ecosystems (SIEs) captures the dynamics of such innovations through various ecosystem configurations. Typically, definitions describe the creation and diffusion of social innovations as distributed, co-produced processes. These ecosystems, formed by networks of actors, are vital for supporting innovative social initiatives and fostering new societal relationships. Pel et al. (2019) propose a relational framework with three empowerment dimensions in SIEs: local embedding, referring to rootedness in specific regions; translocal connectivity, the linking of diverse contexts to amplify impact; and discursive resonance, the legitimization of concepts through shared narratives that grant political and scientific authority. These dimensions operate at various intensities and scales, addressing both local and broader needs, and promoting more integrated and effective social innovation.

Besides this introduction section, this paper is organized as follows: Section 2 presents the research methods; Section 3 presents the results; Section 4 presents the discussion; and Section 5 presents the conclusion with final considerations.

2. Research Methods

This study adopts document analysis, a method suitable for accessing data that would otherwise be difficult or impossible to obtain. It involves extracting and analyzing data from various types of documents, including books, journals, institutional reports and photographs (Morgan, 2022). According to Morgan's (2022) classification, the approach here is qualitative, aiming to interpret how the UN, as an institutional actor, frames the role of technologies and partnerships in advancing the SDGs. It is also descriptive, as it focuses on identifying explicit meanings in the documents, rather than latent ones.

2.1 Document Selection Strategy

The analyzed documents were official UN documents, in English, issued by the General Assembly and select technical or advisory bodies, explicitly addressing digital technologies or technological partnerships for advancing the SDGs. Documents were retrieved from the official UN's website (https://www.un.org). Document selection, data collection and extraction were conducted in November and December 2024. Inclusion criteria prioritized relevance to this study—specifically, documents discussing the development, adoption, and/or use of digital technologies or the establishment of technology partnerships within the SDG context. Eligible document types included treaties, agreements, guidelines, reports, roadmaps, and statements, as well as resolutions or cover letters related to the selected documents (when available). Only documents published from 2015 onward—the launch year of the 2030 Agenda—were considered, with the most recent versions selected. Exclusion criteria ruled out opinion or news articles, documents that were not explicitly directed at the study's scope, drafts, and redundant materials (e.g., executive summaries of already selected full documents).

2.2 Search Strategy

The search followed a navigational browsing approach on the official UN's website, starting from the Global Digital Compact webpage (Table 2). Documents were skimmed to assess potential relevance. An iterative snowballing technique was applied—if a selected document cited another that met the criteria, it was reviewed for inclusion. Additional sections of the website were also explored. Final selections were drawn from the webpages listed in Table 2.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 2 – United Nations webpages where documents were selected.

Webpage	Link
Global Digital Compact	https://www.un.org/en/summit-of-the-future/global-digital-compact
HLAB on Artificial Intelligence	https://www.un.org/ai-advisory-body
Roadmap for Digital Cooperation	https://www.un.org/en/content/digital-cooperation-roadmap

Based on the reading of these documents, additional documents were selected using the 'snowball' search method. After another round of inclusion and exclusion criteria, the final list of documents was defined (Table 3).

Tab. 3 - Final list of selected documents.

Document title (and citation)	Document type
Implementing the Secretary-General's Roadmap for Digital Cooperation (Office of the Secretary-General, 2022)	Non-binding roadmap
Declaration on Future Generations (United Nations, 2024, pp. 52-56)	Non-binding political declaration
Governing AI for Humanity: final report (United Nations AI Advisory Board, 2024).	Report
Global Digital Compact (United Nations, 2024, pp. 37-51)	Non-binding agreement
Letter from the President of the General Assembly (United Nations General Assembly, 2024)	Cover letter
The Pact for the Future (United Nations, 2024, pp. 1-36)	Non-binding agreement

2.3 Data Collection and Extraction

Documents were downloaded in PDF format from the official UN website and stored in a public cloud folder. Data were manually extracted by reading and identifying excerpts explicitly related to the research questions. These excerpts were compiled into spreadsheets with the fields shown in Table 4. As this is a qualitative study, the analysis phase required revisiting the data to extract additional excerpts that could refine, support, or challenge researchers' insights.

Tab. 4 – Spreadsheet fields for the data extraction stage.

Field name	Field description
ID_doc	Document identifier, defined as an abbreviation of the document title.
Document_title	Original title of the document.
Year	Publication year.
Initial_page	Page number where the extracted excerpt begins.
ID_excerpt	Unique code identifying the excerpt.
Excerpt	Selected excerpt, presented as a direct quotation.

2.4 Data Analysis

The analysis began by consolidating the data from the previous step (subsection 2.3) into a single spreadsheet, with additional fields shown in Table 5.

Tab. 5 – Additional spreadsheet fields for data coding and analysis stages.

Field name	Field description
Keywords	Words or expressions identified in the excerpts that were relevant for the research questions.
Coding_cycle_1	Descriptive codes assigned to each excerpt.
Coding_cycle_2	Thematic categories grouping the first-cycle codes.

Data analysis followed a reflexive thematic approach (Morgan, 2022), allowing the coding process to evolve iteratively with the researcher's interpretation. This method supports uncovering "unexpected meanings rather

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

than summarize the data" (p. 73). Procedures were based on the strategies outlined by Miles, Huberman, and Saldaña (2014). In the first coding cycle, descriptive codes were applied; in the second, these were grouped into thematic categories (Table 5). When needed, multiple codes were assigned to a single excerpt to better address the research questions.

3. Results

A total of 145 excerpts were extracted, coded, and organized into thematic categories. These categories were initially based on the RQs and refined during analysis. Four final categories are presented in Table 6.

Tab. 6 – Thematic categories (after the second cycle of coding).

Category name	Category description
Digital technologies	Excerpts addressing digital technologies to advancing the SDGs.
Technological Partnerships	Excerpts addressing cross-sector collaboration to advancing the SDGs through digital technologies.
Global Cooperation	Excerpts addressing international cooperation by UN member states to advancing the SDGs through digital technologies.
Global Governance	Excerpts addressing the role of the UN in global governance of digital technologies.

Figure 1 shows the number of excerpts grouped into each thematic category after the second cycle of coding, and the following subsections present responses to each research question.

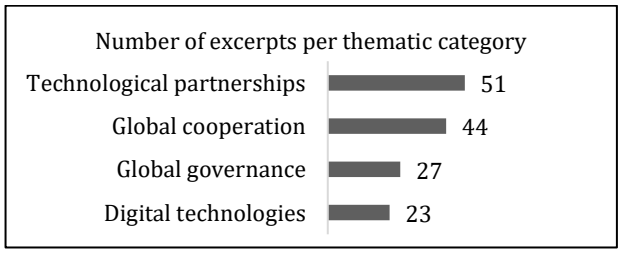


Fig. 1 - Number of excerpts per thematic category.

3.1 RQ1: The UN's approach to digital technologies in the SDGs context

To address this question, excerpts under "Digital Technologies" and "Global Governance" categories were analysed. The UN emphasizes digital technologies as transformative and accelerative tools for achieving the SDGs, stressing the need to reduce digital divides to ensure "no one is left behind." Key themes include digital inclusion, capacity building, data security, ethical AI governance, and human rights. Emerging technologies like AI are seen as essential for tackling global challenges, while unequal access is repeatedly cited as a major barrier. Governance of AI — whether globally centralized or regionally localized — is highlighted as critical to ensuring human rights and global well-being. Several excerpts warn of the risks of AI misuse, including terrorism, criminal use, psychosocial harm to children and youth, gendered digital inequality, and the dangers of unregulated technologies.

3.2 RQ2: The UN's approach to technological partnerships in the SDGs context

To explore this question, excerpts under "Global Cooperation" and "Partnerships" were analyzed. The UN advocates for digital cooperation through cross-sectoral, intergovernmental, and international partnerships. These are seen as essential to addressing complex challenges, guiding technological development, and maximizing benefits. Emphasis is placed on agility, adaptability, and collaborative ecosystems that enable knowledge and resource sharing. International cooperation is promoted as key to strengthening technological capacities and ensuring equitable access, especially for vulnerable populations. Two distinct contexts emerged in the data: a) Technological Partnerships, which involves multisector collaboration (governments, private sector, academia, civil society) to innovate and implement digital solutions tailored to community needs, usually in local or regional level (e.g., education, health, infrastructure); and Global Cooperation, which refers to international intergovernmental coordination in addressing transnational challenges (e.g., cybersecurity, poverty, terrorism). This cooperation is essential for policy alignment, capacity building, and collective responses to global threats. The UN positions this collaboration as a cornerstone of digital security and global stability in an unequal yet interconnected world.

3.3 RQ3: Priority and sensitive topics

To address this question, keywords across all thematic categories were analyzed to identify priority and/or sensitive topics. In the "Digital technologies" category, priorities include digital inequality, innovation, digital

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

inclusion, and the responsible AI use. In "Global Cooperation", digital and resource inequality between countries — particularly those in the Global South, Africa, island nations, and landlocked countries — stands out. In "Technological Partnerships", key issues include the lack of governance, discrepancies in regulations and insufficient technological capabilities. In "Global Governance", the risks associated with the improper use of AI and other emerging technologies were prioritized. Sensitive topics include AI regulation for child protection, with concerns about its effects on mental health, attachment, and cognitive development. Ethical and inclusive AI governance is seen as essential to ensuring equitable and ethical outcomes. Gender digital inequality is also addressed, with initiatives focused on empowering women. A strong emphasis is placed on safeguarding vulnerable groups and ensuring inclusive technological progress. Other sensitive themes include counterterrorism, preventing digital crimes, and reducing digital violence — all identified as urgent challenges requiring effective governance and international cooperation to uphold human rights and global security.

4. Discussion

The data analysis provides a broad view of how the UN approaches digital technologies and partnerships in the context of the SDGs, emphasizing global and local articulation across governmental and non-governmental sectors, responsible, inclusive, and ethical innovation, the defense and promotion of human rights, the reduction of inequalities, attention to vulnerable and marginalized groups, and centralized global governance. Table 7 summarizes the key findings, articulating the RQs and the thematic categories that emerged through the analysis. A distinguishing feature of this set of documents, compared to older UN reports, is that Global Digital Compact, Declaration on Future Generations, and Pact for the Future bring the perspectives of the Global South — particularly Latin America and Sub-Saharan Africa — to the center of the discussion, highlighting their goals, challenges, and interests. The approach reflects a strategy that combines centralization through global governance with the flexibility of partnerships among member states and regional partnerships involving various sectors of society. It also demonstrates a concern for avoiding the cultural imposition of world superpowers values at the expense of the Global South. The UN adopts a strong centralized governance approach, promoting the idea of a robust global governance system that transcends borders and ensures universal standards for the development and use of digital technologies. This global approach is prioritized over regional or local governance models to ensure consistency and effectiveness in technological policies worldwide. Global governance is seen as fundamental for establishing ethical guidelines, protecting human rights, and ensuring that the benefits of digital technologies are distributed equitably and responsibly, preventing asymmetries and exclusions.

Tab. 7 – Summary of key findings.

Research Question	Thematic Categories	Highlighted Topics
RQ1: The UN's approach to digital technologies in the SDGs context	Digital Technologies	Digital inequality; digital inclusion; technological innovation; AI accelerating SDGs; responsible AI use.
	Global Governance	Global coordinated AI governance; inclusive and ethical use of AI and other emerging technologies; human rights protection; children's safety.
RQ2: The UN's approach to technological partnerships in the SDGs context	Technological Partnerships	Local innovation; regional innovation; cross-sector collaboration; digital infrastructure; solutions tailored to community needs; scaling and replicating solutions.
	Global Cooperation	State-led international collaboration to global digital threats; capacity building; resource sharing; cybersecurity; counterterrorism; policy alignment.
RQ3: Priority and sensitive topics	All categories	Gender inequality; children's safety; digital violence; disparities in digital governance across nations and the lack of global digital governance; Global South, Africa, island, and landlocked nations inclusion.

However, some delicate issues stand out. The documents present several challenges that require agile solutions. Yet, many of the recommendations and guidelines rely on global decisions and actions (e.g., AI governance). But what happens in the absence of consensus? Assembly-based decisions can be slow, potentially reducing the agility needed to address urgent challenges. On the other hand, if decisions are made by a small group of member states, how well will these decisions reflect the needs of other countries? The same concern applies to large technology corporations that dominate the development of emerging technologies. Without digital regulation, their power becomes disproportionate, potentially exacerbating digital injustice and inequality. But how should such regulations be structured? Local and regional regulations can be more agile and better suited to specific contextual issues. Yet, power imbalances and injustices related to technology regulation could persist. This tension between the "global" and the "local" permeates the discussion of the most delicate issues, as seen across the analyzed documents.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Regarding the articulation between technological partnerships and Social Innovation Ecosystems (SIEs) in the context of the SDGs: technological partnerships play a fundamental role in promoting social innovation. Collaboration between different sectors — such as governments, NGOs, businesses, and academia — is essential for creating innovative solutions to complex social problems in more effective, efficient, and sustainable ways. These partnerships mobilize resources, knowledge, and technologies, fostering environments conducive to the co-production of social innovations. In the context of SIEs, technological partnerships can support the local adoption of innovations, enabling region-specific initiatives that address local needs while allowing the sharing of critical resources with partners who may otherwise lack access. Furthermore, these partnerships promote translocal connectivity, linking different regions and contexts to amplify the impact of social innovations and encourage the exchange of knowledge and experiences among diverse communities. Discursive resonance — another dimension of SIEs — can also be strengthened through these partnerships, as they can facilitate the collective process of legitimizing innovative concepts, thereby granting them political and scientific authority. Through collaboration, the actors involved in technological partnerships can shape a discourse that supports and legitimizes innovative practices, facilitating the acceptance and adoption of new social solutions. These partnerships can be key components of SIEs, providing the infrastructure needed to develop integrated solutions for complex social challenges. This is particularly significant given that the adoption of technological resources still appears low in many SIEs, even in Global North countries (Ventorini & Siqueira, 2025). SIEs, in turn, offer a favorable environment for this collaboration, as they promote co-creation of solutions, knowledge exchange, and mutual learning between stakeholders. These partnerships are not limited to purely technical innovation. They also involve a commitment to digital inclusion, digital equality, human rights, governance and data security — all of which are fundamental to ensure the ethical and responsible use of technologies. The analysis revealed that, to address global challenges and promote sustainability, technological innovation must be accompanied by regulatory frameworks aligned with human rights and sustainable development goals. Technological partnerships can help implement such regulations locally while facilitating the exchange of best practices across countries and regions. By promoting international cooperation, technological partnerships not only support local adaptation of innovations but also help ensure that the benefits of technological progress are equitably distributed — reducing digital inequality, which remains a significant obstacle to achieving the SDGs. Moreover, technological partnerships within SIEs have strong potential for fostering translocal connectivity. The UN highlights the importance of global cooperation, particularly in areas such as cybersecurity and digital crime prevention. By encouraging collaboration between countries, these partnerships build networks that transcend borders and connect local ecosystems, allowing solutions developed in one region to be adapted and successfully applied in others. This is particularly relevant for initiatives involving emerging technologies like AI, which, as the UN points out, have a transformative impact on key areas of sustainable development — including health, education, and infrastructure. Translocal connectivity is essential for optimizing the impact of these innovations and ensuring that the solutions developed are meaningful and accessible across diverse cultural and economic contexts. Finally, the creation of a collective discourse that legitimizes social innovations — another central component of SIEs — can also be reinforced through technological partnerships. The analysis shows that AI and other emerging technologies often have the potential to generate profound psychosocial impacts, especially on vulnerable populations such as children and women. The ethical governance of these technologies, particularly regarding human rights, is a major concern for the UN. By bringing together different stakeholders, technological partnerships can help construct a shared discourse that legitimizes innovative practices and supports the inclusive adaptation and implementation of these technologies. This collective discourse, underpinned by robust global governance, can serve as a means for the acceptance and dissemination of innovative solutions — while ensuring that these solutions are inclusive and do not reinforce existing inequalities.

5. Conclusions

This study aimed to contribute to the understanding of the UN's approaches to digital technologies and technological partnerships within the context of the SDGs. It also aimed to analyze the data through the lens of SIEs approach. The document analysis revealed that the UN adopts a strong centralizing stance, emphasizing the need for global governance in the management of digital technologies, particularly AI, while seeking to promote inclusion and empowerment of the most vulnerable countries, especially in the Global South. Technological partnerships — both global and local — are seen as essential instruments for fostering social innovation, enabling cross-sector collaboration, including governmental and non-governmental institutions, to maximize the societal impact of digital solutions. The analysis also highlighted the importance of global cooperation in addressing challenges such as digital crimes, terrorism, and online violence — sensitive topics in UN guidelines. The articulation between governmental and non-governmental actors at global and local levels is regarded as a key driver for integrated and sustainable technological responses to complex social problems. However, the analysis identified tensions among UN priorities. Strict governance structures may limit the agility and flexibility required for open collaboration — and vice versa. The study suggests that the SIEs approach is particularly suitable in this context, as it provides a structured, agile, and flexible environment where governments, enterprises, academia, civil society, and other actors could collaborate to co-create solutions, share resources, and scale social innovations across different regions while enabling progressive levels of governance. Promoting strong partnerships, providing funding, and fostering technological development within SIEs may help ensure that governmental and non-

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

governmental institutions work together in a way where the rapid pace of technological advances aligns with human rights, digital equity and broader sustainable development goals.

For future research, it is recommended to include in document analysis the UN's evaluation and monitoring reports on the digital economy of one or more countries. Published periodically by UNCTAD, these reports present data on countries' technological capabilities, inclusive digitalization strategies, and other criteria monitored by the UN. It is also important to note that, on January 1st, 2025, the Office of the Secretary-General's Envoy on Technology transitioned to the United Nations Office for Digital and Emerging Technologies (ODET), leading to significant updates on the sector's website. Therefore, another suggestion for future studies is to incorporate the new resources and documents now accessible on the updated ODET website (https://www.un.org/digital-emerging-technologies/), which were not available at the time of this research.

Acknowledgement

- **Data Access Statement**: The data collected and produced at each stage of this study are available at the following link: https://doi.org/10.5281/zenodo.14768614
- **Contributor Statement**: Conceptualization, methodology: authors 1, 2 and 3. Data curation, investigation, writing – original draft: author 1. Supervision, funding acquisition, writing - review & editing: authors 2 and 3.
- **Use of AI**: During the preparation of this work, the author(s) din't used any AI tools/services.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Albuquerque, B. V. L., & Siqueira, S. W. M. (2025). Digital technologies and information systems in social innovation ecosystems. *Proceedings of the XXI Simpósio Brasileiro de Sistemas de Informação*, Brasil, 798-807. Porto Alegre, SBC. https://doi.org/10.5753/sbsi.2025.246647

Beckman, C., Rosen, J., Estrada, J., & Painter, G. (2023). The social innovation trap: Critical insights into an emerging field. *Academy of Management Annals*, 17(2), 684–709. https://doi.org/10.5465/annals.2021.0089

Bucio-Mendoza, S., & Solis-Navarrete, J. A. (2024). Institutionalising social innovation in the Global South: Lessons learned. *Heliyon*, 10(20), Article e39556. https://doi.org/10.1016/j.heliyon.2024.e39556

Chaudhuri, R., Chatterjee, S., Mariani, M., & Fosso Wamba, S. (2024). Assessing the influence of emerging technologies on organizational data driven culture and innovation capabilities: A sustainability performance perspective. *Technological Forecasting and Social Change*, 200, 123-165. https://doi.org/10.1016/j.techfore.2023.123165

Chueri, L., Afonso, A., Pinheiro, M., Ramos, M., & dos Santos, R. P. (2020). Um estudo exploratório sobre plataformas digitais para ecossistemas de inovação social no Brasil. *Proceedings of the V Workshop sobre aspectos sociais, humanos e econômicos de software, Brasil*, 81-90. https://doi.org/10.5753/washes.2020.11200

Ho, J.-Y., Yoon, S. (2022). Ambiguous roles of intermediaries in social entrepreneurship: The case of social innovation system in South Korea. *Technological Forecasting and Social Change*, 175. https://doi.org/10.1016/j.techfore.2021.121324

Hu, M.-C., Phillips, F., & Wu, C.-Y. (2024). Social innovations mediate technology and economy in the Kondratieff waves. Technological Forecasting and Social Change, 201. https://doi.org/10.1016/j.techfore.2024.123262

Lu, X., & Wang, J. (2024). Is innovation strategy a catalyst to solve social problems? The impact of R&D and non-R&D

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

innovation strategies on the performance of social innovation-oriented firms. *Technological Forecasting and Social Change*, 199. https://doi.org/10.1016/j.techfore.2023.123020

Lyulyov, O., Pimonenko, T., Saura, J. R., & Barbosa, B. (2024). How do e-governance and e-business drive sustainable development goals? *Technological Forecasting and Social Change*, 199. https://doi.org/10.1016/j.techfore.2023.123082

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative data analysis: A methods sourcebook*. SAGE Publications. https://doi.org/ISBN9781452257877

Morgan, H. (2022). Conducting a qualitative document analysis. *The Qualitative Report*, 7 (1). https://doi.org/10.46743/2160-3715/2022.5044

Office of the Secretary-General (2022). *Implementing the Secretary-General's Roadmap for Digital Cooperation* (July 2022 update). United Nations. https://www.un.org/techenvoy/sites/www.un.org.techenvoy/files/Update_on_Roadmap_implementation_July_2022.pdf

Parthasarathy, B., Dey, S., & Gupta, P. (2021). Overcoming wicked problems and institutional voids for social innovation: University-NGO partnerships in the Global South. *Technological Forecasting and Social Change*, 173. https://doi.org/10.1016/j.techfore.2021.121104

Pel, B., Wittmayer, J., Dorland, J., & Jørgensen, M. (2019). Unpacking the social innovation ecosystem: An empirically grounded typology of empowering network constellations. *Innovation: The European Journal of Social Science Research*, 33(3), 311–336. https://doi.org/10.1080/13511610.2019.1705147

Phills Jr., J. A., Deiglmeier, K., & Miller, D. T. (2008). Rediscovering social innovation. *Stanford Social Innovation Review*, 6(4), 34–43. https://doi.org/10.48558/GBJY-GJ47

Pinheiro, M., Chueri, L., & Santos , R. (2021). Investigando Colaboração em Ecossistemas. *Proceedings of the VI Workshop sobre Aspectos Sociais, Humanos e Econômicos de Software, Brasil,* 11-20. Porto Alegre: SBC. https://doi.org/10.5753/washes.2021.15885

Slitine, R., Chabaud, D., & Richez-Battesti, N. (2024). Towards local sustainability: How intermediation fosters social innovation. *Technological Forecasting and Social Change*, 209. https://doi.org/10.1016/j.techfore.2024.123790

Soni, G., Mangla, S. K., Singh, P., Dey, B. L., & Dora, M. (2021). Technological interventions in social business: Mapping current research and establishing future research agenda. Technological Forecasting and Social Change, 169. https://doi.org/10.1016/j.techfore.2021.120818

United Nations (2015). *Transforming our world: The 2030 agenda for sustainable development* (Resolution A/RES/70/1, General Assembly, 25 September 2015). United Nations. https://documents.un.org/doc/undoc/gen/n15/291/89/pdf/n1529189.pdf

United Nations (2024). *Pact for the Future, Global Digital Compact, and Declaration on Future Generations* (Summit for the Future outcome documents, Resolution A/RES/79/1, September 2024). United Nations. https://www.un.org/en/summit-of-the-future/pact-for-the-future

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

United Nations AI Advisory Board (2024). *Governing AI for humanity: final report* (September 2024). United Nations. https://www.un.org/sites/un2.un.org/files/governing_ai_for_humanity_final_report_en.pdf

United Nations Economic and Social Council (2024). *Science, technology and innovation for development* (Resolution E/RES/2024/14, July 2024). United Nations. https://documents.un.org/access.nsf/get?OpenAgent&DS=E/RES/2024/14&Lang=E

United Nations General Assembly. (2024). *Letter from the President of the General Assembly*. 20 September 2024. United Nations. https://www.un.org/sites/un2.un.org/files/soft-pga-letter-pact-for-the-future.pdf

United Nations Trade and Development (2023). *Technology and innovation report 2023*. United Nations. https://unctad.org/system/files/official-document/tir2023_en.pdf

Wamba, S. F., Bawack, R. E., Guthrie, C., Queiroz, M. M., & Carillo, K. D. A. (2021). Are we preparing for a good AI society? A bibliometric review and research agenda. *Technological Forecasting and Social Change*, 164, 120–482. https://doi.org/10.1016/j.techfore.2020.120482

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Drivers and Barriers in Libya's E-Government Implementation - A Case Study.

Amged B. Shwehdy [a]

[a] Affiliation: Independent researcher, Libya, email address: a.shwehdy@outlook.com, ORCID number: 0009-0006-4273-2498.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. This study aims to identify and analyse the key drivers and barriers influencing the implementation of e-government initiatives in Libya's public sector, a developing country with a post-conflict context. Employing a combined theoretical framework based on TOE framework and UTAUT, this research adopts a mixed-methods approach. Semi-structured interviews with digital ecosystem multi-stakeholders, were conducted alongside closed-ended surveys. The findings reveal that e-government implementation in Libya is shaped by technological, organizational, and environmental factors, as well as user acceptance dimensions. The study underscores the importance of addressing structural and institutional challenges through a centralized, strategic approach to enable successful digital transformation. Recommendations include enhancing digital infrastructure, fostering public-private partnerships, improving digital literacy, and reforming public sector policies. The insights gained are not only applicable to Libya but also offer valuable lessons for other nations facing similar challenges in digital transformation.

Keywords. Drivers and Barriers, E-Government, Public Sector, Libya, TOE Framework, UTAUT.
Practical report, DOI: https://doi.org/10.59490/dgo.2025.1043

1. Introduction

Digital transformation is reshaping governance globally, enabling streamlined public services, enhanced transparency, and greater citizen engagement (Mergel et al., 2019). The adoption of e-government varies considerably due to socioeconomic, infrastructural, and governance disparities among countries (EGDI, 2023; Samuel et al., 2020). Developing nations particularly face challenges like limited ICT infrastructure, financial constraints, and governance weaknesses (Bwalya & Healy, 2010; Heeks, 2002).

Libya represents a pertinent case for investigating e-government implementation due to its complex post-conflict context. Despite substantial nominal GDP, literacy rates, and high mobile penetration (World Bank, 2022; GSMA, 2022), Libya struggles with public sector inefficiencies and corruption, ranking poorly in global governance indicators (CPI, 2023; EGDI, 2023). Political instability further complicates digital transformation efforts.

This study aims to identify key drivers and barriers influencing Libya's e-government implementation, suggesting actionable strategies for overcoming challenges. Specifically, it addresses:

- What are the key drivers for e-government implementation in Libya?
- What are the key barriers and challenges to e-government implementation in Libya?
- How can these barriers and challenges be addressed to facilitate successful implementation?

The study focuses exclusively on Libya's public administration sector and employs a mixed-methods approach to

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

analyze qualitative and quantitative data. Semi-structured interviews with stakeholders, surveys of public sector employees and citizens, and policy document reviews form the basis of the analysis. By employing thematic and statistical methods, the research aims to contribute to a nuanced understanding of e-government implementation in Libya and its broader implications for digital transformation in developing contexts.

2. Literature Review

2.1 Foundations of E-Government and Digital Transformation

E-government leverages ICT to improve public service efficiency, transparency, and citizen-government interactions (Musa et al., 2019; Malodia et al., 2021). Adoption rates vary globally due to economic disparities, infrastructural capabilities, and governance quality, highlighting barriers like political resistance, limited stakeholder involvement, and inadequate ICT infrastructure (Abied, 2017; Alsaeh, 2020; Al-Rawahna et al., 2019).

Digital transformation addresses these barriers through citizen-centric services, knowledge management, and institutional reform, improving accountability and public sector competence (Mergel et al., 2019; Alvarenga et al., 2020; Al Yami & Ajmal, 2019). The institutionalization of ICT through clear policies and norms significantly enhances public sector effectiveness, as demonstrated internationally (Manda, 2021; Di Giulio & Vecchi, 2023).

Key technologies driving e-government include social media, blockchain, and cloud computing, which improve communication, accountability, and efficiency (Tapscott & Tapscott, 2016; Al-Ruithe et al., 2018). E-government is further accelerated by increasing digital literacy and mobile technology adoption, aligning with societal behavioral shifts and user expectations (Mensah et al., 2022; Tang et al., 2021; Gounopoulos et al., 2020). Additionally, it serves as a strategic tool for reducing corruption through minimized human intervention (Khan et al., 2021; Adjei-Bamfo et al., 2019).

Despite these benefits, developing countries often encounter significant implementation hurdles including insufficient funding, limited expertise, employee resistance, political interference, and outdated governance frameworks (Dhonju & Shakya, 2019; Filgueiras et al., 2019; Cinar et al., 2019). Successful cases, such as Namibia's public access points for e-government, highlight inclusive strategies as critical for overcoming these barriers (Nengomasha & Shuumbili, 2022).

2.2 Libya's Public Sector and Digital Landscape

Libya's public sector reflects a rentier state model, with oil revenues constituting 90% of national income (CBL, 2022). Approximately 80% of the labor force works in civil service, and public sector wages account for over a third of government expenditures (World Bank, 2015; LAB, 2020). This dependency on oil has fostered inefficiencies, nepotism, and corruption in recruitment and administrative practices, undermining the sector's effectiveness (Vandewalle, 2012; Transparency International, 2023).

Historical efforts to reform the public sector, including workforce reductions and incentives for private sector growth, faced resistance from entrenched informal institutions and public employees (World Bank, 2015). Post-2011, political instability and economic challenges have further strained the public sector. Informal actors, such as tribal leaders and militias, exert significant influence, complicating governance and exacerbating inefficiencies (Tantoush, 2022).

To contextualize the broader theoretical and regional insights, it is critical to examine Libya's unique public sector dynamics, digital infrastructure, and past e-government efforts, all of which shape the country's current opportunities and persistent challenges in digital transformation. Libya's digital infrastructure remains underdeveloped, with limited rural connectivity and outdated telecommunications policies (USAID DECA, 2022). The Libyan Post Telecommunications & Information Technology Company (LPTIC) monopolizes the telecommunications sector, overseeing fiber networks and mobile operators, while regulatory functions are managed by the General Authority for Communication and Informatics (World Bank, 2015). Political instability has impeded infrastructure investments, resulting in $1 billion in damages to telecom facilities since 2011 (OECD, 2016).

Despite these challenges, Libya boasts high mobile penetration (169.6%) but low internet penetration (21%) and modest internet speeds (Ookla, 2023). Digital literacy remains low, with many citizens relying on social media rather than broader digital platforms (USAID DECA, 2022). Recent government initiatives, including the formation of the National Committee for Digital Transformation in 2022, aim to address these gaps and advance digital governance (Government of National Unity 394, 2022)

While Libya's digital infrastructure remains underdeveloped, recent initiatives signal a renewed interest in leveraging technology for governance. These infrastructural realities directly impact the implementation and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

sustainability of e-government programs across the country.

E-government initiatives in Libya date back to the early 2000s but have faced significant setbacks due to political instability. Early efforts, such as the 2013 eLibya initiative, sought to modernize public services through ICT but were suspended following the 2014 conflict (Wynn et al., 2021). Subsequent projects, including the Ejraat Portal for administrative services, have demonstrated potential but remain limited in scope (Ministry of Economy and Trade, 2020).

The establishment of the National Committee for Digital Transformation in 2022 marked a renewed effort to develop a comprehensive digital strategy. This strategy emphasizes regulatory reform, capacity building, infrastructure development, and citizen participation, with a target for implementation by 2030 (GIA, 2022). However, progress has been slow, and Libya continues to rank poorly on global indices such as the UN E-Government Development Index (EGDI), where it placed 169th in 2022 (EGDI, 2023).

Although several e-government initiatives have been launched in Libya, their progress has been uneven and often hindered by systemic issues. A closer look at these challenges — alongside emerging opportunities — reveals the complex landscape in which digital transformation efforts are unfolding. Libya's e-government initiatives face numerous challenges, including inadequate infrastructure, low digital literacy, and entrenched corruption (Ahmed et al., 2013). Resistance to change within the public sector and a lack of trust in government institutions further complicate adoption (Forti, 2019). However, opportunities exist to leverage ICT for improving governance and service delivery, particularly by addressing systemic inefficiencies and fostering citizen engagement.

2.3 Synthesis and Research Gap

Libya's unique socio-political context and underdeveloped digital infrastructure significantly impede e-government adoption. Nonetheless, its youthful population, international support, and emerging strategies offer opportunities for progress. This research addresses existing gaps by analysing Libya's digital transformation potential comprehensively, offering insights applicable to other developing nations.

3. Methodology

3.1 Frameworks Applied

This study adopts a combined theoretical framework integrating the Technology-Organization-Environment (TOE) and Unified Theory of Acceptance and Use of Technology (UTAUT) models to provide a comprehensive understanding of e-government implementation in Libya. The TOE framework, developed by Tornatzky and Fleischer (1990), focuses on how technological, organizational, and environmental contexts influence adoption at the institutional level. In contrast, the UTAUT model (Venkatesh et al., 2003) centers on user-level acceptance factors, including performance expectancy, effort expectancy, social influence, and facilitating conditions. By combining these frameworks, the study captures both macro-level institutional drivers/barriers and micro-level user perceptions, which is particularly important in post-conflict contexts like Libya where fragmented institutions and varying user readiness coexist. This integrative approach is supported by prior research (e.g., Lee & Lee, 2014; Bouteraa, 2024), which highlights the value of combining TOE and UTAUT to gain deeper insights into complex adoption environments.

3.2 Data Collection and Analysis

A mixed-methods approach was employed to gather comprehensive data. The qualitative component involved semi-structured interviews with 23 key informants, including government officials, public sector employees, private sector representatives, and ICT experts. Interviewees were identified using a snowball sampling technique, where each participant recommended additional experts to be consulted. After conducting over 20 interviews, thematic saturation was reached, as responses became repetitive, and no new informants were suggested. This confirmed the adequacy of the sample for capturing a well-rounded understanding of the topic. The quantitative component consisted of a survey administered to 419 respondents, including citizens and public sector employees. The survey featured closed-ended questions to measure perceptions of e-government initiatives and assess the impact of technological, organizational, and environmental factors. The sample size exceeded the minimum threshold required for descriptive and inferential statistical analysis, ensuring robustness and representativeness within the scope of the study.

Qualitative data from the interviews were analyzed using thematic analysis to identify recurring patterns and underlying narratives. This approach allowed for the extraction of key themes related to the drivers and barriers of e-government implementation. Quantitative data from the survey were analyzed using descriptive and inferential statistical techniques, including regression and correlation analyses. These methods helped identify

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

relationships between variables and assess the significance of technological, organizational, and environmental factors in shaping e-government adoption.

3.3 Ethical Considerations

Ethical approval was obtained before data collection, ensuring compliance with guidelines for research involving human participants and data privacy and anonymity.

3.4 Validity

To ensure data validity, both the interview questions and the survey questionnaire were developed based on the combined model of the TOE and UTAUT and reviewed by experts in the field. Moreover, a pilot test was conducted to ensure the clarity and relevance of the questions. The survey and interview guides are available upon request for research transparency.

4. Findings

This chapter presents the main findings from the mixed-method data collection process, divided into quantitative and qualitative sections. The analysis highlights the interconnected themes and correlations between the two methods.

4.1 Quantitative Analysis

Survey respondents evaluated Libya's ICT infrastructure as moderately adequate for e-government implementation. However, gaps in technological compatibility and innovation were noted, particularly regarding system interoperability and reliability. Despite these challenges, respondents expressed confidence in their ability to use ICT and adapt to digital services. This aligns with expert observations, which highlight the need for targeted infrastructure upgrades to meet future demands.

Leadership, organizational culture, resource availability, and readiness emerged as critical organizational factors influencing e-government initiatives. Survey respondents rated leadership effectiveness as low, citing a lack of strategic direction and inconsistent promotion of e-government projects. Resource availability was also identified as moderate, reflecting a misalignment between institutional needs and allocated budgets. These findings echo expert concerns about fragmented strategies and limited leadership competencies within public institutions.

Political instability was highlighted as the most significant environmental barrier, with 77% of respondents identifying it as a major hindrance to e-government adoption. Additionally, only 48% of respondents were aware of existing legal frameworks supporting e-government, underscoring the need for regulatory reforms and increased public awareness.

Survey participants overwhelmingly agreed on the benefits of e-government, particularly in enhancing efficiency, transparency, and communication between citizens and the government. However, effort expectancy scores revealed challenges related to user accessibility and system design, with respondents citing issues such as non-user-friendly interfaces and limited alignment with users' technical expertise.

Respondents noted moderate social influence from peers and superiors in encouraging e-government adoption, suggesting that societal norms and workplace environments play a role, albeit not a decisive one, in shaping attitudes toward digital services.

Facilitating conditions, including training, technical support, and resource availability, were rated as low. This reinforces expert views on the lack of capacity-building initiatives and support mechanisms necessary for successful e-government implementation.

Key barriers identified by respondents include leadership quality, institutional structure, and lack of strategic management, with financial resources deemed less critical. Conversely, drivers such as reducing corruption, increasing transparency, and improving service quality ranked highest, reflecting public demand for accountability and efficiency.

4.2 Qualitative Analysis

Experts emphasized the administrative complexities hindering e-government adoption, including overlapping mandates, a lack of procedural guides, and weak leadership. Political conflict and the absence of legislative

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

oversight exacerbate these issues, creating a fragmented and inefficient public sector.

Experts acknowledged the potential of Libya's extensive fibre optic network but noted significant disruptions due to armed conflict, regulatory constraints, and unreliable power supplies. The government's monopoly over telecommunications infrastructure was identified as a key obstacle, limiting private sector participation and innovation.

A critical shortage of qualified IT personnel in the public sector, coupled with insufficient capacity-building initiatives, was highlighted. Experts also pointed to cultural resistance among employees and decision-makers as a barrier to adopting digital technologies. High reliance on individual initiatives further undermines institutional progress.

Experts observed a high level of digital literacy among Libya's young population but noted gaps in decision-makers' understanding of technology. Citizen trust in digital services remains low due to prior negative experiences, emphasizing the need for reliable, user-centric solutions and robust public communication strategies.

Both experts and survey respondents noted the limited availability and reliability of digital government services. Successful initiatives, such as the Marriage Facilitation Fund, demonstrate the potential for effective e-government when backed by strategic planning, private sector partnerships, and integration with existing systems.

Experts identified the private sector as a critical partner for e-government implementation, particularly in providing infrastructure and hardware. However, regulatory barriers, lack of trust, and limited investment opportunities hinder private sector involvement.

Political instability and weak leadership were identified as major obstacles to e-government initiatives. Experts emphasized the importance of consistent leadership and strategic vision, noting that fragmented governance and frequent leadership changes undermine project continuity.

Outdated and inconsistent legal frameworks were cited as significant barriers to digital transformation. Experts highlighted the absence of laws recognizing electronic transactions and digital identities, as well as regulatory gaps that discourage private sector participation.

Corruption within the public sector presents a dual challenge, both obstructing digital transformation efforts and potentially being mitigated by increased transparency through e-government. Experts advocated for a multi-stakeholder approach to address these issues.

International organizations have played a significant role in supporting Libya's digital transformation efforts. However, the lack of a unified national strategy has resulted in fragmented initiatives, reducing their overall impact.

Based on the experts, the drivers and motives of implementing e-government initiatives in Libya vary from one institution to another and from leadership to another. However, the political aspect and agenda were presented heavily when the experts analysed the current government efforts in this field. Moreover, the understanding is that e-government may increase the citizens' trust, help decentralise government services, and unify the country, especially with current circumstances, by providing the same services to all of Libya, wherever they are. Facilitating those services to the citizens is also one of the motives, where some institutions have issues with long waiting lines and queues. Other institutions are interested in increasing transparency and accountability and fighting bureaucracy and corruption.

4.3 Finding Summary

Both qualitative and quantitative analyses highlighted political instability, inadequate infrastructure, leadership deficits, and regulatory challenges as critical barriers. Despite these obstacles, there is strong consensus on e-government's potential to improve transparency, accountability, and service delivery through targeted reforms, capacity building, and strategic collaboration.

5. Discussion and Recommendations

Administrative challenges, such as rigid hierarchies and lack of procedural guidance, significantly hinder e-government implementation in Libya. Promoting a digital culture, adopting standardized procedures, and fostering innovative leadership are essential to overcoming these barriers. Overlapping institutional mandates create inefficiencies and resource conflicts. A centralized authority should coordinate e-government efforts, ensuring strategic alignment and resource efficiency. Political instability impacts policy continuity and trust. A long-term

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

digital transformation strategy, supported by robust public-private partnerships and transparent civil society oversight, can mitigate these effects and foster resilience. Outdated legal frameworks must be urgently updated to support digital governance, including digital transactions and data privacy. Interim policies and international collaboration can bridge current legislative gaps. Corruption undermines both project procurement and public confidence. Implementing transparent procurement processes and digital accountability tools, alongside civil society monitoring, can enhance integrity and public trust. The shortage of qualified IT personnel requires targeted capacity-building and change management initiatives. International partnerships can supplement immediate expertise needs while developing local capabilities. Enhancing citizen engagement and digital literacy through user-centric digital services and public awareness campaigns is critical. Services should be accessible, reliable, and responsive to encourage widespread adoption. Finally, public-private partnerships and international collaborations are vital. These partnerships should prioritize knowledge transfer and equitable implementation, supporting Libya's long-term digital infrastructure growth.

6. Conclusion

This research provides a focused analysis of the multifaceted factors influencing e-government implementation in Libya. Using the TOE and UTAUT frameworks, it highlights how institutional structures, leadership, political stability, and citizen engagement shape digital transformation efforts. Key barriers identified include overlapping institutional mandates, lack of procedural guidance, public sector inefficiencies, political instability, poor strategic planning, and outdated legal frameworks. Addressing these requires the establishment of a centralized agency with executive support to ensure coherence and effective resource allocation. Leadership is a crucial enabler. Visionary leaders must define strategic direction, foster collaboration, and ensure sustained commitment. This effort must be reinforced by a legal framework that supports electronic transactions, privacy, and digital identity. Upgrading ICT infrastructure and developing human capital are essential. While Libya has foundational infrastructure, expanding coverage and ensuring interoperability are priorities. Capacity-building initiatives are also vital to address the digital skills gap. Combating corruption and fostering public trust are equally critical. Transparent procurement systems, digital accountability tools, and civil society oversight can help build legitimacy and trust in e-government initiatives. Furthermore, public-private partnerships and international collaborations are necessary to provide technical expertise, stimulate innovation, and support capacity development. E-government can contribute to national unity and decentralization by offering equitable access to services across regions. Though Libya's socio-political complexity poses challenges, this study provides actionable insights. Future research should explore the long-term impact of these initiatives and the role of emerging technologies like AI and blockchain. Ultimately, the findings serve as a roadmap for advancing inclusive, accountable, and effective digital governance in Libya and similarly fragile contexts.

Acknowledgement

- **Funding or Grant** (if applicable)**:** Not applicable.
- **Data/Software Access Statement** (if applicable): Not applicable.
- **Contributor Statement***: The author is the responsible for all contributions of this paper.
- **Use of AI***: During the preparation of this work, the author used several AI tools to proofread in order to ensure the readability of the text. After using this tool/service, the author reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Abied, A. 2017. 'Factors affecting citizens' adoption of E-Government services in Libya', F. Shiratuddin and K. Wong (eds.).

Adjei-Bamfo, P., Maloreh-Nyamekye, T., and Ahenkan, A. 2019. 'The role of e-government in sustainable public procurement in developing countries: A systematic literature review', Resources, Conservation and Recycling (142), pp. 189–203.

Ahmed, A. M., Moreton, R., Mehdi, Q. H., and Elmaghraby, A. 2013. 'E-government services challenges and opportunities for developing countries: The case of Libya', in 2013 2nd International Conference on Informatics and Applications, ICIA 2013, IEEE Computer Society, pp. 133–137.

Al Yami, M., and Ajmal, M. M. 2019. 'Pursuing sustainable development with knowledge management in public sector', VINE Journal of Information and Knowledge Management Systems (49:4), pp. 568–593.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Al-rawahna, A. S. M., Chen, S.-C., and Hung, C.-W. 2019. 'The Barriers of E-Government Success: An Empirical Study from Jordan', SSRN Electronic Journal.

Al-Ruithe, M., Benkhelifa, E., and Hameed, K. 2018. 'Key Issues for Embracing the Cloud Computing to Adopt a Digital Transformation: A study of Saudi Public Sector', Procedia Computer Science (130), pp. 1037–1043.

Alpar, P., & Olbrich, S. (2005). Legal requirements and modeling of processes in e-government. *Business Process Management Journal, 11*(6), 650-663. https://doi.org/10.1108/14637150510630843

Alsaeh, S. 2020. 'Challenges Facing the Implementation of E-Government in Libya and their potential solutions', International Journal for Research in Applied Science & Engineering Technology (IJRASET) (8(11)), pp. 132–136.

Alvarenga Ana, Florinda Matos, Radu Godina, and João CO Matias 2020. 'Digital transformation and knowledge management in the public sector', Sustainability (12:14), p. 5824.

Amin, S. F., Saad, A. B., and Lajis, A. 2022. 'Technology Acceptance Factors for Implementing the E-Government Systems in Saudi Arabia', Advances in Internet of Things (12:04), pp. 125–141.

Alpar, P., and Olbrich, S. 2005. 'Legal Requirements and Modelling of Processes in e-Government', University at Marburg, Germany.

Anthopoulos, L., Reddick, C. G., Giannakidou, I., & Mavridis, N. (2016). Why e-government projects fail? An analysis of the healthcare.gov website. *Government Information Quarterly, 33*(1), 161-173. https://doi.org/10.1016/j.giq.2015.07.003

Bannister, F., & Connolly, R. (2014). ICT, public values, and transformative government: A framework and program for research. *Government Information Quarterly, 31*(1), 119-128. https://doi.org/10.1016/j.giq.2013.06.002

Bannister, F., & Connolly, R. (2015). The great theory hunt: Does e-government really have a problem? *Government Information Quarterly, 32*(1), 1-11. https://doi.org/10.1016/j.giq.2014.10.003

Berman, S. J. (2012). Digital transformation: Opportunities to create new business models. *Strategy & Leadership, 40*(2), 16-24. https://doi.org/10.1108/10878571211209314

Bertot, J. C., Jaeger, P. T., and Grimes, J. M. 2010. 'Using ICTs to create a culture of transparency: E-government and social media as openness and anti-corruption tools for societies', Government Information Quarterly (27:3), pp. 264–271.

Bouteraa, M. (2024), "Mixed-methods approach to investigating the diffusion of FinTech services: enriching the applicability of TOE and UTAUT models", Journal of Islamic Marketing, Vol. 15 No. 8, pp. 2036-2068. https://doi.org/10.1108/JIMA-12-2022-0343

Brynjolfsson, E., and McAfee, A. (2016) The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies, W. W. Norton & Company.

CBL 2022. Economic Bulletin Central Bank of Libya first quarter of the year 2022.

Cinar, E., Trott, P., and Simms, C. 2019. 'A systematic review of barriers to public sector innovation process', Public Management Review (21:2), pp. 264–290.

Cordella, A., and Iannacci, F. 2010. 'Information systems in the public sector: The e-Government enactment framework', The Journal of Strategic Information Systems (19:1), pp. 52–66.

CPI 2023. '2022 Corruption Perceptions Index: Explore the results', in Transparency.org.

Ndou, V. (2004). E-government for developing countries: Opportunities and challenges. Electron. J. Inf. Syst. Dev. Ctries., 18(1), 1-24.

Di Giulio, M., and Vecchi, G. 2023. 'How "institutionalization" can work. Structuring governance for digital transformation in Italy', Review of Policy Research (40:3), pp. 406–432.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Dhonju, G. R., and Shakya, S. 2019. 'Analyzing Challenges for the Implementation of E-Government in Municipalities within Kathmandu Valley', Journal of Science and Engineering (7), pp. 70–78.

Dodeen, W. 2019. 'Exploring the quality of e-government service from citizens' perspectives'.

Doush, I. A., and Almeraj, Z. 2019. 'Evaluating the accessibility of Kuwaiti e-government websites', Jordanian Journal of Computers and Information Technology (5:3), pp. 152–169.

EGDI 2023. 'E-Government Development Index', in EGOVKB United Nations Data Country Information.

Elgohary, E., and Abdelazyz, R. 2020. 'The impact of employees' resistance to change on implementing e-government systems: An empirical study in Egypt', The Electronic Journal of Information Systems in Developing Countries (86:6).

Filgueiras, F., Flávio, C., and Palotti, P. 2019. 'Digital Transformation and Public Service Delivery in Brazil', Latin American Policy (10:2), pp. 195–219.

Forti, Y. 2019. A new model fo e-Government in local level administration in Libya, The University of Gloucestershire.

Government of National Unity 394 2022. 'Resolution No. 394 of 2022 regarding the formation of the National Committee for Digital Transformation'.

Gounopoulos, E., Kontogiannis, S., Kazanidis, I., and Valsamidis, S. 2020. 'The Impact of the Digital Divide on the Adoption of e-Government in Greece', KnE Social Sciences.

GSMA 2022. 'Internet Speeds in North Africa are Rapidly Improving, but Still Lag Behind Much of the World'.

GSMA Mobile Economy, 2020.

Heeks, R., & Bailur, S. (2007). Analyzing e-government research: Perspectives, philosophies, theories, methods, and practice. *Government Information Quarterly, 24*(2), 243-265. https://doi.org/10.1016/j.giq.2006.06.005

Heeks, R. 2002. 'Information systems and developing countries: Failure, success, and local improvisations', Information Society (18:2), pp. 101–112.

Khan, A., Krishnan, S., and Dhir, A. 2021. 'Electronic government and corruption: Systematic literature review, framework, and agenda for future research', Technological Forecasting and Social Change (167), p. 120737.

Klievink, B., and Janssen, M. 2014. 'Developing Multi-Layer Information Infrastructures: Advancing Social Innovation through Public–Private Governance', Information Systems Management (31:3), pp. 240–249.

Kunstelj, M., & Vintar, M. (2004). Evaluating the progress of e-government development: A critical analysis. *Information Polity, 9*(3-4), 131-148.

LAB 2020. Libyan Audit Bureau Report 2020.

Lanzolla Gianvito, and Anderson Jamie 2010. 'The digital revolution is over. Long live the digital'.

Lee, S., & Lee, H. (2014). A Study on an Integrative Model for Big Data System Adoption : Based on TOE, DOI and UTAUT. Journal of Information Technology Applications and Management, 21(4_spc), 463–483. https://doi.org/10.21219/JITAM.2014.21.4_SPC.463

Legner, C., Eymann, T., Hess, T., Matt, C., Böhmann, T., Drews, P., et al. 2017. 'Digitalization: Opportunity and Challenge for the Business and Information Systems Engineering Community', Business & Information Systems Engineering (59:4), pp. 301–308.

Manda, M. I. 2021. 'Power, politics, and the institutionalisation of information systems for promoting digital transformation in the public sector: A case of the South African's government digital transformation journey', Information Polity (27:3), pp. 311–329.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Malodia, S., Dhir, A., Mishra, M., and Bhatti, Z. A. 2021. 'Future of e-Government: An integrated conceptual framework', Technological Forecasting and Social Change (173).

Margetts, H., & Dunleavy, P. (2013). The second wave of digital-era governance: A quasi-paradigm for government on the Web. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 371*(1987), 20120382. https://doi.org/10.1098/rsta.2012.0382

Meiyanti, R., Utomo, B., Sensuse, D. I., and Wahyuni, R. 2018. 'e-Government Challenges in Developing Countries: A Literature Review', in 2018 6th International Conference on Cyber and IT Service Management (CITSM), pp. 1–6.

Mensah, I. K., Adams, S., Adjei, J. K., and Mwakapesa, D. S. 2022. 'Drivers of egovernment adoption amidst COVID-19 pandemic: The Information Adoption Model (IAM) approach', Information Development (38:4), pp. 494–509.

Mergel, I., Edelmann, N., & Haug, N. (2019). Defining digital transformation: Results from expert interviews. *Government Information Quarterly, 36*(4), 101385. https://doi.org/10.1016/j.giq.2019.06.002

Mergel, I., Kattel, R., Lember, V., and McBride, K. 2018. 'Citizen-oriented digital transformation in the public sector', in Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age, New York, NY, USA: ACM, pp. 1–3.

Musa, O. Bin, Abuwdn, F., Aini, I., Zolkifly, B., and Almasri, A. 2019. Factors Affecting Libyan Citizens Satisfaction with E-Government Services.

Ndou Dardha 2004. E – Government for Developing Countries: Opportunities and Challenges.

Nengomasha, C. T., and Shuumbili, T. N. 2022. 'Access to e-government services by citizens through public/community libraries in Namibia', Information Development (38:1), pp. 68–82.

OECD 2016. African Economic Outlook 2016 - Libya, OECD.

Ookla 2023. 'Libya's Mobile and Broadband Internet Speeds - Speedtest Global Index', in Speedtest by Ookla.

Relly, J. E., and Sabharwal, M. 2009. 'Perceptions of transparency of government policymaking: A cross-national study', Government Information Quarterly (26:1), pp. 148–157.

Rorissa, A., Demissie, D., and Pardo, T. 2011. 'Benchmarking e-Government: A comparison of frameworks for computing e-Government index and ranking', Government Information Quarterly (28:3), pp. 354–362.

Ruud, O. 2017. Successful digital transformation projects in public sector with focus on municipalities (research in progress).

Sadik-Zada, E. R., Gatto, A., and Niftiyev, I. 2022. 'E-government and petty corruption in public sector service delivery', Technology Analysis & Strategic Management, pp. 1–17.

Samuel, M., Doctor, G., Christian, P., and Baradi, M. 2020. 'Drivers and barriers to e-government adoption in Indian cities', Journal of Urban Management (9:4), pp. 408–417.

Savoldelli, A., Codagnone, C., and Misuraca, G. 2014. 'Understanding the e-government paradox: Learning from literature and practice on barriers to adoption', Government Information Quarterly (31), pp. S63–S71.

Schuppan, T. 2009. 'E-Government in developing countries: Experiences from sub-Saharan Africa', Government Information Quarterly (26:1), pp. 118–127.

Shareef, M. A., Kumar, V., Kumar, U., & Dwivedi, Y. K. (2011). E-government adoption model (GAM): Differing service maturity levels. *Government Information Quarterly, 28*(1), 17-35. https://doi.org/10.1016/j.giq.2010.05.005

Sihotang, D. M., Yudhistira, B. A., Solikin, Nugroho, W. S., Wibowo, W. C., Sensuse, D. I., et al. 2022. 'A Systematic Literature Review of Barriers and Drivers E-Government in Developing Countries: TOE Framework Perspective', in 2022 7th International Conference on Informatics and Computing, ICIC 2022, Institute of Electrical and Electronics Engineers Inc.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Sinha, S. K., Mukhopadhyay, S., Upadhyay, P., Dwivedi, Y. K., Bhattacharyya, S., Paul, M., et al. 2023. 'Challenges and opportunities in IT transformation of public service delivery: case of India Post', Transforming Government: People, Process and Policy (17:1), pp. 134–146.

Tantoush, M. (2022). P. A. and civil service reform in L. F. or success? M. Tantoush. 2022. Public Administration and civil service reform in Libya Failure or success?

Tapscott, D., and Tapscott, A. 2016. Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World, Penguin.

Tang, T., Hou, J. (Jove), Fay, D. L., and Annis, C. 2021. 'Revisit the drivers and barriers to e-governance in the mobile age: A case study on the adoption of city management mobile apps for smart urban governance', Journal of Urban Affairs (43:4), pp. 563–585.

Transparency International, 2023 'Libya - Transparency.org'.

Trček, D. 2019. 'APIs and emerging economy-driving digital transformation through e-government', In SHS Web of Conferences, EDP Science (65), p. 04009.

USAID DECA 2022. DIGITAL ECOSYSTEM COUNTRY ASSESSMENT (DECA) Libya NOVEMBER 2022.

Vandewalle Drik 2012. A History of Modern Libya.

Warschauer, M., Matuchniak, T., Pinkard, N., and Gadsden, V. 2010. 'New Technology and Digital Worlds: Analyzing Evidence of Equity in Access, Use, and Outcomes', Review of Research in Education (34), pp. 179–225.

Weerakkody, V., El-Haddadeh, R., and Al-Shafi, S. 2011. 'Exploring the complexities of e-government implementation and diffusion in a developing country: Some lessons from the State of Qatar', in Journal of Enterprise Information Management (24:2), pp. 172–196.

World Bank 2015. Labor Market Dynamics in Libya: Reintegration for Recovery, The World Bank.

World Bank 2022. 'WGI 2022 Interactive Interactive Data Access', in The World Bank Group.

World Bank 2023. 'The World Bank in Libya', in The World Bank Group.

Wynn, M., Bakeer, A., and Forti, Y. 2021. 'E-government and digital transformation in Libyan local authorities', International Journal of Teaching and Case Studies (12:2), p. 119.

Yildiz, M. 2007. 'E-government research: Reviewing the literature, limitations, and ways forward', Government Information Quarterly (24:3), pp. 646–665.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

From Trust Antecedents to Trust Frameworks: Co-Creating Multi-Actor Agreements for Data Sharing

Louise van der Peet [a*], *Nitesh* Bharosa[a], *Marijn* Janssen[a]

[a]Faculty of Technology, Policy, and Management, Delft University of Technology, Delft, the Netherlands, l.vanderpeet@tudelft.nl, 0009-0008-5022-4279.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 23 May 2025

Abstract. Companies and public agencies who are looking to improve their services can benefit from more data sharing. However, due to regulations and security concerns, data sharing between individuals, businesses and public agencies is complicated. There are many variables to consider in a multi-actor environment where actors with various roles and incentives look for legal and technical certainty. Public and private organizations increasingly acknowledge the need for multi-organizational agreements on data sharing standards. This results in the rise of trust frameworks to guide efforts towards trustworthy data sharing in an interorganizational setting. However, academic literature on trust frameworks is scarce, and we lack a systematic understanding of the factors that constitute trust in a multi-actor data sharing environment. The objective of this paper is to provide a systematic understanding of the antecedents of trust playing a role in trust frameworks. A two-stage approach is followed, starting with a systematic review of antecedents, followed by an empirical inquiry as verification. Our findings indicate a wide range of antecedents -including technological and organizational antecedents - can be considered.

Keywords. Trust frameworks, Multi-actor data sharing, GovTech, Digital infrastructures, Trust antecedents, Data sharing collaboration, Transformative innovations
Research paper, DOI: https://doi.org/10.59490/dgo.2025.1029

1. Introduction

Organizations increasingly recognize the value of sharing data across organizations and sectors to unlock new insights, optimize operations, and create public value (Dawes, 1996). When it comes to public service delivery and private service delivery, organizations seek to provide more personalized and proactive services, requiring more up front data from citizens or clients (Scholta et al., 2019). However, multi-actor data sharing is complex due to increased regulations on data, privacy requirements, heightened security risks, and diverse stakeholder interests. For instance, the General Data Protection Regulation (GDPR) poses strict requirements for personal data collection and processing in Europe. The revised eIDAS regulation (for "electronic IDentification, Authentication and trust Services") adds strict rules for identification, authentication, authorization, data exchange and archiving. And the NIS2 directive requires European organizations to enhance their cybersecurity capabilities, while introducing risk management measures and reporting requirements to entities from more sectors and setting up rules for cooperation, information sharing, supervision, and enforcement of cybersecurity measures. Accumulated, getting data from persons and organizations in a manner that is compliant to such regulations is not easy. There are even more complexities in multi-actor environments, where diverse stakeholders—ranging from individual citizens and private companies to governmental agencies—must balance various roles, cost structures, installed base, incentives, and legal obligations in data sharing decisions. In a sector or networked setting without a hierarchically dominant standard setter, actors looking to avoid costly 1-1 solutions or proprietary standards, must collaborate and agree on open standards that are compliant and scalable.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Trust frameworks seem to be an emerging solution for arranging information-sharing in multi-actor ecosystems. While much has been done on trust and trustworthiness, there is little academic grounding for the construct of trust frameworks in the context of multi-actor data sharing. "Trust" is frequently mentioned as foundational for successful data sharing: trust in responsible data handling, trust in regulatory compliance, and trust in the broader ecosystem of partners, etc. Trust can be both the input for collaboration, as well as the outcome of collaboration. Trust signals certainty, for instance regarding technology investment decisions by public and private organizations. Lack of trust can impede innovation and digital transformations that rely on multi-actor data sharing (Bharosa, 2022). Yet which factors determine trust are not known.

This paper seeks to address this gap by defining and categorizing the antecedents of trust in trust frameworks. The main research question is: *what are the antecedents of trust in multi-actor data sharing?*

We should distinguish between trust and trustworthiness. Although the two are used interchangeably, they have different meanings (Greenwood and Van Buren III, 2010). Trust is situational and exists on the trustor's side when they assess trustworthiness of the trustee (Sekhon et al., 2014). Trustworthiness is based on the characteristics of the trustee that lead the trustor to believe that the trustee will act in their best interest (Greenwood and Van Buren III, 2010). The articles included in the literature review often mean trustworthiness when they mention trust. However, it can be argued that antecedents for trust - factors leading to trust from the trustor - are the same as trustworthiness factors from the trustee. Therefore, and because previous literature refers to trust antecedents, we use trust rather than trustworthiness.

This paper proceeds as follows. Section 2 outlines the research approach. Section 3 presents the results of the systematic review of the literature: a long list of antecedents of trust. Section 4 outlines the empirical verification of the antecedents found in literature. Section 5 provides a discussion of the findings, comparing the literature with practice. Finally, Section 6 concludes this paper and provides recommendations for research and policy-making.

2. Research approach

The paper aims to provide a systematic understanding of the antecedents of trust in trust frameworks. A two-stage approach is followed, starting with a systematic review, followed by an empirical inquiry on antecedents. We found a large number of antecedents in the literature; therefore, explorative empirical research was needed to verify the list of antecedents. The central unit of analysis are the antecedents of trust, organized into categories.

First, we performed a systematic literature review to identify a long-list of trust antecedents from related topics of trust frameworks. We used the PRISMA method (Page et al., 2021) for systematic review of the literature to exclude papers from the search. The search query is discussed in section 3. The resulting long-list presented in Appendix A can be used as a starting point and refined in subsequent research. The goal of this paper is to find antecedents of trust for trust frameworks, but there is a limited amount of research that is about trust frameworks (van der Peet et al., 2024), therefore we investigated trust antecedents for related topics like interorganizational data sharing, information systems, and standardization.

Second, we wanted to explore the antecedents of trust in practice. Therefore, we organized an expert workshop to identify trust antecedents and ultimately verify those discovered in the literature. This workshop took place at a government practitioner's conference in October 2024 in the Netherlands. The workshop was around 45 minutes long. In total, 88 unique respondents participated in the workshop. 88% of the participants had direct experience working with one or more trust frameworks in practice. The first part of the workshop contained introductory questions on the concept of trust frameworks and the second part questioned the antecedents of trust, which were discussed in a large group setting. The antecedents were collected on Slido, an online platform for data collection. The participants contributed by adding trust antecedents in free form.

We used the results from the workshop to verify the long-list of antecedents derived from the literature. This is done by verifying subcategories that emerge from the literature, and adding antecedents mentioned in the workshop that were not found in literature. In this manner, we verify the subcategories for trust antecedents of trust frameworks, and extend the long-list.

2.1. Complexity of trust in multi-actor data sharing

In a multi-actor setting, data sharing becomes inherently more complex due to the involvement of multiple organizations, each with its own objectives, processes, standards, installed base and requirements for data processing and sharing. In such ecosystems, data sharing components (e.g. data specifications, definitions, APIs, exchange patterns, security policies, processing requirements etc) are never in sync. There is a continuous need for further development, harmonization and standardization due to changing regulations, business models, values chains, partners and security requirements. Moreover, as new technologies such as digital identities, cloud systems, wallets, distributed ledgers, sensors, IOT and artificial intelligence mature and enter the board room, new data sharing requirements and architectures emerge. That is why data sharing infrastructures are dynamic and always in transition to a new state. The varying interests and starting points complicate harmonization and standardization efforts. Some standards may cost some actors more than others, and at the same time benefit some actors more than others. The potential cost and benefits of standardization for data sharing is unevenly distributed in the ecosystem (e.g. Bharosa et al., 2015). Consequently, getting actors to collaborate requires a majority to trust that the future data sharing infrastructure is in their best interest and will benefit all of them on the long run, even though it will cost time, money and collective action on the short run. In a multi-actor ecosystem, it is very difficult to know, let alone trust each individual in the ecosystem. This means we have to move from trusting the human, to trusting the infrastructure, creating trustworthy systems. For this, data sharing collaborators can make agreements to ensure the trustworthiness of the system. In practice, these types of agreements are often described within a trust framework. A trust framework, as described by ARF, is "a legally enforceable set of operational and technical rules and agreements that govern a multi-party system designed for conducting specific types of transactions among a community of participants and bound by a common set of requirements." (eIDAS Expert Group, 2023).

The complexity of making these agreements highlights the need to understand trust antecedents for creating trustworthy multi-actor data sharing systems. Identifying and addressing these antecedents helps build confidence among participants, reduces uncertainty, and ensures collaboration in a diverse, multi-actor setting. By designing a framework around these factors of trust, a trustworthy system for multi-actor data sharing can emerge.

3. Literature review on trust antecedents

Although there is limited research about trust related to trust frameworks, there is a large amount of literature on trust antecedents in various settings. To find those applicable in trust frameworks, we performed a literature review that searches for trust in both organizational and technological contexts, specifically: trust in data sharing, interorganizational and cross-domain trust, trust in information systems and technology, trust in standardization, legal trust, operational trust, trust in governance and trust in collaboration. Consumer-centric terms like "social media" and "commerce" were excluded to maintain focus on trust frameworks. A Scopus 'title-keyword-abstract' search for these keywords, excluding social media, commerce, human-robot interaction, the sharing economy related papers, results to the following:

> TITLE-ABS-KEY (("antecedent of*" W/1 trust) OR "trust antecedent" OR "trust factor" OR "trust variable" OR (("antecedent of*" W/1 trustworthiness) OR "trustworthiness antecedent" OR "trustworthiness factor" OR "trustworthiness variable") AND TITLE-ABS-KEY ("data sharing" OR "interorganizational" OR "cross-domain" OR "information systems" OR "technology" OR "standardization" OR "legal" OR "operational" OR "governance" OR "collaboration") AND NOT TITLE-ABS-KEY ("social media" OR "social networking" OR "social network" OR "human-" OR "consumer" OR "customer" OR "commerce" OR "buyer" OR "technology acceptance model" OR "sharing economy")

The query was run in December 2024 and reveals 266 academic papers.

We used the PRISMA method (Page et al., 2021) for systematic literature reviews to exclude papers from the search. After excluding papers that do not identify trust antecedents, or that are not specific to the scope there are 45 papers left. A large amount of noise in the results came from the term trust factor, which is often used to describe a the result of a calculation to determine the trustworthiness of an actor or technical component in a digital environment (e.g. Chen et al., 2023, Wang et al., 2023, Al Shahrani et al., 2024). We systematically reviewed each included paper and extracted all reported trust antecedents, enabling comparison and

Subcategory	Description	Examples of Trust Antecedents
Organizational trustworthiness	Factors used to judge if an organization is credible, competent, and reliable	Reputation, Certifications, Demonstrated reliability, Partner's competence, Perceived similarity
Calculative trust	Rational assessment of costs, benefits, and feasibility in a partnership	Perceived feasibility, Benefit, Adoption by partners, Successful precedents
Transparency	Openness and clarity of communication, processes, and information sharing	Operational and procedural transparency, Open communication, Timely exchange of information, Pricing transparency
Institution-based trust	Formal rules, structures, and legal frameworks	Regulations, Contracts, Structural assurance, Procedural fairness, Consensus mechanisms
Relational trust	Trust arising from interpersonal bonds, goodwill, and shared values over time	Shared values, Commitment/loyalty, Benevolence, Predictability/consistency, Honesty/integrity
Mutuality	Equal distribution of roles, responsibilities, and influence	Equality in decision-making, Collaborative problem-solving, Balance of control, Mutual dependence
Intra-organizational competence	Internal capacity and support	Quality of governance, Organizational/technical support, Stable organizational structure, Power relations
Trust initiator	Roles or actions within the organization that spark or promote trust	Leadership engagement, Organizational encouragement, Recommendation
Data governance	Policies and processes ensuring data security, privacy, and reliability	Security, Regulatory compliance, Confidentiality, Data integrity, Data auditability
Knowledge (Tech)	Stakeholder skill, familiarity, and acceptance of technology	Satisfaction with existing system, Experience with the tech, Perceived usefulness, Positive user skill perception
Ability (Tech)	Technical system's performance, reliability, and user-friendliness	Availability, Usability, Network reliability, Privacy, Simplicity, Speed
Technical components	Specific tools or features that facilitate trust in technology	Smart contracts, Electronic documents, Audit and verification mechanisms

Tab. 1 – Subcategories of trust antecedents for trust frameworks, verified subcategories in italics

categorization of the extracted concepts. All extracted trust antecedents were categorized by grouping into thematically related categories and subcategories. The antecedents can be divided into two main categories: organizational trust and trust in technology. For both of these categories, the defined subcategories and trust antecedents can be found respectively in Appendix A. In total we find 118 trust antecedents, divided into 12 subcategories. The subcategories are defined in Table 1.

Collecting and classifying the trust antecedents mentioned in the literature gave us a starting point for understanding how trust is formed and maintained in multi-actor data-sharing settings like trust frameworks. Our classification into categories and subcategories shows that existing research covers a wide range of areas—such as technology, interorganizational relationships, and internal organizational factors—but does not directly address the context of trust frameworks. This gap highlights the need to study how these trust antecedents apply, or may need to be adapted, for trust frameworks specifically.

3.1. Examples of antecedents in practice

To illustrate the practical use of the identified antecedents, we investigate the paper 'Steering the adoption of Standard Business Reporting for cross domain information exchange' by Bharosa et al., 2018, which outlines adoption of the SBR trust framework.

Standard Business Reporting (SBR) is a government-led initiative that aims to standardize the way businesses

Trust category	Trust antecedent	Implementation in SBR
Transparency	Operational and procedural transparency	Open governance, clearly defined procedures
	Timely exchange of relevant information	Expert working group where knowledge is shared as much as possible
Institutional	Regulations	Mandate by public organizations
	Contract	Covenant to adopt SBR
	Consensus mechanism	Decision-making bodies
	Support structure	Direct feedback when parties encounter problems
Mutuality	Clarity of roles and responsibilities	Governance with Board, Platform and Expert groups
	Equality in decision-making and resource sharing	All parties have a say
Data governance	Data accuracy / authenticity	Standardized data formats, business rules
Technical ability	interoperability	Generic and shared exchange infrastructure
	Simplicity	Technically simple syntax and interface
	Compatibility	Reuse technical components as much as possible

Tab. 2 – Examples of how trust antecedents are implemented in Standard Business Reporting based on Bharosa et al., 2018

report information to public agencies. It was designed to reduce administrative burdens on businesses by enabling Qualified Information Exchange (QIE), achieved through a set of standards and a shared technical infrastructure.

The study highlights how various steering instruments were used to positively influence adoption. These strategies map well to the trust antecedents discussed in our framework. For example, transparency is reinforced through open governance structures and expert working groups that facilitate knowledge sharing; institutional trust is built through formal agreements; mutuality is reflected in the inclusive governance model, where all stakeholders, public agencies, businesses, intermediaries, and software providers, have a voice; data governance is strengthened through the use of business rules that ensure accuracy and authenticity; and technical trust is fostered through interoperability and simplicity. More examples of the antecedents in SBR can be found in table 2.

As highlighted in prior work the SBR case, where standardization was advanced through a deliberate combination of engineering and learning approaches (Bharosa et al., 2011), trust similarly emerges not from a single mechanism but from the intentional design, iterative learning, and adaptation of technical, institutional, and relational practices. This case serves as a practical demonstration of how trust antecedents can be implemented in a complex, multi-stakeholder setting.

4. Empirical verification: five additional antecedents

As the literature review focused on concepts related to trust, rather than trust frameworks specifically, we conducted a workshop with practitioners experienced in government-related trust frameworks. This allows us to verify the applicability and completeness of the literature-derived antecedents in a real-world setting. The participants were asked to come up with antecedents for trust in collaborative trust frameworks in free-form. In Table 1, the subcategories in italics were verified during the workshop. Furthermore, there were five antecedents mentioned in the workshop that did not appear in the literature, namely the following:

1. Oversight: Supervision, inspection and enforcement to ensure compliance, accountability, and alignment with agreed-upon standards or goals. This transparency reduces uncertainty and risk of hidden opportunistic behavior, reassuring parties that if something goes wrong, it will be detected and corrected.

2. Shared responsibility: The partners collectively bear the obligations, decision-making authority, and consequences of an initiative or process. Shared responsibility aligns incentives among partners, reducing suspicion of opportunism and creating trust.
3. Inclusion: The practice of actively involving diverse stakeholders—regardless of background, status, or perspective—in decision-making, processes, or benefits. The more people believe their voices influence outcomes and that processes are fair to all, the stronger the foundation for trust.
4. Trust services: An electronic service normally provided for remuneration that ensure the reliability, security, and legal validity of electronic transactions, as mentioned in eIDAS article 3 (European Parliament and the Council of the European Union, n.d.). This technical and legal assurance removes much of the guesswork and fear of fraud, making parties feel safer to interact or do business online.
5. Design: The purposeful planning and creation of processes, or systems optimize experiences, and align with overarching objectives. A well designed system makes expectations clear, minimizes errors, and prioritizes user needs, creating more confidence in the system or organization.

Given that the participants are all related to government agencies, the emphasis on oversight and shared responsibility may reflect public-sector norms of accountability and transparency, which might not be as pronounced in purely private-sector collaborations. Similarly, some of the trust frameworks that participants were involved in are related to digital identity, explaining why trust services related to eIDAS and digital identity were mentioned.

These findings underscore the importance of situational factors—like regulatory oversight and digital identity requirements—in shaping trust frameworks. Overall, the workshop validated most of our literature-derived subcategories and revealed additional considerations unique to governmental and regulated environments.

5. Discussion

The findings from our literature review and workshop show that there are many different trust antecedents potentially relevant to designing a trust framework. While this variety captures the complexity of trust, it also creates what we call 'trust design overload.' Practitioners aiming to design trust frameworks can quickly become overwhelmed by the extensive list of potential factors to consider.

This overload is further complicated by the fact that some trust antecedents are context-dependent. For instance, public-sector environments tend to emphasize formal oversight and regulated trust services, whereas private-sector collaborations may focus more on financial incentives or calculative trust. Similarly, small or medium-sized organizations might weigh resource availability and ease of implementation more heavily than larger entities with more capacity.

One way to address trust design overload is through prioritization. Practitioners can evaluate which trust antecedents are most relevant, deciding how to balance the need for different forms of trust. Nonetheless, prioritization demands overview of trust antecedents and insights in various design options and consequences. A potential solution for prioritization is tooling that can help practitioners navigate these choices.

This raises the question of whether a trust framework can be deliberately designed or whether it must grow organically through collaboration and trial and error—a question largely shaped by one's epistemological outlook. In this study, we adopt a positivistic stance by identifying and verifying antecedents for trust. Rather than viewing trust solely as an organic outcome, we treat it as a construct that can be systematically measured and deliberately shaped through specific interventions. However, the degree to which each antecedent is "designable" varies: for example, perceived similarity is contextual and not easily engineered, whereas certifications can be straightforwardly designed and implemented.

6. Conclusion and recommendations

6.1. Conclusion

The main goal of this paper is to contribute to an understanding of trust frameworks, specifically to provide a systematic understanding of antecedents of trust in trust frameworks. By systematically reviewing the literature and validating our findings with expert practitioners, we fill a gap in existing research on trust frameworks. The defined set of trust antecedents specifically addresses multi-actor data-sharing contexts.

In section 3, we create a long-list of antecedents of trust in trust frameworks through a systematic literature review. This results in 118 antecedents, which can be divided in 12 subcategories, and 2 categories. The practical relevance of these antecedents is illustrated through the case of Standard Business Reporting (SBR), highlighting that trust does not emerge only from implementing predefined mechanisms, but from the deliberate design combined with learning and continuous adaptation of technical, institutional, and relational practices.

We verified these antecedents with 88 trust framework practitioners in a workshop. Of the twelve subcategories in our original framework, nine were discussed in detail: 1. Organizational trustworthiness (e.g., reputation, certifications), 2. Calculative trust (e.g., perceived feasibility, successful precedents), 3. Transparency (e.g., open communication, timely exchange of information), 4. Institution-based trust (e.g., regulations, contracts), 5. Relational trust (e.g., shared values, benevolence), 6. Mutuality (e.g., equality in decision making, mutual dependence), 7. Data Governance (e.g., security, regulatory compliance), 8. Knowledge of technology (e.g., experience, perceived usefulness), and 9. Ability in technology (e.g., availability, usability). Practitioners also identified five additional antecedents not found in the literature: Oversight, Shared Responsibility, Inclusion, Trust Services, and Design.

By summing these antecedents and clarifying their relevance to multi actor collaborations, our study fills a research gap in the field of trust frameworks. Specifically, it provides an empirically validated set of trust antecedents that practitioners and researchers can use to develop, refine, and implement trust frameworks in diverse data sharing scenarios.

6.2. Limitations and Recommendations

We acknowledge several limitations. First, due to the scarcity of academic research on trust frameworks, our literature review focused on related areas. While this approach enabled the generation of a broad list of antecedents, it may have overlooked unique factors specific to trust frameworks. Second, the focus on Dutch public sector might limit the generalizability of the findings to private sector collaborations or other national contexts. Third, the use of free-text input through an online platform allowed for an open exploration of ideas, yet it may have resulted in less structured and consistent data, potentially missing subtle or implicit antecedents.

Public private organizations seeking to share data in a trustworthy way can use the insights from this study to inform collaborative data sharing agreements. By systematically incorporating the trust antecedents identified here, data sharing initiatives can better address legal and technical uncertainties, leading to more secure and trustworthy multi actor collaborations. However, implementing too many trust measures at once risks creating 'trust design overload,' emphasizing the need for further research on how to prioritize and balance these antecedents.

From a theoretical standpoint, we recommend three directions of research. First, tools or decision support systems are needed to simplify the design and implementation of trust frameworks, guiding organizations in selecting the most relevant antecedents without overcomplicating their agreements. Second, a further foundation for advancing or refining trust theory in multi-actor data sharing contexts can be developed. Third, research should expand the scope by examining diverse countries, industries, and settings to validate and deepen our understanding of trust antecedents in multi actor collaborations.

References

Abbas, R. M., Carroll, N., Richardson, I., & Beecham, S. (2018). Trust factors in healthcare technology: A healthcare professional perspective.

Adjei, J. K. (2015). Explaining the role of trust in cloud computing services. *info*, *17*(1), 54–67.

Al Shahrani, A. M., Rizwan, A., Sánchez-Chero, M., Cornejo, L. L. C., & Shabaz, M. (2024). Blockchain-enabled federated learning for prevention of power terminals threats in iot environment using edge zero-trust model. *The Journal of Supercomputing*, *80*(6), 7849–7875.

Alzahrani, A. S., Tsai, Y.-S., Aljohani, N., Whitelock-Wainwright, E., & Gasevic, D. (2023). Do teaching staff trust stakeholders and tools in learning analytics? a mixed methods study. *Educational technology research and development*, *71*(4), 1471–1501.

Ando, N., & Kee Rhee, D. (2009). Antecedents of interorganizational trust: Joint decision-making, cultural adaptation, and bargaining power. *Journal of Asia Business Studies*, *3*(2), 16–28.

Aulakh, P. S., Kotabe, M., & Sahay, A. (1996). Trust and performance in cross-border marketing partnerships: A behavioral approach. *Journal of international business studies*, *27*, 1005–1032.

Ayong, K., & Naidoo, R. (2020). An institutional trust perspective of cloud adoption among smes in south africa. *Information and Cyber Security: 18th International Conference, ISSA 2019, Johannesburg, South Africa, August 15, 2019, Proceedings 18*, 145–157.

Barroso-Méndez, M. J., Galera-Casquet, C., Valero-Amaro, V., & Nevado-Gil, M. T. (2019). Antecedents of relationship learning in business-non-profit organization collaboration agreements. *Sustainability*, *12*(1), 269.

Bharosa, N. (2022). The rise of govtech: Trojan horse or blessing in disguise? a research agenda. *Government Information Quarterly*, *39*(3), 101692.

Bharosa, N., Hietbrink, F., Mosterd, L., & Van Oosterhout, R. (2018). Steering the adoption of standard business reporting for cross domain information exchange. *Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age*, 1–10.

Bharosa, N., van Der Voort, H., Hulstijn, J., Janssen, M., De Winne, N., & Van Wijk, R. (2011). Impose with leeway: Combining an engineering and learning approach in the management of public-private collaboration. *Electronic Government: 10th IFIP WG 8.5 International Conference, EGOV 2011, Delft, The Netherlands, August 28–September 2, 2011. Proceedings 10*, 392–403.

Bharosa, N., van Wijk, R., & de Winne, N. (2015). *Challenging the chain: Governing the automated exchange and processing of business information*. Ios Press.

Chen, J., Wang, X., & Shen, X. (2023). Rte: Rapid and reliable trust evaluation for collaborator selection and time-sensitive task handling in internet of vehicles. *IEEE Internet of Things Journal*, *11*(7), 12278–12291.

Cheng, X., Fu, S., & de Vreede, G.-J. (2021). Determinants of trust in computer-mediated offshore software-outsourcing collaboration. *International Journal of Information Management*, *57*, 102301.

Cheng, X., Fu, S., & Druckenmiller, D. (2016). Trust development in globally distributed collaboration: A case of us and chinese mixed teams. *Journal of Management Information Systems*, *33*(4), 978–1007.

Cheng, X., Liu, J., Druckenmiller, D., & Fu, S. (2016). Trust development in globally distributed collaboration: A case study in china. *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 480–489.

Cheng, X., Liu, J., Huang, J., Yan, X., & Han, Y. (2016). Investigating trust factors in global virtual collaboration: A case study of a manufacturing company in china. *2016 49th Hawaii International Conference on System Sciences (HICSS)*, 697–706.

Cheng, X., & Macaulay, L. (2014). Exploring individual trust factors in computer mediated group collaboration: A case study approach. *Group Decision and Negotiation*, *23*, 533–560.

Cheng, X., Macaulay, L., & Zarifis, A. (2009). A case study of individual trust development in computer mediated collaboration teams. *2009 International Conference on Computational Science and Engineering*, *3*, 277–282.

Curcuruto, M., Mariani, M. G., & Lippert, S. K. (2009). La fiducia nei sistemi informatici. contributo alla validazione italiana di un modello. *Psicologia sociale, Social Psychology Theory Research*, (2/2009), 255–276. DOI: https://doi.org/10.1482/30126.

Dawes, S. S. (1996). Interagency information sharing: Expected benefits, manageable risks. *Journal of policy analysis and management*, *15*(3), 377–394.

De Jong, G., & Woolthuis, R. K. (2008). The institutional arrangements of innovation: Antecedents and performance effects of trust in high-tech alliances. *Industry and Innovation*, *15*(1), 45–67.

eIDAS Expert Group. (2023). EUDI Wallet Architecture and reference framework [Accessed: 2025-02-06]. https://eu-digital-identity-wallet.github.io/eudi-doc-architecture-and-reference-framework/1.1.0/arf/

Emaminejad, N., & Akhavian, R. (n.d.). Trust in construction ai-powered collaborative robots: A qualitative empirical analysis. In *Computing in civil engineering 2023* (pp. 513–521). DOI: https://doi.org/10.1061/9780784485224.062.

Ennen, N. L., Stark, E., & Lassiter, A. (2015). The importance of trust for satisfaction, motivation, and academic performance in student learning groups. *Social Psychology of education*, *18*, 615–633.

European Parliament and the Council of the European Union. (n.d.). Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC (Article 3) [Accessed: 2025-01-20]. https://eur-lex.europa.eu/eli/reg/2014/910/oj

Fischer, T. A., Hirschheim, R., & George, B. (2012). Governance in outsourcing relationships–the role of information technologies.

Ford, J. K., Riley, S. J., Lauricella, T. K., & Van Fossen, J. A. (2020). Factors affecting trust among natural resources stakeholders, partners, and strategic alliance members: A meta-analytic investigation. *Frontiers in Communication*, *5*, 9.

Gil-Garcia, J. R., Guler, A., Pardo, T. A., & Burke, G. B. (2010). Trust in government cross-boundary information sharing initiatives: Identifying the determinants. *2010 43rd hawaii international conference on system sciences*, 1–10.

Greenwood, M., & Van Buren III, H. J. (2010). Trust and stakeholder theory: Trustworthiness in the organisation–stakeholder relationship. *Journal of business ethics*, *95*, 425–438.

Hasche, N., Linton, G., & Öberg, C. (2017). Trust in open innovation–the case of a med-tech start-up. *European Journal of Innovation Management*, *20*(1), 31–49.

Hsu, M.-H., & Chang, C.-M. (2014). Examining interpersonal trust as a facilitator and uncertainty as an inhibitor of intra-organisational knowledge sharing. *Information Systems Journal*, *24*(2), 119–142.

Kett, H., Kasper, H., Falkner, J., & Weisbecker, A. (2012). Trust factors for the usage of cloud computing in small and medium sized craft enterprises. *Economics of Grids, Clouds, Systems, and Services: 9th International Conference, GECON 2012, Berlin, Germany, November 27-28, 2012. Proceedings 9*, 169–181.

Khorassani, J. M., Al-Karaghouli, W., & Ayios, A. (2011). Antecedents of trust in international joint ventures'(ijvs) performance in developing countries: A review of empirical evidence.

Kim, C.-S., Dinwoodie, J., & Seo, Y.-J. (2018). Inter-firm cooperation and collaboration in shipper—shipping company relationships for enhancing sustainability. *Sustainability*, *10*(10), 3714.

Kivijärvi, H., Leppänen, A., & Hallikainen, P. (2013). Technology trust: From antecedents to perceived performance effects. *2013 46th Hawaii International Conference on System Sciences*, 4586–4595.

Lai, I. K., & Tong, V. W. (2013). The impact of company, subject, and system characteristics on the trust factors affecting the adoption of internet-based interorganizational systems. *Information systems management*, *30*(4), 280–292.

Lai, I. K., Tong, V. W., & Lai, D. C. (2011). Trust factors influencing the adoption of internet-based interorganizational systems. *Electronic Commerce Research and Applications*, *10*(1), 85–93.

Lee, H.-W., Robertson, P. J., Lewis, L., Sloane, D., Galloway-Gilliam, L., & Nomachi, J. (2012). Trust in a cross-sectoral interorganizational network: An empirical investigation of antecedents. *Nonprofit and Voluntary Sector Quarterly*, *41*(4), 609–631.

Lippert, S. K., & Forman, H. (2006). A supply chain study of technology trust and antecedents to technology internalization consequences. *International Journal of Physical Distribution & Logistics Management*, *36*(4), 271–288.

Martins, J. T., & Baptista Nunes, M. (2016). Academics'e-learning adoption in higher education institutions: A matter of trust. *The Learning Organization*, *23*(5), 299–331.

Moon, S., Jung, S., & Jung, S. (2018). A study on trust factors in a multimedia service environment. *2018 International Conference on Information Networking (ICOIN)*, 67–69.

Mukherjee, D., Renn, R. W., Kedia, B. L., & Mukherjee, D. (2012). Development of interorganizational trust in virtual organizations: An integrative framework. *European Business Review*, *24*(3), 255–271.

Nilsson, M., & Mattes, J. (2015). The spatiality of trust: Factors influencing the creation of trust and the role of face-to-face contacts. *European Management Journal*, *33*(4), 230–244.

Oba, B., & Semercioöz, F. (2005). Antecedents of trust in industrial districts: An empirical analysis of inter-firm relations in a turkish industrial district. *Entrepreneurship & Regional Development*, *17*(3), 163–182.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The prisma 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. DOI: https://doi.org/10.1136/bmj.n71.

Pinem, A. A., Immanuella, I. M., Hidayanto, A. N., & Phusavat, K. (2018). Trust and its impact towards continuance of use in government-to-business online service. *Transforming Government: People, Process and Policy*, *12*(3/4), 265–285.

Putz, B., & Pernul, G. (2019). Trust factors and insider threats in permissioned distributed ledgers: An analytical study and evaluation of popular dlt frameworks. *Transactions on Large-Scale Data-and Knowledge-Centered Systems XLII*, 25–50.

Rashid, F., & Edmondson, A. C. (2011). Risky trust.

Rusman, E., Van Bruggen, J., Sloep, P., & Koper, R. (2010). Fostering trust in virtual project teams: Towards a design framework grounded in a trustworthiness antecedents (twan) schema. *International journal of human-computer studies*, *68*(11), 834–850.

Rychkova, I., & Ghriba, M. (2023). Trustworthiness requirements in information systems design: Lessons learned from the blockchain community. *Complex Systems Informatics and Modeling Quarterly*, (35), 67–91.

Salampasis, D., Mention, A.-L., & Torkkeli, M. (2014). Open innovation and collaboration in the financial services sector: Exploring the role of trust. *International Journal of Business Innovation and Research*, *8*(5), 466–484.

Scholta, H., Mertens, W., Kowalkiewicz, M., & Becker, J. (2019). From one-stop shop to no-stop shop: An e-government stage model. *Government Information Quarterly*, *36*(1), 11–26.

Sekhon, H., Ennew, C., Kharouf, H., & Devlin, J. (2014). Trustworthiness and trust: Influences and implications. *Journal of marketing management*, *30*(3-4), 409–430.

St. John, M. F., & Dustin Young, M. (2021). A decision support tool for assessing trust in an enterprise data sharing partner. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *65*(1), 1015–1019.

van den Heuvel, R., van de Wetering, R., Kruidhof, O., Bos, R., & Trienekens, J. (2021). How distributed ledger technology can influence trust improving data sharing in collaborative networks. *Exploring Innovation in a Digital World: Cultural and Organizational Challenges*, 62–76.

van der Peet, L., Bharosa, N., Dijkhuis, S., & Janssen, M. (2024). Understanding trust frameworks: Goals and components identified through a case study. *International Conference on Electronic Participation*, 223–238.

Wang, S., Zheng, X., Yang, S., & Wang, X. (2023). Towards efficient blockchain-based cross-domain trust reputation management for ls-hetnet. *GLOBECOM 2023-2023 IEEE Global Communications Conference*, 5129–5134.

Zhang, Y., Tavalaei, M. M., & Parry, G. C. (2024). Trustless is not trust free: How to build trust for organisations adoption of blockchain technology. *IET Conference Proceedings CP881*, *2024*(7), 163–168.

Zuppa, D., Olbina, S., & Issa, R. (2016). Perceptions of trust in the us construction industry. *Engineering, Construction and Architectural Management*, *23*(2), 211–236.

Appendix A

Tab. 3 – Inter-organizational trust antecedents

Subcategory	Trust Antecedent	References	Trust antecedent	references
Organizational trustworthiness	Reputation	Zhang et al., 2024 Cheng et al., 2021 Ford et al., 2020 Moon et al., 2018 Nilsson and Mattes, 2015 Cheng and Macaulay, 2014 Kett et al., 2012 Lee et al., 2012 Oba and Semercioöz, 2005	Relational history, previous experience	Zhang et al., 2024 Alzahrani et al., 2023 Ford et al., 2020 Kett et al., 2012 Mukherjee et al., 2012 Khorassani et al., 2011 De Jong and Woolthuis, 2008
	Partner's environment	Moon et al., 2018 Cheng, Fu, and Druckenmiller, 2016 Cheng, Liu, Huang, et al., 2016 Khorassani et al., 2011	Perceived similarity	Ennen et al., 2015 Nilsson and Mattes, 2015 Khorassani et al., 2011 Rusman et al., 2010
	Trusting stance	Nilsson and Mattes, 2015 Kivijärvi et al., 2013 Lee et al., 2012	Certifications	Kett et al., 2012
	Knowledge of partners	Gil-Garcia et al., 2010	Project as main business focus	Alzahrani et al., 2023
	Demonstrated reliability	Cheng et al., 2021 van den Heuvel et al., 2021 Cheng, Fu, and Druckenmiller, 2016 Zuppa et al., 2016 Alzahrani et al., 2023 Cheng and Macaulay, 2014 Moon et al., 2018 Rusman et al., 2010 Cheng et al., 2009	Partner's competence	St. John and Dustin Young, 2021 van den Heuvel et al., 2021 Moon et al., 2018 Hasche et al., 2017 Zuppa et al., 2016 Mukherjee et al., 2012 Rusman et al., 2010 Oba and Semercioöz, 2005 Lee et al., 2012
	Shared sectoral affiliation	Lee et al., 2012		
Calculative trust	Perceived feasibility	Zhang et al., 2024	Adoption by partners and competitors	Ayong and Naidoo, 2020
	Benefit	Cheng, Liu, Druckenmiller, and Fu, 2016 Cheng, Liu, Huang, et al., 2016 Cheng and Macaulay, 2014 Cheng et al., 2009 Cheng et al., 2021	Successful precedents	Zhang et al., 2024
Transparency	Operational and procedural transparency	Putz and Pernul, 2019 van den Heuvel et al., 2021 Alzahrani et al., 2023 Rashid and Edmondson, 2011	Open communication	Ford et al., 2020 Kim et al., 2018 Cheng, Fu, and Druckenmiller, 2016 Mukherjee et al., 2012 Khorassani et al., 2011 De Jong and Woolthuis, 2008
	Timely exchange of relevant information	Kim et al., 2018 De Jong and Woolthuis, 2008 Oba and Semercioöz, 2005 Aulakh et al., 1996	Pricing and cost transparency	Kett et al., 2012
	Transparency facilitated by IT	Fischer et al., 2012		
Institution-based trust	Structural assurance	Cheng et al., 2021 Nilsson and Mattes, 2015	Adaptability of agreements	van den Heuvel et al., 2021

	Procedural fairness	Ford et al., 2020 Rusman et al., 2010 Ando and Kee Rhee, 2009 Rashid and Edmondson, 2011	Regulations	Ayong and Naidoo, 2020 Kim et al., 2018 Salampasis et al., 2014
	Contracts	Ayong and Naidoo, 2020 Hasche et al., 2017 De Jong and Woolthuis, 2008	Standards	Ayong and Naidoo, 2020
	Consensus mechanisms	Putz and Pernul, 2019	Rewards and recognition	Martins and Baptista Nunes, 2016
	Support structure	Martins and Baptista Nunes, 2016	Consistency in policy and guidelines	Martins and Baptista Nunes, 2016
	Informal institutional arrangements	Oba and Semerciöz, 2005		
Relational trust	Shared values	van den Heuvel et al., 2021 Ford et al., 2020 Barroso-Méndez et al., 2019 Ayong and Naidoo, 2020 Kivijärvi et al., 2013 Mukherjee et al., 2012 Rusman et al., 2010	Commitment / loyalty	van den Heuvel et al., 2021 Khorassani et al., 2011 Rusman et al., 2010
	Benevolence / supportiveness	van den Heuvel et al., 2021 St. John and Dustin Young, 2021 Ford et al., 2020 Hasche et al., 2017 Adjei, 2015 Mukherjee et al., 2012 Rusman et al., 2010	Predictability / consistency	van den Heuvel et al., 2021 Moon et al., 2018 Rusman et al., 2010
	Friendliness	van den Heuvel et al., 2021 Cheng and Macaulay, 2014 Rusman et al., 2010	Spirit of cooperation	van den Heuvel et al., 2021 Cheng, Liu, Huang, et al., 2016 Salampasis et al., 2014 Cheng and Macaulay, 2014
	Honesty / integrity	van den Heuvel et al., 2021 Moon et al., 2018 St. John and Dustin Young, 2021 Adjei, 2015 Mukherjee et al., 2012 Rusman et al., 2010	Equitable treatment of partners	Kim et al., 2018
	Positive attitude	Moon et al., 2018	Effective collaboration	Zuppa et al., 2016
	Face-to-face communication	Zuppa et al., 2016	Engagement and motivation	Cheng, Liu, Druckenmiller, and Fu, 2016 Cheng, Liu, Huang, et al., 2016 Cheng and Macaulay, 2014 Rusman et al., 2010
	Direct social exchange	Nilsson and Mattes, 2015	Social interaction ties	Hsu and Chang, 2014
	Shared knowledge-sharing vision	Hsu and Chang, 2014	Shared goals	Lee et al., 2012 Mukherjee et al., 2012 Rusman et al., 2010
	Relationship multiplexity	Lee et al., 2012	Boundary spanner trust	Mukherjee et al., 2012
	Strategic bond	Khorassani et al., 2011	Flexibility	Khorassani et al., 2011 Aulakh et al., 1996
	Shared language	Rusman et al., 2010	Availability	Rusman et al., 2010

	Discretion	Rusman et al., 2010	Cultural adaptation	Ando and Kee Rhee, 2009
	Continuity expectation	Aulakh et al., 1996	Shared interest	Nilsson and Mattes, 2015
	Interactional expertise	Rashid and Edmondson, 2011		
Mutuality	Equality in decision making and resource sharing	Kim et al., 2018 Khorassani et al., 2011 Rusman et al., 2010	Collaborative problem solving	Kim et al., 2018
	Monitoring mechanisms	Kim et al., 2018 Aulakh et al., 1996	Balance of influence / control	Cheng, Liu, Druckenmiller, and Fu, 2016 Cheng, Liu, Huang, et al., 2016 Cheng and Macaulay, 2014 Gil-Garcia et al., 2010
	Complementarity / compatibility	Khorassani et al., 2011	Clarity of roles and responsibilities	Gil-Garcia et al., 2010 Rusman et al., 2010 Emaminejad and Akhavian, n.d.
	Mutual dependence	De Jong and Woolthuis, 2008	Consequences for actions	Oba and Semerciöz, 2005
	Fair distribution of risks and profits	Kim et al., 2018 Khorassani et al., 2011		
Intra-organizational competence	Organizational and technical support and training	Alzahrani et al., 2023 Abbas et al., 2018 Emaminejad and Akhavian, n.d.	Quality of governance and leadership	Abbas et al., 2018 Adjei, 2015 Cheng, Fu, and Druckenmiller, 2016 Martins and Baptista Nunes, 2016
	Alignment with organizational culture	Martins and Baptista Nunes, 2016	Proprietary Legacy	Salampasis et al., 2014
	Societal orientation	Salampasis et al., 2014	Financial education	Salampasis et al., 2014
	Stable organizational structure	Kivijärvi et al., 2013	Power relations	Kivijärvi et al., 2013
	Understanding and education regarding tech	Emaminejad and Akhavian, n.d. Alzahrani et al., 2023		
Trust initiator	Leadership engagement	Zhang et al., 2024 Rashid and Edmondson, 2011 Cheng et al., 2009	Organizational encouragement	Kivijärvi et al., 2013 Emaminejad and Akhavian, n.d.
	Recommendation	Kett et al., 2012 Pinem et al., 2018	Authoritative endorsements	Zhang et al., 2024

Tab. 4 – Technical trust antecedents

Subcategory	Trust Antecedent	References	Trust antecedent	references
Data governance	Security	Zhang et al., 2024 Abbas et al., 2018 Lai and Tong, 2013 Kett et al., 2012 Lai et al., 2011	Regulatory compliance	Zhang et al., 2024 Abbas et al., 2018

	Access control / Authentication / Authorization	Alzahrani et al., 2023 Putz and Pernul, 2019 Rychkova and Ghriba, 2023	Data accuracy / Authenticity	Alzahrani et al., 2023 Putz and Pernul, 2019 Zhang et al., 2024
	Data understandability	Alzahrani et al., 2023	Confidentiality	Rychkova and Ghriba, 2023 van den Heuvel et al., 2021
	Accountability	Rychkova and Ghriba, 2023	Data integrity	Rychkova and Ghriba, 2023
	Data compliance	Rychkova and Ghriba, 2023	Data auditability	Rychkova and Ghriba, 2023
Knowledge	Satisfaction with existing system	Lippert and Forman, 2006	Experience with the tech	Lippert and Forman, 2006 Abbas et al., 2018 Pinem et al., 2018 Lippert and Forman, 2006
	Perceived usefulness / ease of use	Pinem et al., 2018	Positive perception of user skill	Kivijärvi et al., 2013
Ability	Competence of task	Rychkova and Ghriba, 2023 Abbas et al., 2018 Adjei, 2015 Cheng and Macaulay, 2014	Automation	Rychkova and Ghriba, 2023
	Decentralization	Rychkova and Ghriba, 2023	interoperability	Rychkova and Ghriba, 2023 Lai and Tong, 2013 Lai et al., 2011
	Performance / quality	Rychkova and Ghriba, 2023 Ford et al., 2020 Pinem et al., 2018 Kett et al., 2012	Resilience	Rychkova and Ghriba, 2023 Kett et al., 2012
	Availability	Rychkova and Ghriba, 2023 Putz and Pernul, 2019 Lai and Tong, 2013 Kett et al., 2012 Lai et al., 2011	Usability	Rychkova and Ghriba, 2023 Abbas et al., 2018 Lai and Tong, 2013 Kett et al., 2012 Lai et al., 2011 Cheng et al., 2009 Curcuruto et al., 2009 Lippert and Forman, 2006
	Non repudiation	Rychkova and Ghriba, 2023	Tech transparency	Rychkova and Ghriba, 2023
	Traceability	Rychkova and Ghriba, 2023	Privacy	Rychkova and Ghriba, 2023 Adjei, 2015
	Storage integrity	Putz and Pernul, 2019	Cryptographic reliability	Putz and Pernul, 2019
	Network reliability	Putz and Pernul, 2019	System reliability	Abbas et al., 2018 Lai and Tong, 2013 Lai et al., 2011 Curcuruto et al., 2009
	Compatibility	Abbas et al., 2018	Simplicity	Salampasis et al., 2014
	Speed	Kett et al., 2012	Predictability	Curcuruto et al., 2009
	Absence of problems	Curcuruto et al., 2009		
Technical components	Smart contracts	Putz and Pernul, 2019	Electronic documents	Zuppa et al., 2016
	Audit and verification mechanisms	Lai and Tong, 2013 Lai et al., 2011		

LiS - An AI for reviewing user service letters using plain language.

Adelnei de L. C. Felix[a] , *A. Carolina* Lopes Pessoa[b],

[a] Secretaria de Administração de Pernambuco, Recife, PE, Brasil, adelnei.felix@gmail.com
[b] Secretaria de Administração de Pernambuco, Recife, PE, Brasil, carol.lopes.sad@gmail.com

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 21 May 2025

Abstract. Digital transformation is a consolidated topic on government agendas and the use of AI-Artificial Intelligence in this context is increasingly expanding. However, efforts are needed to ensure that the digital transformation of public services no longer creates a channel for social exclusion. A key component in this sense is the use of clear language in products and information for access to digital public services. The main objective of this work is to describe the experience report of the construction of an Artificial Intelligence-AI, called LiS, with the purpose of improving the quality of the contents of service letters to users, from bodies of a subnational entity in Brazil. We will present the stages of developing the LiS, to review the contents of service letters to users, using plain language writing techniques. The combination of an automatic review, using LiS and a manual step, in the process of preparing and reviewing service letters for users, presented significant results in the services, which had their contents reviewed in this process. This gain was observed from the analysis of the results of evaluations of the content of services accessed by citizens. Another significant result presented was the reduction in review time for service letters. The use of the AI tool balanced with a human review stage, in the context of building and reviewing service letters for users, demonstrates efficiency in this process. Additionally, this combination reflects an approach to increase inclusion in citizen access to public services.

Keywords. Digital transformation, plain language, Artificial Intelligence, Inclusivity
Short case practical report, DOI: https://doi.org/10.59490/dgo.2025.1003

1. Introduction

Digital transformation is a reality in the business models of government entities both at the federal level and also in the states and municipalities of a federation. Governments have expanded the use of information and communication technologies to improve services delivered to citizens, reduce operational costs, increase transparency, support decision-making, as well as increase citizen engagement in government policies. This process of digital transformation has a lot of complexity involved, and this advancement of technologies and the development of digital public services is often not fully inclusive, UN (2024). Digital transformation is not just about technologies and innovations. It requires, among other things, well-defined strategies to promote initiatives so that this process does not create new layers of inequality. As presented by the UN (2022), the new face of inequality is digital and digital government can be a driver to equalize this phenomenon. Therefore, in the context of public organizations, it is necessary to encourage initiatives to combine the effective use of new technologies, in order to minimize factors that lead to exclusion. Inclusion, from the conception of projects, must be prioritized in relation to digital by standard, UN (2024).

One of the aspects identified as a facilitator in this context is the use of plain language in the Government's communication with society. The objective of this work is to report the case of building an Artificial Intelligence-AI tool, called LiS, for use in the process of building and updating service letters for users. This article is organized as follows: in Section 2, a basic set of concepts and work related to the article, in Section 3, the stages of building the tool are described with the main results presented. Finally, Section 4 presents conclusions.

Copyright ©2025 by the authors. This conference paper is pubLiShed under a CC-BY-4.0 license

2. Concepts and related works

2.1 User services letters

Brazilian federal law, 13,460 of June 2017, Brazil (2017), known as the code for the defense of the rights of users of public services, is an instrument created with the aim of expanding the capacity of public entities to meet social demands, simplifying the lives of citizens. Applicable to all public bodies and entities, at different levels of the federation, the law determines, among other things, the preparation of user service letters. The user services letter is an instrument that aims to inform users about the services offered by public bodies and entities, the forms of access and quality commitments.

The regulations determine that each service described in the user service letters must provide clear and precise information regarding how the user can access the service. The minimum information that must be included is: requirements, documents necessary to obtain the service, forms and information necessary to access the service, main steps for carrying out the service, forecast of the maximum period for providing the service, places and ways for the user to present any statement about the provision of the service. Once prepared, user service letters must be updated periodically with permanent dissemination and publication on the body or entity's website. The user services charter is also cited as one of the essential components for the digital provision of services. Brazil (2021).

2.1 Plain language in the public sector

The concept of plain language according to the International Plain Language Federation (2024), defines that a communication is in plain language if the words, structure and design to which the readers are addressed, allows this audience to easily find the information they need, understand what you found and use the information for your purpose. The focus is on the reader of the content, so that they can understand a document written in plain language on the first reading. In this sense, it is necessary to understand what the reader wants to know, what information they need and thus achieve their goals PLAIN (2024) .

In the context of Brazilian public organizations, the use of plain language has initiatives that are growing more and more. From a regulatory perspective, Federal Law 13,460 of June 2017, Brazil (2017), which in the chapter on basic rights and duties of users, estabLiShes among its guidelines the use of plain and understandable language, avoiding the use of acronyms, jargon and foreign language. In a subnational approach, the Municipal Plain Language Program of the City of São Paulo, estabLiShed based on Decree 59,067 of 2019, São Paulo (2019), and state Law No. 18,246 of December 1, 2022, which estabLiShes the language policy plain, in the State of Ceará, Ceará (2022), are examples of regulatory initiatives. Work carried out in innovation laboratories such as LAB 11. São Paulo City Hall Government Innovation Laboratory, Lab11 (2022) and the Innovation and Data Laboratory, Iris (2023), are other examples of initiatives to encourage the use of plain language in the context of Brazilian public organizations.

In addition to the examples cited and in the direction of making the use of plain language more effective in all communication with citizens, in public administration bodies and entities in Brazil, bill no. 6,256 of 2019 is being processed in the Brazilian Senate, which estabLiShes the National Plain Language Policy in bodies and entities of direct and indirect public administration of all federative entities, Brazil (2019).

Considering the importance of the topic and the need to promote the theme of plain language, at a subnational level in Brazil, the Brazilian Association of State and Public Entities of Information and Communication Technology, ABEP-TIC (2024) included in its Supply Index Digital Public Services of State and District Governments 2024, a dimension that evaluated the use of Plain Language in the description of public services presented on the Service Portals of Brazilian States, seeking to verify the engagement of federative units in better service to citizens. In the same direction of boosting the use of plain language, ABEP-TIC (2022) prepared the Guide for Using Simple Language for Presenting Services.

In the context of this work, we will use plain language techniques to prepare the texts presenting the services contained in the service letters to users, described in the previous section.

2.2 Artificial Intelligence - AI

Artificial Intelligence, although currently in evidence, is not a new concept. Since the beginnings of AI, researchers such as Russell and Norvig (2021) highlight that the evolution of intelligent systems has occurred through different approaches, from rule-based systems to deep neural networks. The recent advancement of generative AIs, especially those developed by OpenAI, has popularized the use of language models based on neural networks through accessible interfaces and simple prompts. GPT (Generative Pre-trained Transformer) is a notable example of this technology, supported by the Transformer architecture, which takes advantage of attention

Copyright ©2025 by the authors. This conference paper is publiShed under a CC-BY-4.0 license

mechanisms to understand the relationship between words in large text sequences in a parallel and contextualized way.

The Transformer architecture revolutionized natural language processing (NLP) by allowing the model to process and generate text while simultaneously considering multiple contexts within the same sentence or paragraph. Through the self-attention mechanism, the model is able to "weigh" different parts of the input text, understanding long-distance relationships between terms that, in other approaches, would be disconnected (Vaswani et al., 2017). As described by Sejnowski (2018), this advance in PLN enabled the creation of more robust and versatile models, allowing for diverse applications, from virtual assistants to automatic diagnoses.

The development and application of a GPT model can be divided into three main steps. In the first of them, pre-training, the model is trained with a large amount of textual data collected from different sources on the internet, which allows it to acquire knowledge of grammar, linguistic structures and general information about the world, although it is not yet targeted at a specific task. The ability to predict the next word in any context allows the model to build a solid foundation of linguistic understanding (Brown et al., 2020).

Next, the fine-tuning stage takes place, in which the GPT undergoes an adaptation focused on more specific tasks, such as translation, summarization or, in the case of this work, the review and generation of User Service Letters . This tuning is performed with smaller, specialized datasets that contain examples and instructions specific to the target task. According to Kai-Fu Lee (2018), this step is crucial to ensure that AI models are adaptable to different contexts and can meet the specific requirements of sectors such as health, education and public administration.

Finally, for organizational or government tasks, there is often a third step focused on personalized training and ongoing validation, in which the model is tested in controlled scenarios and receives constant feedback from experts. These adjustments are made through "prompt engineering", which consists of adding or modifying instructions to correct inconsistent output. It is also at this stage that, for example, a good practice guide is recorded, documenting recommendations and recurring corrections to guide the safe and effective use of the model.

3. Case description

3.1 Context

State law No. 16,420 of September 17, 2018, of the state of Pernambuco, Brazil, Pernambuco (2018), determined, among other matters, the obligation of public entities in the State, to prepare their User Service Letters, in accordance with the guidelines of Federal Law 13,460 of June 2017, Brazil (2017). The Pernambuco State Administration Secretariat was the government body with the responsibility of defining the methodology for pubLiShing the Services Letters to Users services on the State services portal, for citizens to access. Tab 1 shows the evolution of the number of services pubLiShed on the portal over the years, starting from the launch in August 2018.

Tab. 1 - Number of public services, pubLiShed on the services portal

Year	Number of services
2018	639
2019	725
2020	950
2021	1.003
2022	1.026
2023	1.065
2024	693

Despite the increase in the number of services pubLiShed on the services portal over the years, originating from service letters to users, some problems were identified when analyzing the content of the services, two of which are main: i. pubLiShed services, which were not public services for the citizen and ii. the quality of the texts presented difficulties in understanding from the citizens' perspective.

Copyright ©2025 by the authors. This conference paper is pubLiShed under a CC-BY-4.0 license

Based on the identification of these main problems, some actions were defined, including: i. adjustment to the methodology for preparing user service letters, with greater emphasis on the use of Plain Language; ii. definition of clearer criteria for distinguishing "what is and what is not a public service for user service letters", with contextualized examples; iii. implement a routine for updating public agents responsible for preparing service letters for users, based on monthly courses.

In parallel to these actions, in 2024 the development of Artificial Intelligence - AI began to support the team in the process of reviewing service letters for users.

3.2 Implementation of LiS

The success of using GPT models strongly depends on an iterative training and validation cycle. In particular, for public bodies, aspects such as clarity, coherence, use of civil language and legal compliance are fundamental. Adjusting the GPT for a government context requires additional care, such as ensuring data curation that excludes biases and misinformation, in order to protect the institutional image and ensure the correct provision of services; promote transparency and explainability, as AI models can generate convincing but incorrect content, which makes continuous training and validation by experts essential; maintain a constant concern with ethics and security, observing principles of data protection and non-discrimination, as well as ensuring human reviews that validate the content; in addition to enabling customization and scalability, allowing, upon mastering the task, the model to be applied on a large scale, such as reviewing hundreds of services in a few weeks, significantly optimizing efficiency in the public sector.

During LiS's initial training and learning phase, the creation and review of the first 20 services most accessed by the population were monitored by a multidisciplinary team that sought to identify flaws and possible adjustment needs in real time. Whenever inconsistencies or errors occurred in the generation of content, they were corrected through *prompt engineering*—either by reinforcing instructions from pre-training or by introducing new guidelines.

To consolidate learning, the most recurrent failures were recorded in a guide on good practices for using LiS, with direct instructions on how to overcome them when preparing prompts. Still in the controlled testing stage, LiS reviewed another 100 service descriptions, which subsequently underwent human validation to check for any remaining inconsistencies. In less than two weeks, the AI had already reviewed more than 300 service letters from 13 agencies of the Government of Pernambuco, demonstrating scalability potential and contributing to speeding up the process of producing official documents in simple language.

3.3 Results

The combination of using LiS with a manual review stage of service texts was initially implemented in a set of the 20 services most accessed by the population, starting in November 2024. To monitor citizen satisfaction regarding service texts, the service portal has a content evaluation, where citizens can leave their opinion on whether the content of the service they accessed was useful to them, marking "yes", positive evaluation, or "no", otherwise, evaluation negative. Tables 2, 3 and 4 show the evolution of this content assessment of the three services most accessed by the population throughout 2024, respectively: "Obtain 1st copy Identity Card service", "Obtain 2st copy Identity Card service", and "Get a Job Vacancy".

It is important to note that the review of services with the LiS was made available together with a new version of the service portal, which brought changes to the tool's design, and this update was publicized in the press and social media. To consider this situation, when analyzing the results, we included the following information in the tables: "% of positive evaluations", proportion of positive evaluations in relation to the total number of evaluations and "number of accesses" to the service by citizens on the portal.

Copyright ©2025 by the authors. This conference paper is pubLiShed under a CC-BY-4.0 license

Tab. 2 - Evolution of content assessment - Obtain 1st copy Identity Card service

Month	It was useful	It wasn't useful	% positive	number of access
January	401	46	89,71	189.772
February	218	28	88,62	119.715
Mach	243	38	86,48	137.289
April	400	87	82,14	208.387
May	296	43	87,32	160.142
June	209	39	84,27	119.093
July	276	55	83,38	173.846
August	238	42	85,00	152.571
September	225	54	80,65	147.233
October	147	38	79,46	147.328
November	2.709	127	95,52	900.429
December	1.418	39	97,32	681.263

Tab. 3 - Evolution of content assessment - Obtain 2st copy Identity Card service

Month	It was useful	It wasn't useful	% positive	number of access
January	522	59	89,85	389.962
February	304	34	89,94	278.047
Mach	421	65	86,63	327.077
April	507	76	86,96	405.755
May	322	48	87,03	352.398
June	290	40	87,88	271.081
July	421	64	86,80	349.857
August	332	47	87,60	336.063
September	205	32	86,50	304.907
October	198	41	82,85	321.610
November	5.740	306	94,94	2.359.464
December	3.217	168	95,04	1.777.558

Copyright ©2025 by the authors. This conference paper is pubLiShed under a CC-BY-4.0 license

Tab. 4 - Evolution of content assessment. Get job vacancy service

Month	It was useful	It wasn't useful	% positive	number of access
January	56	12	82,35	20.782
February	29	5	85,29	14.569
Mach	17	5	77,27	14.673
April	50	9	84,75	19.129
May	55	8	87,30	20.502
June	33	7	82,50	16.407
July	37	6	86,05	21.969
August	40	4	90,91	20.741
September	32	4	88,89	17.209
October	31	7	81,58	19.173
November	67	16	80,72	39.660
December	100	6	94,34	29.033

It is possible to identify, when analyzing the tables, a significant evolution in the evaluation of content by citizens, in the first two months (November and December) of using LiS in reviewing texts, with a human conference stage, in the two main services, Tab 2 and Tab 3. The increase in the number of accesses to both services in the same period can be seen as a reason for the launch of the new portal, and the publicity actions in the press, as mentioned previously. Even with this situation, of launching the new portal, at the same time of using LiS in reviewing texts, the percentage above 90% of positive evaluations, not identified in the months prior to November, and remaining high in the second month, December, is an indicator of success in reviewing the texts.

According to Tab 4, it is possible to identify in the month of November, the second lowest percentage of positive evaluations, 80.72%, of the service in the year 2024. However, in December, it presented the highest percentage 94.34%, similar to the same month's percentages for Tab 2 and Tab 3 services, above 94%.

Another aspect in this process of reviewing the contents of service letters to users is the time spent reviewing the service texts by the team. Before implementing LiS, a revised service with human interaction took an average of 30 minutes. Using LiS, a service reviewed with LiS lasts, on average, 3 seconds, with a human review taking an average of two minutes.

4. Conclusion

The objective of this work was to present an experience report on the construction of an Artificial Intelligence-AI, called LiS, to support the process of reviewing the contents of service letters to users, based on Plain Language guidelines, in order to improve citizen understanding when accessing public services. To this end, we present the main problems in the preparation of user service letters identified over six years, and the stages in the development of LiS. Following the implementation of the user services letters reviewed by LiS, in November 2024, it was possible to perceive a relevant set of significant results that demonstrate an improvement in the usefulness of texts for citizens, detected from the analysis of content evaluations. Another relevant result for the process was the reduction in time spent by teams reviewing the contents of user service letters.

The experience with LiS illustrates the potential of generative AIs like GPT to modernize the writing and review of official documents. The process, which includes pre-training, fine-tuning and constant validation, allows the technology to be gradually improved for the public services context, ensuring clarity, reliability and adherence to legal standards. The use of GPT models has proven to be a valuable tool for public management, as it optimizes time, standardizes processes and contributes to improving communication between government and citizens. The key to success, however, lies in the training phase and the active participation of multidisciplinary teams, which guarantee alignment between knowledge of the model and the real demands of communication, transparency and accessibility of public administration.

Copyright ©2025 by the authors. This conference paper is pubLiShed under a CC-BY-4.0 license

It is important to highlight that, despite the initial satisfactory results, for the first services in the first two months of monitoring, it is necessary to continue monitoring for a longer period, as well as expanding the evaluation to other services, including identifying services that do not present good evaluations. of content by citizens, so that it is possible to identify possible adjustments to the LiS.

Among the contributions that this case provided is the protocol of intent, signed between the State Government and the Federal Government, through the Ministry of Management and Innovation, to estabLiSh a cooperative or partnership link in the use of the solution. MGI (2024).

Finally, this work is just an effort within a theme of growing relevance in digital transformation in governments, which is understanding that language is a key component in human interaction and a way to reinforce inclusion in digital services and government initiatives.

References

NU. (2022) United Nations. E-Government Survey 2022 - The Future of Digital Government. https://desapublications.un.org/sites/default/files/publications/2022-09/Web%20version%20E-Government%202022.pdf.

NU. (2024) United Nations. E-Government Survey 2024 - Accelerating Digital transformation for sustainable Development. https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2024.

BRAZIL. (2017, June). Law 13,460, of June 26, 2017. Code to defend the rights of users of public services. https://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/lei/l13460.htm.

BRAZIL. (2021, March). Law 14,129, of March 29th. Digital Government Law. https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/l14129.htm

INTERNATIONAL PLAIN LANGUAGE FEDERATION. (2024). What is Plain Language? https://www.iplfederation.org/our-work.

PLAIN. (2025). PLAIN LANGUAGE ASSOCIATION INTERNACIONAL. What is plain language? https://plainlanguagenetwork.org/plain-language/what-is-plain-language/;

SÃO PAULO. (2019, November). State Decree No. 59,067 of November 11, 2019. Municipal Simple Language Program within the scope of Municipal Public Administration. https://legislacao.prefeitura.sp.gov.br/leis/decreto-59067-de-11-de-novembro-de-2019.

CEARÁ. (2022, December). State Law No. 18,246 of December 1, 2022. EstabLiShes the state policy of plain language in public bodies and entities in the State of Ceará. https://www.seplag.ce.gov.br/wp-content/uploads/sites/14/2022/12/Lei-No-18.246_01122022_Politica-Estadual-Linguagem-Simples.pdf

LAB 11. São Paulo City Hall Government Innovation Laboratory. (2020, July). Plain language brings government closer to people. How to use? https://repositorio.enap.gov.br/bitstream/1/6181/1/Apostila%20do%20curso%20Linguagem%20Simples%20no%20Setor%20Pu%cc%81blico.pdf

Iris. Innovation and data laboratory. (2023). Law No. 18,246, of December 1, 2022. https://irislab.ce.gov.br/

ABEP-TIC. (2024). Brazilian Association of State and Public Information and Communication Technology Entities - Digital Public Services Offering Index for State and District Governments 2024. https://abep-tic.org.br/indice-abep-2024/.

ABEP-TIC. (2022). Brazilian Association of State and Public Information and Communication Technology Entities - Guideline to using plain language for presenting public services. https://abep-tic.org.br/wp-content/uploads/2023/04/Guia-Abep-5oVersao-Final-1.pdf/.

BRAZIL. (2019). Bill No. 6256, of 2019. National Plain Language Policy in bodies and entities of direct and indirect public administration of all federative entities. https://legis.senado.leg.br/sdleg-getter/documento?dm=9525183&ts=1736279134356&disposition=inline.

Copyright ©2025 by the authors. This conference paper is pubLiShed under a CC-BY-4.0 license

PERNAMBUCO. (2018, September). Law No. 16,420, of September 17, 2010. Provides for participation, protection and defense of the rights of users of public services of the state public administration.https://legis.alepe.pe.gov.br/texto.aspx?tiponorma=1&numero=16420&complemento=0&ano=2018&tipo=&url=

MGI. (2024, November). Ministry of Management and Innovation. Management and Government of Pernambuco sign a protocol of intentions to share an Artificial Intelligence solution. https://www.gov.br/gestao/pt-br/assuntos/noticias/2024/novembro/gestao-e-governo-de-pernambuco-assinam-protocolo-de-intencoes-para-compartilhamento-de-solucao-de-inteligencia-artificial

OpenIA. (2024). Creating a GPT: How to create a GPT. Open AI. https://help.openai.com/en/articles/8554397-creating-a-gpt.

Brown, T. et al. (2020). "Language Models are Few-Shot Learners." Advances in Neural Information Processing Systems (NeurIPS).

Lee, K.-F. (2018). "AI Superpowers: China, Silicon Valley, and the New World Order." Houghton Mifflin Harcourt.

Russell, S., & Norvig, P. (2021). "Artificial Intelligence: A Modern Approach." Pearson.

Sejnowski, T. J. (2018). "The Deep Learning Revolution." MIT Press.

Vaswani, A. et al. (2017). "Attention Is All You Need." Advances in Neural Information Processing Systems (NeurIPS).

Copyright ©2025 by the authors. This conference paper is pubLiShed under a CC-BY-4.0 license

Reflections on Collaborative Design: Lessons from Creating a Digital Public Service App.

Elaine Venson[a*], *Julia* de Souza[a], *Sara* Campos[a], *Rejane* Figueiredo[a], *George* Marsicano[a], *Wander* Pereira Silva[a],

[a]Information Technology Research and Application Center (ITRAC), University of Brasilia (UnB), Brazil, elainevenson@unb.br, 0000-0002-7607-5936)

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 26 May 2025

Abstract. Digital Transformation in public services requires a comprehensive understanding of the value creation to improve services and government operations. Designing digital public services is challenging, but Service Design methods can help achieve services that align with democratic values like accessibility, reliability, and a positive user experience. This article reports on the collaborative design of a mobile app for a regulatory agency in Brazil, using co-creation, co-design, and co-production methods through two workshop cycles. The first cycle, based on Lean Inception principles, defined the Minimum Viable Product (MVP), while the second cycle, utilizing Design Sprint techniques, refined and tested the MVP with citizens. Feedback from users and public servants is also shared, emphasizing the importance of involving citizens and government employees in developing public service solutions.

Keywords. Digital Public Services, Collaborative Design, Lean Inception, Design Sprint, User Testing, Prototyping.
Practical report, DOI: https://doi.org/10.59490/dgo.2025.1044

1. Introduction

Digital transformation has reached the public sector, with government agencies aiming to harness its benefits. Successful initiatives highlight the importance of designing a great citizen experience (Mergel et al., 2019b). Approaches like co-creation, co-design, and co-production have been used to engage stakeholders and citizens in the digitization of public services (Figueiredo et al., 2024; Scupola & Mergel, 2022).

According to Luna et al., 2024, citizens perceive the value of digital public services when they are accessible, reliable, user-friendly, intuitive, and provide clear instructions, complete information, and easy tracking of requests. Meeting these expectations is challenging and requires integrating user-centered approaches into the software development process (Szabó & Hercegfi, 2023).

In this paper we show the experience of a Brazilian regulatory agency in the health sector in designing a digital public service centered on the citizens, with special focus on elderly users. The service aims to provide simple and straightforward access to relevant information for citizens, while also enabling them to file complaints about the regulated entities that they believe are violating sector regulations. This dual functionality ensures both accessibility and accountability, promoting the proper functioning of the health sector.

Two workshop cycles were held with public servants and included citizen participation in the final stages. The first, in October 2023, used an adapted Lean Inception to define a Minimum Viable Product (MVP). The second, in March 2024, applied Design Sprint techniques to enhance the MVP by designing and testing a prototype with citizens.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The report is organized as follows: Section 2 outlines the collaborative design context and motivation within the government agency. Section 3 describes the methods used for the design process. Section 4 discusses the challenges faced and their impact. Section 6 presents the results and outcomes. Section 7 shares lessons learned, and Section 8 concludes with key findings and future work directions.

2. Context and Motivation

Digital Transformation in Public Services requires holistic efforts to understand the value creation process when using technology to provide services for citizens (Mergel et al., 2019a). Co-design and Co-production can both help in collaboratively understanding viable value propositions and designing better government services (Osborne et al., 2016, 2022; Strokosch & Osborne, 2020).

The experience we report in this paper is an example of collaborative design where a government agency from the health sector in Brazil is working to enhance an existing service. At present, the service is primarily provided via a toll-free 0800 number, ensuring that citizens can access assistance without incurring any costs.

In 2020, the agency received around 270,000 information requests and 150,000 complaints, with a resolution rate of over 90%. However, the service is mainly human-operated and conducted by telephone. Citizens can also access the service through the agency's website or mobile app, but many report difficulties navigating the website, citing confusing language and complex navigation. The existing mobile app is also criticized for poor usability, as one agency employee remarked, "If we, who are from the agency, have difficulties accessing the app, imagine the user who doesn't have much knowledge?"

To improve service delivery to citizens, the agency partnered with LabQ Gov.br[1]—a government lab focused on experimenting and redesigning digital public services. In collaboration with the authors' lab, they applied UX, Citizen Experience, and Service Design methods to identify opportunities for improvement and innovation in federal government services.

The project's goal for the agency was to develop an application for citizens using health services, offering personalized information to improve their understanding of available services and empower them to make informed decisions about health plan options in Brazil.

3. Approaches and Methods

The collaborative design initiative employed activities from both Lean Inception and Design Spring approaches, detailed in the following subsections.

3.1. Lean Inception

Lean Inception (LI) is a collaborative method supported by principles from Lean Startup and Design Thinking (Caroli, 2018). LI proposes that the participants work together to comprehend and elaborate the MVP. LI works with an incremental iterative logic, where small parts of the product (MVPs) are gradually added to the whole in order to test hypothesis (Caroli, 2018).

LI method is usually conducted through a week and follows eight activities: 1. Product Vision; 2. Scoping; 3. Personas; 4. User Journeys; 5. Brainstorming of Features; 6. Analysis of Features Values; 7. Sequencing Features; and 8. Canvas MVP. (Ferreira et al., 2021).

The initial activities of the workshop seek to align the participants about the context and define the goals of the product or service (Lobão et al., 2023). First, the Product Vision helps to structure the product's focus and what is the strategy, ultimately defining the essence and the values the company wishes to pass to the user. Then, at the Scoping moment, the product is defined by characteristics of what it is/is not and what it does/does not do; and by the objectives. At the end of these activities, the team is much more aligned towards the goals of the product/service (Caroli, 2018).

[1]https://www.gov.br/governodigital/pt-br/estrategias-e-governanca-digital/transformacao-digital/central-de-qualidade/labq

At the following moment, Personas and User Journeys are established, which moves the focus from business strategy to the user perspective. This phase allows the team to create empathy and understand the pains and necessities of costumers. While personas represent a realistic vision of roles and goals of users, a user journey specifies tasks the system must execute to help them (Caroli, 2018; Ferreira et al., 2021; Lobão et al., 2023).

After that, the Brainstorming of Features tries to answer the questions: "*What must the project have to resolve the user's necessities? What features must the product have to fulfill it's goals?*" (Caroli, 2018). These features are evaluated in the Analysis of Features by their level of effort, business value, user experience (UX) and developer's confidence to implement. This classification helps prioritize the features (Caroli, 2018).

With the level of complexity and business and UX values defined, the team is able to conceive the Feature Sequencer. In this step, the MVP is finally stipulated from combining enough features to validate a hypothesis. Ultimately, the Canvas MVP is generated by all the information gathered in the workshop (Caroli, 2018).

3.2. Design Sprint

Google Design Sprint (DS) is a collaborative design strategy based on Design Thinking and Agile methodologies. Design Sprint offers a five-day long structured process that focuses on not planning much ahead and failing rapidly, so the team can learn at every iteration (Knapp et al., 2016; Lárusdóttir et al., 2023).

Usually, the five stages of the process are divided in five days: (a) Map; (b) Sketch; (c) Decide; (d) Prototype; and (e) Test. The input of the DS methodology is a Challenge, and by the end of the process the output generated is what is Learned, the knowledge assembled. By the end of the DS sessions, the solution is set, anchored on the knowledge, strategy and ideas of the team, and the product or service can go on to the next phase, implementation (Lárusdóttir et al., 2023).

On Monday, the team maps the service and how the costumer interacts with it. Then, by the end of the day, a target problem for the workshop is chosen within what was mapped. Tuesday begins with a consultation of existing ideas using the Lightning Demos technique, consisting of three-minute presentations by each member about their favorite known solutions; then, each participant create their own sketch of the solution, a storyboard of three steps.

Wednesday starts with deciding which solutions resulted from Tuesday are more aligned with the goal, using a voting system. Then, the teams builds a more detailed storyboard of the system to help creating the prototype on the next day. On Thursday, the focus is building a high-fidelity prototype, so that by Friday it is used to test with real users. The users are invited to be interviewed, they are contextualized, shown the prototype, given tasks to achieve using the product and lastly asked some questions such as what they liked most/least or what worked for them (Knapp et al., 2016).

4. Challenges Encountered

While LI and DS approaches have reached success in industry, their use offers some challenges when applied to improve digital public services.

Both approaches, LI and DS, require a full five-day week for a team to complete the activities. A key challenge in applying these methods in a government context is securing a team of civil servants who can dedicate such a substantial amount of time exclusively to the project. Typically, the most knowledgeable individuals in the agencies are the least likely to participate in these activities. This difficulty led us to gather as much information as possible about the service and focus on the activities that were deemed essential, aiming to extract the maximum value from the approaches for the project. We also used on-line forms to collect information from the workshop participants after the session when necessary.

Another issue impacting the project was the large number of stakeholders appointed to participate and contribute. On the first day of the initial cycle, 19 civil servants from various areas were present. While the diversity of areas is an important factor for innovation, it also presents challenge in working effectively to achieve the initiative's goals. While planning the workshops, we adopted a strategy of dividing the participants into two groups to work on the activities. Subsequently, we consolidated the results into one single outcome.

Original LEAN INCEPTION AGENDA

	MON	TUE	WED	THU	FRI
MORNING	Kick off	Persona	Tech, UX & Business Review	Journey & Features	MVP Canvas
	Product Vision				
	LUNCH				
AFTERNOON	Is – Is Not Does – Does Not	Features Brainstorming	User Journeys	Sequencer	Showcase

Adapted LEAN INCEPTION AGENDA

	DAY 1	DAY 2	DAY 3
AFTERNOON	Kick off	Persona	Journey & Features
	Problem Statement		
	Product Vision	Features Brainstorming	MVP Canvas
	Is – Is Not Does – Does Not	User Journeys	Showcase

Fig. 1 – Original Lean Inception Agenda (adapted from Caroli, 2018) and Adapted Lean Inception Agenda (from authors). Gray cells indicate removed activities and orange cell indicate the added activity.

Additionally, the participants were spread across multiple locations in the country, making it difficult to assemble everyone in one place. Consequently, a restriction for the initiative was that it had to be conducted remotely with all participants attending virtually through a conferencing tool. For promoting the active contribution of the participants in the activities we used Miro[2], an online collaborative whiteboard platform designed for team collaboration.

5. Solutions and Strategies

The challenges described in the previous section conflict with the recommendations from the LI and DS approaches. This section outlines the solutions and strategies we used to adapt these approaches to conduct the project in light of the challenges faced.

5.1. Lean Inception Adaptations

Figure 1 presents both the original and adapted agendas of LI, where the gray cells indicate removed activities and orange cell indicate the added activity. The original LI agenda spans a full five-day week, while our proposed agenda was condensed into three full afternoons. Most of the LI activities were retained, albeit with shortened execution times.

In this case, we also utilized an online questionnaire to gather specific data that could not be obtained during the workshops. As a result, participants were required to make an an additional effort outside the workshop.

Two original activities were removed: the Tech, UX & Business Review, and the Sequencer. These activities are structured methods for performing feature prioritization. Due to time constraints, we conducted the prioritization in a more informal manner, like using the voting feature of the Miro board tool.

Originally, LI starts with the Product Vision, but a new activity, the Problem Statement, was introduced at the very beginning of the workshop. Given that this project involved a large team of civil servants from different areas from the agency, each with distinct perspectives on the problem, it was decided that including activities to get a consensus on the problem would be definitive in converging towards a solution within a shortened time-box (Ferreira et al., 2021). As in Ferreira et al., 2021, we noticed that by starting with a scope defined we could reduce the time spent in the Product Vision activity and have a more oriented discussion.

[2]https://miro.com

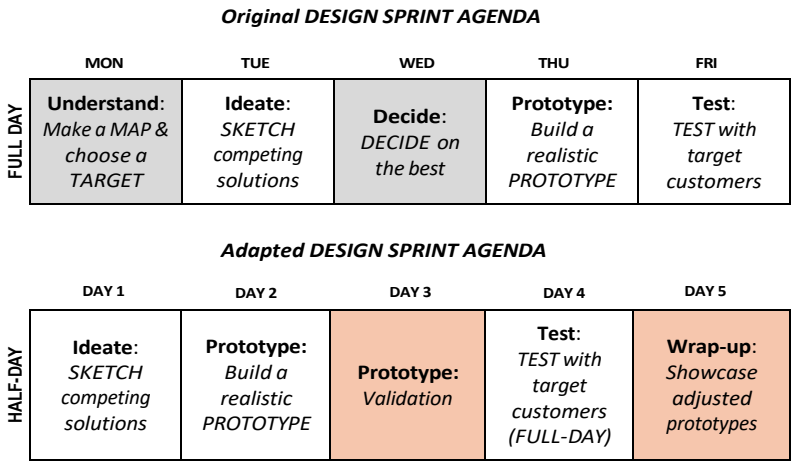


Fig. 2 – Original Design Sprint Agenda (adapted from Knapp et al., 2016) and Adapted Design Sprint Agenda (from authors). Gray cells indicate removed activities and orange cells indicate the added activity.

To manage the large number of individuals attending the workshops, some activities were executed in two steps. In first step, the group was divided into two breakout rooms within the conferencing tool to discuss the matter in smaller teams. Afterward, the entire group reconvened, and a representative from each breakout room briefly presented their group's conclusions. These conclusions were then consolidated into one shared result.

When dividing the groups, care was taken to compose the room with individuals from different areas whenever possible. One member of the facilitation team supported each group during discussions.

5.2. Design Sprint Adaptations

Similar to Pelinson and Campese, 2023, in a public service context of digital transformation, DS was adapted to be conducted remotely and with participants that included civil servants.

Figure 2 presents both the original and adapted agendas of DS. Gray cells indicate removed activities and orange cells indicate the added activity. The original DS agenda spans a full five-day week, while our proposed agenda took four full afternoons and one full day for the testing with users.

Since the user journeys and features were previously defined in Cycle 1, the Understand activities from Monday and the Decide activities from Wednesday were not necessary. The remaining days of the original DS agenda were used to sketch ideas for the MVP features, build and test the prototypes.

The agency required the development of high-fidelity prototypes. Therefore, two designers collaborated with the agency team to deliver these prototypes, using Figma[3], a web-based design tool used for interface design, user experience (UX) design, and collaborative design projects. This decision necessitated adding one additional meeting for prototype validation before the user test, as well as a final activity to present the adjusted prototypes after the user testing.

Due to the workshops being run remotely, a hybrid solution was planned to conduct the test the new solution with the citizens. The tests were conducted at one of the agency's service center. After a citizen was attended to as usual, they were invited by the civil servant to participate in the tests for the new solution. The facilitators conducted the test in a separate room. The workshop participants, who were located in other cities, observed the testing sessions through the conferencing tool from two perspectives: (1) they could see the and hear the user through the camera and microphone, and (2) they could see the user navigating the prototype through the screen sharing feature on the mobile phone used for testing. While observing, the sprint participants were asked to take notes on the perceptions of the user for each screen or features analyzed.

[3]https://www.figma.com/

6. Conduction of the Workshops

The workshops were planned and facilitated by three of the authors, with the support of LabQ.

The first cycle of workshops, based on the LI method, was conducted in October 2023 and produced the MVP for the app. Initially, two afternoons were planned for the complete execution of a Lean Inception (Caroli, 2018) workshop to establish the initial parameters for constructing a Minimum Viable Product (MVP) of a mobile app. The MVP aimed to synthesize a unified vision from the collaboration between various stakeholders of the agency.

At the beginning of 2024, the public agency realized that they needed a prototype to pitch the project and allocate the budget for its development. Consequently, a second cycle of DS workshops were conducted in March 2024 to prototype and test the solution with citizens prior to the initiation of the software development project.

6.1. Cycle 1 - LI Workshop

LI workshops can be very beneficial, as they enable the development of experienceable products with minimal effort, enabling customers and users to early validate the product without the need for further development (Zimmermann et al., 2021).

The goal of the LI workshop conducted was to establish parameters for developing the app's MVP by consolidating a shared vision through the involvement of stakeholders from various areas related to the service. In this first cycle 19 stakeholders from various areas were involved.

The first day of the LI workshop started with gaining a better understanding of the citizens' problem when using the agency services. A set of insights was collected to identify the users' issues and needs. Using Miro boards, they gathered and consolidated these insights into a single, clear problem statement: "The user encounters difficulties in easily and quickly accessing their health plan data, available useful services, and general information about their rights".

In the second part of the workshop, the product vision was developed, in order to decide what would be the initial focus of the solution and the positioning strategy. First, the participants were divided into two groups. Each group created a Miro board describing their shared product vision, which contained information regarding which types of users would be using the app, their problems and the description of the app. Later, both product visions were consolidated into one clear product vision.

Additionally, an activity was held to ease the development of a clear definition of the product. In this step, the participants defined the product by what it is and it isn't, and what it does and it doesn't. Also, this activity promotes the creation of a more precise and aligned vision for the strategic decisions regarding the product, including what the product does, what it doesn't do yet and what it will never do.

On the second day of the workshop, the goal was to establish proto-personas that would later be used to identify features and user journeys. Personas are used to represent a user of the system, its behavior, goals and motives (Blomkvist, 2002).

In this regard, the participants created two different personas, one representing a user who already has a healthcare plan and the other representing a user who is interested in acquiring one. Both personas had a profile with personal information, a description of their behavior and habits, problems and frustrations, and needs and goals.

With the personas in mind, a brainstorming section was conducted to identify the essential features of the app. In addition, the participants built user journeys based on the personas they had previously created.

On the third day, an important discussion was held regarding the prioritization of personas created on the previous day. The participants decided to focus on one persona, the one who represents the user who already has a healthcare plan. Based on this persona, the user journey was consolidated and associated with the features previously gathered.

Throughout the three days of the workshop, we gathered the essential information to develop an MVP Canvas, including an MVP proposal, personas, user's journey and features. Also, through a form shared asynchronously with the participants, we collected the expected results and metrics to validate the business hypothesis.

The expected outcomes for the MVP canvas include: aiding in the procurement planning to develop the app for this public service in a minimal amount of time. Also, improve the current app, as there is a larger scope to be dealt with. Finally, the app should be user-friendly, easy to use, and different from what users have available today. It should also have to evolve to be considered as a reference in the healthcare plan field.

Moreover, the metrics gathered to complete the MVP canvas include increasing app downloads, user numbers, and access compared to the current app history, They also include boosting consumer support channel access relative to other channels, expanding available services, and increasing this service's consultations and searches on the Rol database. Additionally, there is improving user satisfaction, enhancing existing services through digitization, improvement of the satisfaction survey results for the app support channels, and enhancing the app image in society.

6.2. Cycle 2 - Prototyping Workshop

The second cycle lasted for 5 days, using the Design Sprint strategy. The goal was to create a storyboard with wireframes, develop high-fidelity prototypes, and test them with users.

On the first day, the agenda focused on developing two storyboard proposals for the app. The session began with an overview of the MVP proposal and a discussion of the metrics gathered in the first cycle. Participants took notes on their observations and highlighted key points they considered important.

Next, participants were divided into two groups to conduct the Crazy 8s activity, aimed at generating innovative ideas. Using a piece of paper folded three times, each participant reviewed their notes, selected one or more ideas to explore, and created quick one-minute sketches. They experimented with different shapes, structures, content, and other elements, either iterating on a single idea eight times, sketching two different ideas four times each, or varying their approach as needed.

Furthermore, participants developed a storyboard illustrating the user journey, drawing inspiration from the ideas generated in the Crazy 8s activity. The storyboard highlighted key moments where users might face difficulties, ensuring those areas were addressed with greater precision. By the end of the day, each group had drafted a low-fidelity prototype, putting the selected ideas into practice.

On the second day, each group presented the storyboard created on the previous day. The best ideas were then consolidated into a single storyboard. Following this, the groups began developing the high-fidelity prototype, which the designers refined between workshop sessions.

On the third day, the designers presented the high-fidelity prototype, which was validated by the DS participants with minor adjustments.

On the fourth day, user testing was conducted to validate the prototype. The evaluation involved observing different user profiles, including four public agents from the office and four citizens interacting with the prototype. The interviews took place in the government agency responsible for the service. To begin, users were asked introductory questions to better understand their background, such as: 'What brought you here today?', 'Have you tried other means of communication?', and 'Is this your first time seeking this service?'.

Users were then introduced to the prototype and encouraged to verbalize their thoughts following the *think-aloud technique* (Knapp et al., 2016). Observations focused on how they navigated the home screen and their initial impressions. Next, the interviewer asked users to perform specific tasks with the prototype, simulating real interactions with the service.

While users tested the prototype, the DS team observed the sessions remotely via a conferencing tool, taking notes on user perceptions for each feature of the solution using a Miro board. To organize and visualize the collected feedback, a structured board was created with sections corresponding to different areas of the app interface, such as the home screen and healthcare plan information.

Feedback from various users was recorded systematically: positive comments were noted on green post-its, negative feedback on red post-its, and neutral observations on yellow post-its. This structured approach enabled a thorough analysis of user experiences and areas for improvement.

On the fifth day, the DS team reconvened to discuss the user testing results and finalize adjustments to the prototype.

By applying a set of techniques from the Design Sprint approach, we successfully achieved the goal of this cycle: developing a high-fidelity prototype for this government service that is user-friendly, simple, and easy to use.

Overall, participants considered the app prototype a significant advancement for the public service provided by the agency. It streamlines and accelerates service delivery, eliminating the need for users to visit the agency in person. Several users highlighted the time they previously spent traveling to the agency for tasks that could now be completed online through the application.

Additionally, the application would improve communication between citizens and agents. One agent noted that contacting citizens is often challenging, as many do not respond to emails. Addressing complaints via phone or email can also be time-consuming, making effective communication difficult. Furthermore, obtaining necessary documents from users is often problematic, as they frequently delay or fail to send the required materials. The agent believes the app will streamline communication by making it more direct and centralized, helping users better understand requests and respond promptly.

During the user testing observation, one participant praised the team's approach, particularly highlighting their demonstration of empathy. She emphasized that listening carefully to users' needs is crucial. While recognizing that the app is not a complete solution, she noted that it can significantly enhance human interaction. Additionally, she pointed out that optimizing the scheduling system is an area that requires improvement, as users still want to maintain dialogue with real people.

7. Reflections and Lessons Learned

7.1. MVP and Roadmap

The time constraints for involving civil servants in LI and DS workshops led us to streamline these approaches by removing some activities. Specifically for the LI, the removal of the Tech, UX & Business Review, prevented us from and the Sequencer activities required prioritizing personas, journeys, and features throughout the process. Originally, the removed activities are intended to help prioritize the features to be implemented in the MVP, while the other (non-prioritized) features are organized in a Roadmap.

We observed that some participants tend to get anxious about the scope of the MVP when they have to leave behind part of the ideas that are discussed during the workshop. We believe that the lack of a roadmap that includes the non-prioritized feature contributed to this concern. Treating the non-prioritized ideas more formally may help address this issue. An intermediary solution between the informal prioritization and the removed activities might provide a balanced solution.

7.2. Prototypes Quality Level

The public agency required the delivery of a high-fidelity prototype to pitch the project internally within the organization. As a result, we decided to involve designers and work with high-fidelity prototypes starting from the third day of the Design Sprint. This decision required more effort than initially planned, causing the creation and adjustment of prototypes to take more time than anticipated.

While the DS approach recommends that prototypes should be realistic, it emphasizes the need to find a "Goldilocks" level of quality (Knapp et al., 2016). The prototype's quality cannot be too low, as users might not perceive it as a real product, but it also cannot be too high, making it impossible to deliver in time for the user testing session the next day.

Achieving the "Goldilocks" quality level for prototypes is challenging. The use of Figma was invaluable in creating a realistic prototype that simulates the design patterns of digital public services used by the Brazilian government. However, adhering closely to these design patterns required the team to put in extra hours to prepare the prototypes for the user testing session.

In hindsight, we might consider omitting the design pattern and working with a simpler prototype until all necessary adjustments are made. The high-fidelity prototype could then be delivered at the end of the process.

7.3. Value of User Testing Session

The final stage of testing the solution with citizens and civil servants working at the service center proved highly effective in identifying opportunities to improve the user experience with the service and enhance the functionalities selected for the MVP.

The User Testing session provided the workshop participants with an opportunity to understand the value perceived by citizens when using the proposed app. During the session, civil servants were able to clearly observe how citizens interact with the digitized service, the language they use (which sometimes contrasts with the internal jargon of the agency), the difficulties in navigating between screens and potential areas for improvement. They also identified which information should be highlighted for a better user experience. Therefore, this practice is recommended to be adopted whenever possible before developing new features for the application.

Additionally, the agency's DS team found that engaging with users extends beyond the scope of the solution prototype. The context surrounding the user testing sessions offers valuable insights and learning opportunities for enhancing public service offerings to citizens.

8. Conclusion

In this experience report, we reflect on how collaborative design can enhance the user experience of digital public services. A mobile application solution was designed through two cycles of workshops, adapting both Lean Inception and Design Sprint approaches.

While the Lean Innovation and Design Sprint approaches have proven successful in industry, applying them to improve digital public services presents unique challenges. Both methods require a full week of dedicated participation, but securing such a commitment from civil servants is difficult, especially from the most knowledgeable individuals. Adaptations were made to address the challenges encountered when applying these methods in the public services context. We focused on essential activities and used online forms to gather additional input. Another challenge - managing a large, diverse group of stakeholders from different areas - was mitigated by splitting participants into smaller groups and consolidating their results.

This approach enabled effective collaboration, even with civil servants who had limited availability. The project outcomes were praised by the government agency as an exemplary process for innovation in digital public service design. Involving citizens in user testing sessions was particularly noted as a valuable opportunity to improve public services.

Reflections on the workshops execution provided insights into practices that can be refined for the future collaborative design projects in the government.

Acknowledgment

- **Funding or Grant**: This research is part of a cooperation agreement between the Information Technology Research and Application Center (ITRAC) at the University of Brasilia (UnB) and the Ministry of Management and Innovation in Public Services (MGI), Secretariat for Digital Government (SGD), Directorate for Digital Transformation Dissemination.
- **Contributor Statement**: Elaine Venson: Conceptualization, Data Curation, Investigation, Methodology, Writing - Original Draft. Julia de Souza: Data Curation, Methodology, Writing - Original Draft. Sara

Campos: Data Curation, Methodology, Writing - Original Draft. Rejane Figueiredo: Funding acquisition, Supervision, Resources. George Marsicano: Data Curation, Writing - Review & Editing. Wander Pereira Silva: Conceptualization, Data Curation.

- **Use of AI**: During the preparation of this work, the author(s) used OpenAI's ChatGPT for language refinement and translation support. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Blomkvist, S. (2002). Persona–an overview. *Retrieved November*, *22*(2004), 15.

Caroli, P. (2018, October). *Lean inception: Como alinhar pessoas e construir o produto certo*. Editora Caroli.

Ferreira, B., Kalinowski, M., Gomes, M. V. D. C., Marques, M. C., Lopes, H., & D.J. Barbosa, S. (2021). Investigating Problem Definition and End-User Involvement in Agile Projects that Use Lean Inceptions. *XX Brazilian Symposium on Software Quality*, 1–10. DOI: https://doi.org/10.1145/3493244.3493268.

Figueiredo, R., Pedrosa, G. V., Gardenghi, J. L. C., Venson, E., Judice, M. O., Judice, A. C. B., Costa, F. F., Silva, W. M. P. d., & Marsicano, G. (2024). Co-design and Co-creation in Digital Public Services: A Service Design Approach [ISSN: 2763-8723]. *Workshop de Computação Aplicada em Governo Eletrônico (WCGE)*, 62–73. DOI: https://doi.org/10.5753/wcge.2024.2440.

Knapp, J., Zeratsky, J., & Kowitz, B. (2016). *Sprint: How to solve big problems and test new ideas in just five days*. Simon; Schuster.

Lárusdóttir, M. K., Cajander, Å., & Roto, V. (2023). *User centred design approaches and software development processes*. Reykjavik University, Uppsala University, Aalto University.

Lobão, L., Rabaioli, B. T. V., Gauthier, E., Araújo, L. L. d., & Meireles, M. A. C. (2023). The use of design thinking in creating projects and improving customer value perception: An experience report on software projects at a research and development institute in amazonas. *Proceedings of the Instituto de Desenvolvimento Tecnológico-INDT*.

Luna, D. E., Picazo-Vela, S., Buyannemekh, B., & Luna-Reyes, L. F. (2024). Creating public value through digital service delivery from a citizen's perspective. *Government Information Quarterly*, *41*(2), 101928. DOI: https://doi.org/10.1016/j.giq.2024.101928.

Mergel, I., Edelmann, N., & Haug, N. (2019a). Defining digital transformation: Results from expert interviews. *Government Information Quarterly*, *36*(4), 101385. DOI: https://doi.org/https://doi.org/10.1016/j.giq.2019.06.002.

Mergel, I., Edelmann, N., & Haug, N. (2019b). Defining digital transformation: Results from expert interviews. *Government Information Quarterly*, *36*(4), 101385. DOI: https://doi.org/10.1016/j.giq.2019.06.002.

Osborne, S. P., Powell, M., Cui, T., & Strokosch, K. (2022). Value Creation in the Public Service Ecosystem: An Integrative Framework. *Public Administration Review*, *82*(4), 634–645. DOI: https://doi.org/10.1111/puar.13474.

Osborne, S. P., Radnor, Z., & Strokosch, K. (2016). Co-Production and the Co-Creation of Value in Public Services: A suitable case for treatment? *Public Management Review*, *18*(5), 639–653. DOI: https://doi.org/10.1080/14719037.2015.1111927

Um dos mais citados do OSBORNE - 2016.

Pelinson, T., & Campese, C. (2023). Sprint design – aplicação em portal web de serviços públicos de São Paulo - SP, Brasil. *Brazilian Journal of Science*, *2*(12), 94–105. DOI: https://doi.org/10.14295/bjs.v2i12.387.

Scupola, A., & Mergel, I. (2022). Co-production in digital transformation of public administration and public value creation: The case of Denmark. *Government Information Quarterly*, *39*(1), 101650. DOI: https://doi.org/10.1016/j.giq.2021.101650.

Strokosch, K., & Osborne, S. P. (2020). Co-experience, co-production and co-governance: An ecosystem approach to the analysis of value creation. *Policy & Politics*, *48*(3), 425–442. DOI: https://doi.org/10.1332/030557320X15857337955214.

Szabó, B., & Hercegfi, K. (2023). User centered approaches in software development processes: Qualitative research into the practice of Hungarian companies. *Journal of Software: Evolution and Process*, *35*(2), e2501. DOI: https://doi.org/10.1002/smr.2501.

Zimmermann, V., Heimicke, J., Schnurr, T., Bursac, N., & Albers, A. (2021). Minimum viable products in mechatronic system engineering: Approach for early and continuous validation. *R&D Management Conference 2021-Innovation in an Era of Disruption*.

Transformative Synergies: Partnership and Collaborative Governance for best Breast Cancer Patient Journey

Neusa Andrade [a] *Diogo Moreira* Carneiro [b].

[a] University of São Paulo. Department of Electrical Energy and Automation Engineering. Postdoctoral Researcher. Neusa.andrade@usp.br, https://orcid.org/0000-0001-8390-4563.

[b] University of São Paulo. School of Economics, Business, Accounting and Actuary. PhD Researcher. diogo.carneiro@gmail.com | diogo.carneiro@usp.br, https://orcid.org/0000-0001-5550-2815.

Abstract. This study presents the development and validation of a breast cancer patient journey as a real-world demonstration of how public-private collaboration can address digital government challenges while advancing Industry 4.0 and Government 4.0/5.0 paradigms. Using Curitiba, Brazil, as a pilot city, the initiative highlights how technologies, standards, and governance frameworks can foster social cohesion and reduce health inequalities by improving breast cancer care. By leveraging AI-driven tools, participatory governance, and data interoperability, the project aligns population health goals with economic efficiency, ensuring accessible and high-quality care. The results demonstrate the potential of collaborative digital health strategies to enhance public health equity and inform scalable governance models for broader applications across sectors. This research offers a replicable framework for advancing digital transformation in health systems, focusing on preventive and cost-effective interventions to promote resilient and inclusive health ecosystems.

Keywords. Pilot Project, Breast Cancer Journey, Ecosystem Governance, Triple Helix, KPI´s

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 15 May 2025
Practical report, DOI: https://doi.org/10.59490/dgo.2025.923

1. Introduction

According to the World Health Organization (WHO) no one should face breast cancer alone. Breast cancer is the most common cancer globally, with approximately 2.3 million new cases annually. It remains a leading cause of morbidity and mortality worldwide, necessitating a comprehensive approach that integrates public, private, and civil society stakeholders working together to reduce this burden (WHO, 2025),

In the United States, approximately one in eight women will be diagnosed with breast cancer during their lifetime. Only this country estimated that 310,720 women and 2,800 men will receive a diagnosis of invasive breast cancer, but the approach for early detection and treatment have significantly improved survival rates, especially when the disease is caught in its earliest stages. According to Cancer

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Statistics (2025), female breast cancer mortality peaked in 1989, and recent studies reveal likely declines in breast cancer mortality and stable prevalence of mammography as primarily diagnostic research (SIEGEL et al, 2025, Breast cancer facts & stats., 2019)

In Brazil, breast cancer primarily affects women over 50 and is the leading cause of cancer-related deaths among women. Men represent a smaller group, accounting for about 1% of cases. The National Cancer Institute (INCA) highlights the growing need for improved systems to address these disparities (INCA, 2024).

Curitiba, a Brazilian city, has pioneered a patient-centric pilot project aimed at aligning digital transformation with social impact goals. By fostering partnerships across the public and private sectors, the initiative tackles health system fragmentation and promotes interoperability, guided by Value-Based Health Care principles.

This collaboration involves the municipality, patient organizations, and a pharmaceutical company working with experts and academic researchers to create an innovative solution for breast cancer care. Focused on leveraging digital tools and preventive strategies, this initiative drives transformation in healthcare, reducing inequalities and improving population health. The Curitiba pilot demonstrates how collaboration and technology can catalyze impactful change, offering a model for broader replication.

2. Materials and Methods

The focus of this initiative on the digital journey of breast cancer patients in Curitiba, Paraná, Brazil was based on the Triple Helix model, which emphasizes collaboration between government, industry and academia and served as a basis for using consolidated WHO standards to improve and implement a data exchange platform and promote interoperability.

This study adopts a single-case design, since context-rich field research enhances practical usefulness, so the study aims to generate insights considering real-world impact. By focusing on Curitiba's pilot, the study captures complex dynamics often missed in broader, decontextualized approaches. This practice allows the identification of leading-edge practices, which, once understood and explained, can inform the adaptation and replication of similar initiatives in comparable settings (Merchant, 2012).

Based on principles of triple helix model, the project's innovation addresses systemic inefficiencies and promotes equity through the initiative, highlighting the transformative potential of collaborative digital health strategies through resource-directing indicators, such as increasing screening coverage by 35% in underserved areas, with AI tools identifying high-risk cases for immediate follow-up.

Table 1 below presents the context found and the actions taken. In this context, the municipality and its patient organizations and a pharmaceutical company that funded the project funded experts and academic researchers who contributed to the design of an innovative solution.

Table 1: Approach and Actions Taken

Journey	Detection and Screening	Diagnosis	Therapeutic Planning	Treatment Delivery	Education, Follow-Up and Survivorship
Context	Low screening rates in underserved areas due to fragmentation in service delivery.	Delays in confirming diagnoses due to bottlenecks in laboratory processing.	Limited integration of patient data across systems led to fragmented treatment plans.	Inconsistent reporting of adverse events and treatment outcomes.	Gaps in long-term patient monitoring post-treatment.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Actions	Collaborative efforts between municipal health departments, NGOs, and technology providers launched mobile mammography units equipped with AI-based imaging tools. Data was integrated into the municipal e-SUS APS platform and analyzed to prioritize follow-ups.	Public-private partnerships established expedited diagnostic workflows using centralized databases and automated case triage in the Federal Breast Cancer systems	Multisectoral tumor boards utilize interoperable platforms adhering to standards to co-design personalized treatment pathways. Patients were actively involved through digital consultation tools.	Deployment of patient-reported outcome (PRO) systems and real-time monitoring apps allowed seamless integration with federal health registries	A coordinated follow-up program, supported by local community organizations, offered education and support through interactive platforms. Data from wearable devices were incorporated into municipal health dashboards.

3. Results

The initiative is projected to deliver significant advancements in breast cancer care by integrating digital health solutions. Analysis of the current and desired patient journeys shows that leveraging AI-enabled management tools to prioritize high-risk cases can increase screening coverage in underserved areas by 35%. These tools also enhance equity by focusing resources on populations with limited access to healthcare.

Adherence to best practices for early detection and intervention is expected to significantly reduce the average time to diagnosis, enabling earlier interventions. Patient satisfaction and adherence to treatment plans are targeted to improve by 20%, leading to more timely initiation of therapy. Enhanced monitoring systems, including real-time tracking of treatment outcomes, are anticipated to reduce emergency admissions caused by adverse events, further improving care efficiency and equity.

For example, AI-supported workflows can address diagnostic delays by streamlining processes, shortening the time to diagnosis, and promoting adherence to treatment plans through education and digital engagement. This approach is expected to yield a 20% improvement in therapy initiation within recommended timeframes. Additionally, strengthened adherence to follow-up care, supported by interoperable data systems, can lead to measurable gains in five-year survival rates, showcasing the transformative potential of collaborative digital health strategies.

To strengthen the evaluation's rigor, considered KPIs were aligned with internationally recognized frameworks, such as ICHOM, and validated through iterative consultations with local experts, public health managers, and patient organizations. Data sources included municipal health records, e-SUS APS, and patient-reported outcomes integrated via interoperable platforms.

By linking these outcomes to Key Performance Indicators (KPIs)—such as expanded screening coverage, reduced diagnostic delays, and improved treatment adherence—the project highlights the role of digital governance in promoting equitable healthcare systems and addressing disparities in access and outcomes, as detailed in Table 2.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Table 2: KPI´s and expected results

Phase	Detection and Screening	Diagnosis	Therapeutic Planning	Treatment Delivery	Education, Follow-Up and Survivorship
KPI´s	Screening coverage increased by 35% in targeted areas, with high-risk cases flagged for immediate follow-up.	Measuring of time frame average time to diagnosis reduced days, improving early-stage detection rates/ according to best practices	Improving patient satisfaction and adherence to treatment plans, with a 20% increase in therapy initiation within recommended timeframes.	Enhancing tracking of therapy effectiveness and reduced emergency admissions related to adverse events.	Improving adherence to follow-up care, with a measurable increase in five-year survival rates.

The collaboration between the Curitiba municipality, patient organizations, a pharmaceutical company, and academic experts to redesign breast cancer care exemplifies how accurate data collection serves as the cornerstone for implementing affordable, actionable KPIs and metrics in public health systems. By prioritizing precision in data capture, integration, and analysis, this initiative demonstrates how Brazil's fragmented healthcare ecosystem can evolve into a cohesive, patient-centered model while addressing systemic inequities. The points listed below explain its transformative potential:

---

1. Data Accuracy as the Foundation for Affordable KPIs

Accurate data collection ensures that KPIs are reliable, relevant, and cost-effective. In Brazil's decentralized system, inconsistencies in tracking patient outcomes across municipal, state, and federal platforms often lead to inefficiencies. For example:

Municipal-level data (e.g., screening rates, follow-up adherence) must align with state-level data (e.g., access to mammography, chemotherapy quotas) and federal databases (e.g., mortality rates, funding allocations).

By standardizing metrics using global frameworks like ICHOM, the project ensures that KPIs reflect outcomes prioritized by patients (e.g., survival rates, quality of life, care continuity) rather than purely administrative targets.

This alignment reduces duplication, minimizes manual data reconciliation costs, and enables governments to allocate resources based on evidence-driven priorities, a critical step for affordability in resource-constrained settings.

---

2. Interoperability and Real-Time Insights

The project's integration of open standards for interoperability bridges siloed systems, allowing seamless data exchange across care levels. For instance:

- A patient's diagnostic data from a municipal clinic can instantly inform state-level treatment authorization, while federal systems monitor population-level trends.
- AI-driven analytics process real-time data to identify bottlenecks (e.g., delays in biopsy results) or disparities (e.g., low screening rates in rural areas), enabling proactive interventions.
- By automating data flows, the system reduces administrative overhead and ensures KPIs (e.g., time-to-treatment, patient satisfaction) are updated dynamically, avoiding the costs of retrospective audits.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3. Patient-Centered Outcomes and Equity

Adopting ICHOM's framework shifts focus from volume-based metrics (e.g., number of screenings) to value-based outcomes (e.g., reduced recurrence rates, psychosocial support access). Accurate patient-reported data ensures metrics reflect lived experiences, such as:

- Financial toxicity (e.g., out-of-pocket costs for low-income patients).
- Geographic barriers to care (e.g., travel times to oncology centers).
- Cultural factors influencing treatment adherence.

These insights allow policymakers to design targeted, equitable interventions, such as subsidized transportation for rural patients or telehealth follow-ups—strategies that maximize impact per dollar spent.

4. Scalability and Cost-Effective Governance

The Curitiba pilot leverages modular, open-source technologies to create a replicable model. For example: AI algorithms trained on local data can predict demand for therapies, optimizing procurement and reducing waste and federated learning allows hospitals to share insights without compromising patient privacy, lowering R&D costs for new treatments. This approach avoids proprietary system lock-in, ensuring scalability to other regions or disease areas (e.g., diabetes, prenatal care) at minimal marginal cost.

5. Reducing Financial Risks Through Predictive Analytics

Accurate historical and real-time data enables predictive modeling to anticipate budget impacts. For instance:

- Early detection rates correlate with lower long-term costs; investing in screening KPIs today reduces late-stage treatment expenses tomorrow.
- AI identifies high-risk populations for preventive campaigns, curbing avoidable hospitalizations.

By linking KPIs to financial sustainability, the system aligns clinical goals with fiscal responsibility, a key tenet of Government 4.0/5.0.

6. Strengthening Social Cohesion via Transparency

Public trust in healthcare systems erodes when data is opaque or perceived as biased. This Project fosters transparency by:

Sharing de-identified outcome data with patient organizations, ensuring accountability. Using dashboards to visualize progress on KPIs (e.g., reduced mortality disparities across socioeconomic groups). Such transparency builds collective ownership among stakeholders, reinforcing social cohesion and incentivizing sustained collaboration.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

While the study emphasizes the positive outcomes of the Curitiba pilot, it also recognizes critical challenges inherent to digital health transformation. These include data privacy concerns in cross-institutional exchanges, regulatory fragmentation across government levels, and high initial implementation costs for infrastructure and training. Addressing these barriers required strict adherence to national data protection laws (LGPD), phased deployment strategies, and strong stakeholder alignment—factors essential for scalability and sustainability.

4. Conclusions

In this context, the municipality, patient organizations, and a pharmaceutical company collaborated with experts and academic researchers to develop an innovative solution. This partnership, focused on the breast cancer care line, exemplifies how digital governance can foster social cohesion and reduce health disparities by implementing preventive, cost-effective, and patient-centered processes aimed at improving population health.

In Brazil, navigating the breast cancer care journey requires seamless integration between municipal, state, and federal systems. Municipal systems manage initial tracking and follow-up data, state platforms regulate access to specialized exams and treatments, and federal databases store centralized information for monitoring and financing. The Curitiba pilot project establishes a new paradigm for interoperability, bridging these levels of care and spheres of government to create a cohesive, patient-centered healthcare model.

This initiative is the first in Brazil to combine global standards with the ICHOM (International Consortium for Health Outcomes Measurement) framework for patient-centered breast cancer care. By focusing on outcomes that matter most to patients, the project highlights the importance of collaborative efforts among health professionals, specialists, and patients. The adoption of these standardized measures represents a global commitment to improving quality of care, enhancing the quality of life for patients, and driving advancements in breast cancer treatment (ICHOM, 2025).

To achieve these goals, the project integrates open standards for interoperability, enabling real-time information exchange across municipal, state, and federal levels. Leveraging AI and global benchmarks, it establishes a replicable, sustainable model for digital governance in healthcare, with the potential to be scaled to other lines of care and regions.

The results highlight the transformative potential of digital health strategies under the Government 4.0/5.0 paradigm. By aligning technological innovation with social and economic goals, the framework uses AI-driven indicators to minimize financial impacts while keeping the patient at the center of the process. This approach underscores how digital governance can build equitable, efficient, and resilient healthcare systems, fostering social cohesion and reducing disparities across diverse populations.

The Curitiba initiative could prove that accurate data collection is not a technical afterthought but a strategic enabler of affordable, equitable healthcare. By harmonizing global standards with local realities, Brazil can transform its public health systems into agile, patient-centered networks. The project's success hinges on three pillars:

1. Interoperability to unify fragmented systems.
2. Outcome-focused metrics to prioritize value over volume.
3. AI-driven governance to minimize costs and maximize impact.

As this model scales, it offers a roadmap for low- and middle-income countries to leverage digital innovation as a tool for equity—proving that precision in data collection is inseparable from progress in population health.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

Breast cancer facts & stats. (2019, agosto 28). National Breast Cancer Foundation. https://www.nationalbreastcancer.org/breast-cancer-facts/

ICHOM. (2018, junho 1). ICHOM. https://www.ichom.org/patient-centered-outcome-measure/non-metastatic-breast-cancer/

INCA- Instituto Nacional de Câncer (Brasil). Controle do câncer de mama no Brasil: dados e números: 2024 / Instituto Nacional de Câncer. – Rio de Janeiro: INCA, 2024.

MERCHANT, K. A. (2012). *Making management accounting research more useful*. Pacific Accounting Review, 24(3), 334–356. https://doi.org/10.1108/01140581211283904

SIEGEL, R. L., Kratzer, T. B., Giaquinto, A. N., Sung, H., & Jemal, A. (2025). Cancer statistics, 2025. CA: A Cancer Journal for Clinicians, 75(1), 10–45. https://doi.org/10.3322/caac.21871

WHO Global Breast Cancer Initiative: Breast cancer awareness month. (sem data). Who.int. Obtido 23 de janeiro de 2025, de https://www.who.int/news-room/events/detail/2024/10/01/default-calendar/who-global-breast-cancer-initiative--breast-cancer-awareness-month

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Track 23: Panels

Contents

Advancing AI Adoption in the Public Sector: Toward Hybrid Intelligence with Stakeholder Perspectives 1544
H. K. Liu, G. Musiatowicz-Podbiał, H.-L. Tseng, W.-J. Ko, and M. Ciesielska

Beyond the Bureaucracy: Modeling Scenarios of Non-Mediated Governance with Liquid Democracy 1549
A. Paulin

Digital government and meaningful connectivity: Opportunities and challenges for theory and practice 1554
M. M. Ribeiro, M. A. Cunha, E. Estevez, and J. R. Gil-Garcia

Responsible application of artificial intelligence in the Brazilian public sector: Governance and mitigation of inequalities 1558
A. L. S. Antonio and M. F. de Moraes

Advancing AI Adoption in the Public Sector: Toward Hybrid Intelligence with Stakeholder Perspectives

Helen K. Liu[a*], Grażyna *Musiatowicz-Podbiał* [b], *Hsien-Lee Tseng* [c], *Wei-Jan Ko* [d], *Magdalena Ciesielska* [b]

[a] Department of Political Science and the Graduate Institute of Public Affairs, National Taiwan University, Taipei, Taiwan, email address: helenliu4@gmail.com, ORCID number: 0000-0002-9186-2292.

[b] Department of Informatics in Management, Faculty of Management and Economics, Gdańsk University of Technology, Gdańsk, Poland, e-mail: Grazyna.Podbial@pg.edu.pl, ORCID 0000-0002-9343-1883

[c] Department of Public Administration and Management, National University of Tainan, Tainan, Taiwan, email address, nova1219@gmail.com, ORCID 0009-0001-0082-9922

d Department of Public Administration, National Yang Ming Chiao Tung University, Hsinchu, Taiwan

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Governments are increasingly adopting AI to improve public services as part of smart city development, and hybrid intelligence plays an essential role in this developmental process. This panel, emphasizing stakeholder perspectives, explores the opportunities and challenges of adopting hybrid intelligence for smart city development. We include three papers and six authors for the panel. The first paper investigates how smart city initiatives facilitated through citizen-government participation platforms differ in terms of stakeholder groups, types of participation, and technology employed. The second paper examines how the municipal city, Hsinchu City Government, utilizes intersection fisheye camera images to analyze traffic flow and their related stakeholders' views on such adoption. The last study examines data-driven public services by combining the strengths of human experiences and artificial intelligence. This paper discusses studies utilizing open data, big data, or linked data to support informed decision-making through an inclusive process and inter-governmental collaboration and innovation transfer, as shown in the second paper. The panel will also reserve time for the audience to join the discussions and share their related research in applying hybrid intelligence for smart city development.
Keywords. AI, hybrid intelligence, digital twin, big data, smart city.
Panel, DOI: https://doi.org/10.59490/dgo.2025.928

1. Theme and Goals

Increasingly, governments are adopting AI to improve public services and increase automation processes as part of the smart city development. Liu, Tang, and Collard (2025) show that hybrid intelligence plays an essential role in smart city development through a review of over 10,000 articles (e.g., Kitchin, 2014; Anttiroiko et al., 2014; Gil-Garcia et al., 2015; Gil-Garcia et al., 2016; Meijer & Bolívar, 2016; Elazhary, 2019; Kumar et al., 2020). Liu et al. (2025) show that existing literature focuses on technological and engagement components for designing hybrid intelligence in smart city development. For instance, Elazhary (2019) shows that TransWiseway utilizes sensors and cloud computing to improve safety and efficiency. TransWiseway is a smart transportation system, also known as Web of Wisdom Things, developed by Intel technologies by utilizing crowd information and accumulating user experiences for decisions (Elazhary, 2019).

Besides technological advancements in analyzing massive crowd information and behaviors, Liu et al. (2025) point out the essential aspect of engagement in adopting AI, developing hybrid intelligence, and keeping the crowd informed regarding how their information is utilized or actively engages the crowd for AI development. For

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

instance, Gil-Garcia, Zhang, and Puron-Cid (2016) introduce the concept of "smartness" in government, identifying fourteen key components: "integration, innovation, evidence-based decision-making, citizen-centricity, sustainability, creativity, effectiveness, efficiency, equality, entrepreneurialism, citizen engagement, openness, resiliency, and technology savviness" (p.525). Developing a smart city should include these steps to foster collaboration and citizen participation (Gil-Garcia et al., 2016). Also, the government should involve citizens as co-producers in policy development and service implementation (Liu, 2021). Often, governments adopt strategies for open data sharing, data-driven services (Nikiforova et al., 2023), and guidelines tapping into crowd information (Liu et al., 2025). For instance, Nikiforova et al. (2023) highlight the importance of stakeholders' aspects in the high-value dataset literature.

This panel, emphasizing stakeholder perspectives, explores the opportunities and challenges of adopting hybrid intelligence for smart city development. We include three papers and six authors for the panel. The first paper investigates how smart city initiatives facilitated through citizen-government participation platforms differ in terms of stakeholder groups, types of participation, and technology employed. The second paper examines how the municipal city, Hsinchu City Government, utilizes intersection fisheye camera images to analyze traffic flow and their related stakeholders' views on such adoption. The last study examines data-driven public services by combining the strengths of human experiences and artificial intelligence. This paper investigates studies utilizing open data, big data, or linked data to support informed decision-making through inclusive process (Ciesielska et al., 2022) and inter-governmental collaboration and innovation transfer (Ciesielska et al., 2021). The panel will also reserve time for the audience to join the discussions and share their related research in applying hybrid intelligence for smart city development.

2. Panel Content

2.1 Hybrid Intelligence for Smart City Development: Stakeholders Perspective

Increasingly, governments adopt various stakeholders in smart city development (Gil-Garcia et al., 2016). With the rise of AI technology, incorporating crowds into the development and implementation process has become essential (Liu, 2017a; Liu, 2021). Liu, Guo, and Chen (2023) reveal an interesting case where the government adopts a living lab concept, allowing various stakeholders to experiment with emerging technologies before scaling up or adopted by the governments. That study provides online smart city proposals and achieves data from the Taipei City Government. Digital technology can replace the government in its dominant position (Linders, 2012, 451). Musiatowicz-Podbial (2024) mentioned that successful collaboration among stakeholders requires certain upfront conditions of common platform establishment, introduction of government incentives and inducements, and the perceiving the mutual benefits of collaboration among stakeholders. Municipal governments could develop platforms for stakeholder participation in smart city development (Liu et al., 2023) and citizen participation in public service provisions (Liu, Chao, & Chen, 2024). This study builds on the platform framework and stakeholder analysis to further investigate how smart city initiatives facilitated through citizen-government participation platforms differ, in terms of collaborating parties, the role of technology in enhancing collaboration and the results of collaboration measured both as direct outputs and longer-term outcomes. Our study conducts a systematic review of the social partners and state collaboration in smart city development. Building on existing literature, our paper proposes a stakeholder analytical framework to understand interactions characteristics. Using an archived dataset, our paper shows that most citizen-initiated projects could not be sustained or implemented due to lacking capital or resources. Successful projects build solid relationships with different governmental units and private enterprises. Based on our findings, governments could provide monetary resources as seed funds and should also offer networking opportunities for selected projects to sustain.

2.2 Fisheye Camera Images for Traffic Flow Detection in Hsinchu City

Although digital twins have become a standard technology in smart city development—particularly in traffic flow monitoring—establishing a comprehensive digital twin system across an entire city requires careful consideration of financial resources, technical capabilities, and privacy concerns. This challenge is especially pressing for cities with limited budgets, which must find cost-effective ways to achieve similar outcomes. This case study highlights the smart transportation initiative led by the Hsinchu City Government. Hsinchu City and Hsinchu County form a major hub of Taiwan's high-tech industry, with clusters of chip manufacturing facilities such as TSMC. During peak commuting hours, traffic congestion is a significant issue. To address this, the Hsinchu City Government utilized fisheye cameras installed at intersections to analyze traffic flow—yielding promising results. In this initiative, the Hsinchu City Police Department provided the traffic video footage, while the National Center for High-Performance Computing and National Yang Ming Chiao Tung University conducted the data analysis. This collaborative effort exemplifies a successful public-private partnership, underpinned by secure data-sharing practices among various data holders. It also reflects the formation of a data ecosystem between government and academic institutions. A traffic flow model was established using 40 fisheye cameras at intersections, enabling intelligent traffic management and control.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



Fig. 1 - Vehicle Identification

2.3 Enabling Data-Driven Public Services and Governance through Hybrid Intelligence

Increasingly, governments adopt strategies for open data sharing, data-driven services (Nikiforova et al., 2023), and guidelines tapping into crowd information (Liu et al., 2025). However, data-driven services and governance face challenges, including awareness of data input (Liu et al., 2025), misinformation (Lorenz-Spreen et al., 2020), and representation (Liu, 2017a). Liu et al. (2025) reveal two types of conditions for data inputs in the designs of hybrid intelligence, including conscious crowd and unconscious crowd. The conscious crowd actively provides information and data by acknowledging how the data is used and for what purposes (Liu et al., 2025). On the other hand, the unconscious crowd might not fully realize how their data is analyzed (Liu et al., 2025). Valentino et al. (2020) show that the public might not be aware of the documentation of their behaviors by the sensing technologies. This talk discusses the transformation of high-value datasets (Nikiforova et al., 2023; Ciesielska et al., 2021; Ciesielska et al., 2022) for public services and governance by utilizing artificial intelligence, crowd intelligence, and hybrid intelligence.

3. Significances to the Attendees

The panel is designed for international academic scholars across different disciplines, government officials, policymakers, practitioners, and other industry leaders interested in engaging diverse stakeholders to address the impacts and challenges of AI or HI adoption in the public sector. The discussion will provide both theoretical constructs and practical suggestions for designing inclusive and effective AI and CI in public governance.

4. Panel Structure

Tab. 1 – Panel Program.

Session	Duration	Theme	Presenter
Introduction	5 min.		Chair
1st Presentation	20 min.	Hybrid Intelligence for Smart City Development: Stakeholders Perspective	Grażyna Musiatowicz-Podbiał;
2nd Presentation	20 min.	Fisheye Camera Images for Traffic Flow Detection in Hsinchu City	Hsien-Lee Tseng; Ko Wei-Jan
3rd Presentation	20 min.	Enabling Data-Driven Public Services and Governance through Hybrid Intelligence	Helen K. Liu
Discussions	20 min.	Q&A	Open to the audience
Closing	5 min.		Chair

5. Panalists

Helen K. Liu: Professor in the Department of Political Science and Director of the NTU Center for Collective Intelligence, National Taiwan University (NTU). Her research develops crowdsourcing platform design principles for the public sector to engage citizens. Her research interests are crowdsourcing, online engagement, collaborative governance, e-governance, and inter-organizational networks. She serves as a conference co-chair of the dg.o

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

conference 2024. She also serves on the *Government Information Quarterly* and *Public Administration* editorial board.

Grażyna Musiatowicz-Podbiał: Assistant Professor at Department of Informatics in Management, Faculty of Management and Economics, Gdańsk University of Technology, Poland. Her research includes applied information technology, IT strategies, digital transformation, economic, digital business, digital government, and digital platforms. She served as a conference co-chair of the dg.o conference 2023.

Hsien-Lee Tseng is an Associate Professor at the Department of Public Administration and Management at the National University of Tainan, Taiwan, specializing in e-governance, data governance, and public policy. He is also a research fellow at the Taiwan E-Governance (TEG) Research Center. His recent research focuses on digital rights and principles, and AI application in public sectors.

Wei-Jan Ko is a PhD candidate at National Yang Ming Chiao Tung University and currently serves as a researcher at Center of Research Acquisition, National Institute of Cyber Security, Taiwan. His expertise lies in information security, data governance, and digital policy.

Magdalena Ciesielska: Assistant professor at the Department of Informatics in Management, Faculty of Management and Economics, Gdańsk University of Technology, Poland. Her research includes e-government, smart city, and sustainability.

Acknowledgement

- **Funding or Grant:** This research project was supported by the Ministry of Science and Technology, Taiwan, R.O.C. [NTSC 112-2410-H-002-116-SS3], and Yushan (Young) Scholar Award [MOE-112-YSFSL-0003-002-P2].
- **Contributor Statement***: Conceptualisation; Methodology; Funding; Writing - Original Draft; Writing-Editing: All Authors; Visualisation: Hsien-Lee Tseng;
- **Use of AI***: During the preparation of this work, the author(s) used Grammaly in order to proof-read the proposal. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Anttiroiko, A. V., Valkama, P., & Bailey, S. J. (2014). Smart cities in the new service economy: building platforms for smart services. *AI & society*, 29, 323-334.

Ciesielska, M.; Rizun, N.; Janowski, T. (2021). Interdisciplinarity in Smart Sustainable City education: Exploring educational offerings and competencies worldwide. In *Proceedings of the 54th Hawaii International Conference on System Sciences (HICSS)*, Kauai, HI, USA, 2434–2443.

Ciesielska, M., Rizun, N., & Chabik, J. (2022). Assessment of E-government inclusion policies toward seniors: A framework and case study. *Telecommunications Policy*, 46(7), 102316.

Elazhary, H. (2019). Internet of Things (IoT), mobile cloud, cloudlet, mobile IoT, IoT cloud, fog, mobile edge, and edge emerging computing paradigms: Disambiguation and research directions. *Journal of network and computer applications*, 128, 105-140.

Gil-Garcia, J. R., Pardo, T. A., & Nam, T. (2015). What makes a city smart? Identifying core components and proposing an integrative and comprehensive conceptualization. *Information Polity*, 20(1), 61-87.

Gil-Garcia, J. R., Zhang, J., & Puron-Cid, G. (2016). Conceptualizing smartness in government: An integrative and multi-dimensional view. *Government Information Quarterly*, 33(3), 524-534.

Kitchin, R. (2014). The real-time city? *Big data and smart urbanism*. GeoJournal, 79, 1-14.

Linders, D. (2012) From e-government to we-government: Defining a typology for citizen coproduction in the age of social media. *Government Information Quarterly*, 29.4 (2012): 446-454

Liu, H. K. (2017a). An analysis of online interaction in idea generation for public policies. *Information Polity*, 22(2-3), 117-135.

Liu, H. K. (2017b). Crowdsourcing government: Lessons from multiple disciplines. *Public Administration Review*, 77(5), 656-667.

Liu, H. K. (2021). Crowdsourcing: Citizens as coproducers of public services. Policy & Internet, 13(2), 315-331.

Liu, H. K., Guo, Y. W., & Chen, L. Y. (2023). Crowdsourcing Smart City: SmartTaipei Project. In *Proceedings of the 24th Annual International Conference on Digital Government Research* (pp. 44-54).

Liu, H. K., Chao, S. L., & Chen, H. M. (2024). Exploring Government-Citizen Relationships through TaipeiPASS and TiapeiOn Platforms. In *Proceedings of the 25th Annual International Conference on Digital Government Research* (pp. 383-392).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Liu, H. K., Tang, M., & Collard, A. S. J. (2025). Hybrid intelligence for the public sector: A bibliometric analysis of artificial intelligence and crowd intelligence. *Government Information Quarterly*, 42(1), 102006.
Lorenz-Spreen, P., Lewandowsky, S., Sunstein, C. R., & Hertwig, R. (2020). How behavioural sciences can promote truth, autonomy and democratic discourse online. *Nature human behaviour*, *4*(11), 1102-1109.
Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. *Technological forecasting and social change*, 153, 119281.
Meijer, A., & Bolívar, M. P. R. (2016). Governing the smart city: a review of the literature on smart urban governance. *International review of administrative sciences*, 82(2), 392-408.
Musiatowicz-Podbial, G. (2024, June). How digital platforms support public values through government-citizen collaboration?. In *Proceedings of the 25th Annual International Conference on Digital Government Research* (pp. 415-422).
Nikiforova, A., Rizun, N., Ciesielska, M., Alexopoulos, C., & Miletić, A. (2023, August). Towards High-Value Datasets determination for data-driven development: a systematic literature review. In *International Conference on Electronic Government* (pp. 211-229). Cham: Springer Nature Switzerland.
Valentino, N. A., Neuner, F. G., Kamin, J., & Bailey, M. (2020). Testing Snowden's hypothesis does mere awareness drive opposition to government surveillance?. *Public Opinion Quarterly*, *84*(4), 958-985.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Beyond the Bureaucracy: Modeling Scenarios of Non-Mediated Governance with Liquid Democracy

Alois Paulin [a,b*]

[a] Faculty of Management and Law, University of Applied Sciences, Ludwigsburg, Germany, alois@apaulin.com, ORCID number 0000-0002-5353-2006.

[b] ZIS Pomurje, Murska Sobota, Slovenia.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 27 June 2025

Abstract. Nonmediated Governance (nm-Gov) refers to a visionary state of a society in which members of the society steer their government through Liquid Democracy. This for now purely theoretical concept assumes that every citizen is represented in a digital form, that all assets of the society are represented digitally, as well as that rules that govern the community are digital. This paper summarizes nm-Gov and Liquid Democracy and describes a diagraming technique used to model use-cases to better understand how data in nm-Gov can be translated to concrete governance action. Deeper exploration of nm-Gov through modeling further use-cases with this diagraming technique is the theme of the Beyond Bureaucracy workshop at the dg.o 2025 in Porto Alegre, Brazil.

Keywords. Liquid democracy, self-governance, nonmediated governance
Panel, DOI: https://doi.org/10.59490/dgo.2025.1052

1. Introduction

Impulsive administrative behavior has early become the hallmark of the Trump II administration in the USA, causing ripples all around the world. By April 2025 their executive orders regarding themes such as *diversity, inclusion, equity, and inclusion* (DEI) programs (EO 14151, 14173, 14190, etc.), birthright citizenship (EO 14160), foreign aid programs (EO 14169), public administration workforce (EO 14210, 14238), or tariffs (EO 14245, 14257, 14259, 14266), have substantially affected the legal, economic, and social fates of many US-American inhabitants, citizens, and voters. The swiftness and character of the actions brings up two important aspects of modern democracies: the aspect of buyer's remorse in relation to a continued democratic support of a government administration by its voters (Curtice, 2018; Krieger, 2025), as well as the question of the ability of traditional institutions of democracies to enforce the *rule of law* where governments result to *nonacquiescence* (Matthew, 2019). An indication for an ongoing conflict between the branches of government in the USA is the outcry by popular media outlets on the legal challenges faced by the Trump II administration regarding their executive orders. But other Western nations are also facing similar conflicts. Thus, the *International Criminal Court's* (ICC) issuance of an arrest warrant against the prime minister of Israel and his minister of defense put ICC member states in a position where defiance of the ICC was considered openly (Diekjobst, 2025; Sabel, 2024).

More direct democracy has been argued as a remedy against newly elected governments getting off the democratic leash (Kogan, 2016). A special kind of direct democracy is *Liquid Democracy* (Paulin, 2014, 2020; Valsangiacomo, 2021), a way of democratic representation in which individuals revocably delegate their political *trust* to other members of a community and vote on matters of common concern by the power of their received delegated *trust*. Liquid Democracy (LD) considers also delegated trust as a form of semi-active political participation and thus, it can maximize the number of members of a society that back political decisions. As such, LD is considered the most democratic way for a community to arrive at common decisions (Blum & Zuber, 2016; Valsangiacomo, 2025). The

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

defining characteristic of LD is the ability of an individual to revoke their trust delegation at any time (hence "liquid"). This characteristic can serve as a mechanism for a community to implement policies that can *erode* and eventually *vanish* once the community is no longer backing them by a sufficiently high intensity of support.

The practicability of LD remains a subject of active debate amongst scholars (Butterworth & Booth, 2023; Caragiannis & Micha, 2019; Valsangiacomo, 2025; Valsangiacomo & Zuber, 2025). Scholars who argue in favor point out at the superior democratic properties of this model, while scholars who argue against it bring forward fears of utter chaos stemming from a high frequency in changes to laws, citizens overburdened with too much choice, and a lack of institutional checks and balances if LD was to be used as a tool for passing laws and public policies. One way or another, LD remains a concept with different possible implementations with not enough empirical observations from real-world experiments (Paulin, 2019a, Section 3.5-"Apropos: the Pirates & co.", 2020).

Liquid Democracy can only be implemented by digital systems that rely on *informated* (Paulin, 2018) relations between members of a community; *informated* means that the identities of individuals are described as digital data that resides in cyberspace. One way of implementing LD has been described by Paulin (2014, 2019e): to apply it in such a way that the action of agents and agencies, which collectively make up government, can be steered by controlling access to informated resources such as public funds (use of money for concrete undertakings), societal ranks and roles (who can call themselves "head of state" in relation to other nations, who has the trust to adjudicate conflicts, etc.), and the eligibilities that come with such ranks or roles in a society (who has access to state secrets, to the nation's bullion vault, to weapons systems, etc.). Such use of LD for *steering* the agents and agencies of a state is quite different from using LD for gathering a public's opinion on a policy issue that would merely *instruct* agencies to behave in a certain way. This approach is called *Nonmediated Governance* and examples on how this could work out are provided in chapter 10 of the book *Smart City Governance* (Paulin, 2019d).

The objective of this paper is twofold: (1) to outline *Nonmediated Governance* (nm-Gov) as a visionary concept, and (2) to describe a toolset to plan and model scenarios for nm-Gov. The rest of this paper is structured as follows: Section 2 presents nm-Gov in terms of a vision. Section 3 presents nm-Gov scenarios to illustrate the concept and a toolset for modeling nm-Gov scenarios that shall be used to further explore nm-Gov scenarios as part of the Beyond Bureaucracy workshop at the dg.o 2025.

2. Nonmediated Governance

The term *Nonmediated Governance* – nm-Gov (Paulin, 2019d), refers to a visionary state of a society in which members of the society steer their government through Liquid Democracy – LD. In nm-Gov, LD is not used as a tool to form public policy, but as a tool to *steer* (by assigning / revoking) societal roles of individuals, budgets of projects, and access to *resources* such as information, data, or systems. This concept is *visionary*, as it can be imagined only as a hypothetical state and has not been directly implemented in modern states. To implement it, a society / state would need to assure that all citizens' identities, as well as *resources* of such society were represented in form of digital data that can be accessible from within cyberspace.

As of today, such interaction between *identities* and *resources* in cyberspace already exists: e-mail providers, e-banking systems, cloud storage, as well as cyber-physical systems (systems that can be steered from within cyberspace as part of the *Internet of Things* paradigm (Kopetz & Steiner, 2022)) are nothing but systems that provide *informated* resources of some kind, and govern who can access these resources under what conditions (cf. van Steen & Tanenbaum, 2023). Representing individuals and their properties in cyberspace is easily doable by state-of-art technology, and so is representing resources such as money, information, or systems. Controlling access to such *informated* identities, properties, and resources can easily be done (Paulin, 2019b) and is well established in online services and "smart" products that are connected to the Internet for purposes of control and maintenance, such as cars, farming machinery, household appliances, drones, etc.

Modern states however did not do the leap into cyberspace in a way that would leverage this potential just yet. The focus of states is on e-government, which is about *digitalizing* processes that have been designed and implemented before the digital age (Bovens & Zouridis, 2002; Paulin, 2019b, 2019a). The outcome of (digitalized at best) government processes are typically certificates of some kind – birth certificates, marriage certificates, high school and university diplomas, building permits, etc. Some government bodies issue and accept *informated* certificates (Austria, for example provides the app "eAusweise", which provides one's driving license, car registration certificate, and personal ID in form of a dynamically generated QR code), but they remain *certificates* even so. The objective of such certificate is to manifest that its holder has a given set of characteristics (e.g. has graduated high school, is married, or has been deemed fit to operate a vehicle). These characteristics can have a meaning under specific circumstances: some jobs might require a university diploma, alimony and inheritance rights will depend on whether one has been married, and authorities might punish one for starting construction without a building permit.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

In contrast, whenever we check e-mails, transact money via e-banking, or access cloud files, we do not present certificates that would demonstrate our *eligibilities* within these digital systems. Obviously, it would be counterintuitive to do so, but one might still ask: why not? The reason is, that digital systems have built-in mechanisms that govern the access to resources based on the *identity* of the accessor. These *resources* are *objects* such as folders, files (also e-mails are files!), records (e.g. bank transactions), and user accounts, as well as *properties* of these objects, which define their characteristics. Even the rules by which access to the *resources* of a digital system is governed, are *resources* of the digital system, and hence, can be inspected and modified if one has the required *eligibilities* to do so.

Resources in a digital system are nothing but digital *data* that can be created, read, modified, and deleted. Changes to this data can change the way a system behaves and can change who can access what resources under which conditions. This paradigm could be – in theory at least, applied to govern entire states. This would require each citizen's identity to be represented as digital data within a system, as well as all resources of the state, such as funds, information, or access to technical systems that can be controlled from within cyberspace. Such system could be either a monolithic program, or a distributed system consisting of many connected systems as is the World Wide Web (Berners-Lee et al., 1992). By accessing the data stored in such system one could *determine* at any time the role, the rank, and the *eligibilities* of a person in a given context. By modifying this data, one would shape one's own or other people's role / rank / eligibilities.

If also the rules governing access to this data would be stored in the same way as other data in that system, then an interesting possibility would arise: a society could change these rules by means of LD, thus organically morphing the rules under which the society operates. The rules by which the liquid democratic decision making would operate in such society – i.e., what is needed for a decision to be binding, can be represented in this way as well. Such self-altering system is technically possible, as has been demonstrated by Paulin (2015, 2019c), who used relational databases and the SQL language to show how such digital rules can be accessed and changed by means of Liquid Democracy.

3. Modeling rules for nm-Gov: Constellation-Based Reasoning

In nm-Gov, *eligibilities* are derived ad-hoc from data know to the system without human mediation in creating, accessing or manipulating this data. Parts of this data would be *assertions* by officials and professionals on conditions such as one's knowledge level on a certain matter, physical health, or judgments in criminal or civil proceedings. Other data would be provided during vital events (birth, marriage, death), education, employment, etc. By interacting with this data, one might be able to conduct things like:

- Registering the birth of another person. *Conditions*: 1) one is registered as a professional with a role that allows for a creation of such data; 2) the person to be registered has not yet been registered already.
- Give one's newborn a name. *Conditions*: 1) one is a parent of the newborn; 2) the person to be given a name has no name yet.
- Authorize a payment to a company to build a new park in the city. *Conditions:* 1) one has the backing of the required number of community members in the LD network; 2) there is enough money on the community's account.
- Impose tariffs by implementing a rule according to which if one wants to pay money to a company that is on a long list of foreign companies, they first must have paid 25% of that sum to the community. *Conditions:* 1) one has the backing of the required number of community members in the LD network to change the rules.
- Claim one's monthly salary. *Conditions:* 1) one is on a list of people entitled to a salary.
- Remove somebody from the list of people entitled to a salary. *Conditions:* 1) one is on a list of people entitled to change data in the list of people entitled to a salary.
- Claim one's monthly payment of unemployment allowance. *Conditions*: 1) one is not making active contributions to the unemployment insurance; 2) one has been paying unemployment insurance contributions for six months before claiming the allowance; 3) one has not been claiming unemployment allowance for six months already.

Above conditions can be thought differently and for sure would differ by jurisdiction and time. They serve to illustrate the relation between one's intended action and conditions that need to be fulfilled so one has the *eligibility* to conduct the desired action. One's eligibility derives from a *constellation* of data know to the nm-Gov system – data such as whether one exists, is on the payroll of some public agency, has been contributing to unemployment insurance, has the backing of a community to change its rules, etc.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

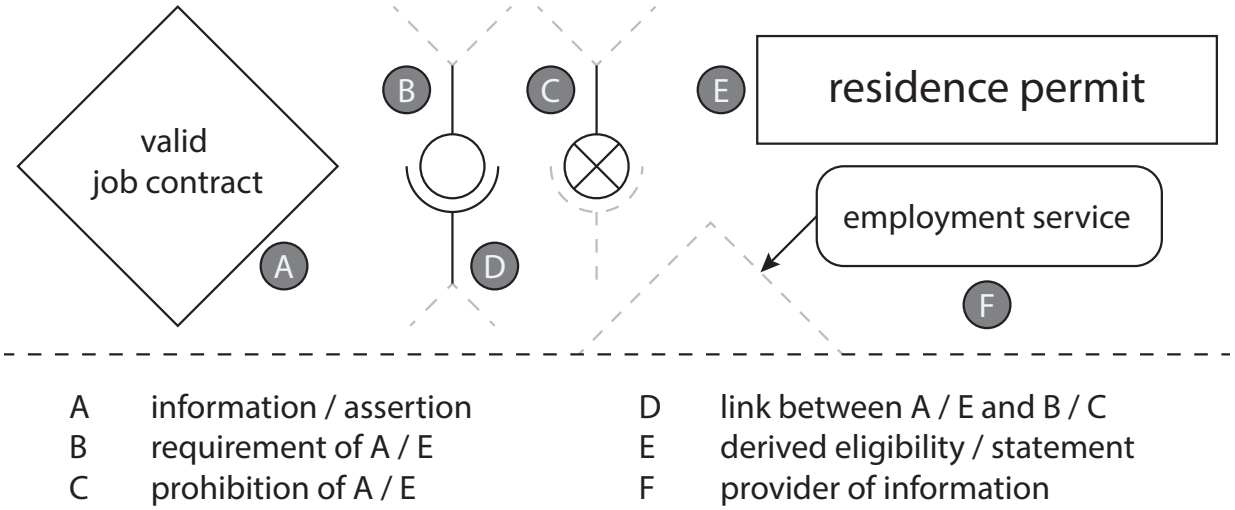


Fig. 1 - Elements for depicting constellation-based-reasoning (CBR) by means of a diagram.

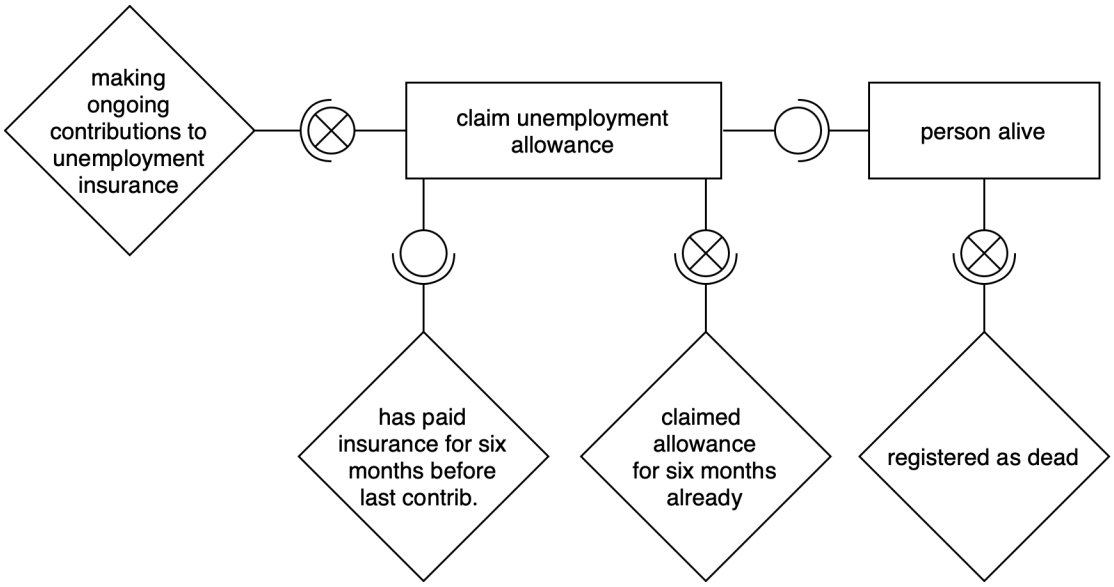


Fig. 2 - CBR diagram depicting the constellation of data required so that one can obtain their monthly unemployment allowance payment

To model and communicate such constellations of preconditions visually, a diagramming technique has been devised (Paulin, 2019d, Section 9.3), as shown in Fig. 1.: Element *A* is used to express data known to the nm-Gov registry; element *E* stands for the eligibility one desires; *B*, [C], and [D] are connectors, whereby [B] indicates that the assertion from the connected [A]-element must be existing and / or true, while [C] indicates that the data / assertion from the connected [A]-element must either not exist, or not be true. Element [F] is used to indicate who can provide the data / assertion. An implementation of this toolset for Draw.io is available on GitHub (Paulin, 2025).

Fig. 2 shows how the CBR diagram can be used to model a claim for monthly unemployment allowance payments.

Further use-cases of nm-Gov reasoning were modelled by this technique as part of the Beyond Bureaucracy workshop at the dg.o 2025. The first part of the workshop aimed at creating a deeper understanding of nm-Gov and LD. The diagramming technique as described here was introduced to the participants using the Draw.io implementation. Finally, workshop participants selected complex scenarios to be modelled and discussed with regards to their real-world implications.

Acknowledgement

- **Conflict Of Interest (COI)**: There is no conflict of interest.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

Berners-Lee, T., Cailliau, R., Groff, J.-F., & Pollermann, B. (1992). World-Wide Web: The Information Universe. *Internet Research*, *2*(1), 52–58. https://doi.org/10.1108/eb047254

Blum, C., & Zuber, C. I. (2016). Liquid Democracy: Potentials, Problems, and Perspectives: Liquid Democracy. *Journal of Political Philosophy*, *24*(2), 162–182. https://doi.org/10.1111/jopp.12065

Bovens, M., & Zouridis, S. (2002). From Street-Level to System-Level Bureaucracies: How Information and Communication Technology is Transforming Administrative Discretion and Constitutional Control. *Public Administration Review*, *62*(2), 174–184. https://doi.org/10.1111/0033-3352.00168

Butterworth, G., & Booth, R. (2023). A Contribution to the Defense of Liquid Democracy. *Proceedings of the 24th Annual International Conference on Digital Government Research*, 244–250. https://doi.org/10.1145/3598469.3598496

Caragiannis, I., & Micha, E. (2019). A Contribution to the Critique of Liquid Democracy. *Proceedings of the 28th International Joint Conference on Artificial Intelligence*. IJCAI-19.

Curtice, J. (2018). Buyer's Remorse: Has Britain Changed Its Mind on Brexit? *Political Insight*, *9*(1), 12–15. https://doi.org/10.1177/2041905818764700

Diekjobst, R. (2025). Editorial #43: The Ides of March. *Völkerrechtsblog*. https://doi.org/10.17176/20250313-000814-0

Kogan, V. (2016). When Voters Pull the Trigger: Can Direct Democracy Restrain Legislative Excesses? *Legislative Studies Quarterly*, *41*(2), 297–325. https://doi.org/10.1111/lsq.12115

Kopetz, H., & Steiner, W. (2022). Internet of Things. In H. Kopetz & W. Steiner, *Real-Time Systems* (pp. 325–341). Springer International Publishing. https://doi.org/10.1007/978-3-031-11992-7_13

Krieger, N. (2025). Buyer's Remorse, Betrayal, and Blame: Who Will Be Held Responsible for the Adverse Health Impacts of the US Elections? *American Journal of Public Health*, *115*(3), 324–325. https://doi.org/10.2105/AJPH.2024.307985

Matthew, T. W. (2019). *Ignoring the Courts: A Contextual Analysis of Administrative Nonacquiescence*. https://doi.org/10.15779/Z387W6762V

Paulin, A. (2014). Through Liquid Democracy to Sustainable Non-Bureaucratic Government—Harnessing the Power of ICTs for a novel form of Digital Government. *eJournal of eDemocracy and Open Government*, *6*(2), 216–230. https://doi.org/10.29379/jedem.v6i2.307

Paulin, A. (2015). *Towards a sustainable system for non-bureaucratic government: Doctor of science thesis* [Doctoral thesis, University of Maribor]. https://dk.um.si/IzpisGradiva.php?id=47605

Paulin, A. (2018). Digitalisation vs. Informatisation: Different Approaches to Governance Transformation. *Central and Eastern European eDem and eGov Days*, *331*, 251–261. https://doi.org/10.24989/ocg.v331.21

Paulin, A. (2019a). Controlling Citizens or Controlling the State? In *Smart City Governance* (pp. 61–79). Elsevier. https://doi.org/10.1016/B978-0-12-816224-8.00003-0

Paulin, A. (2019b). Controlling Through Technology. In *Smart City Governance* (pp. 143–158). Elsevier. https://doi.org/10.1016/B978-0-12-816224-8.00007-8

Paulin, A. (2019c). Describing Legal Rules Through a System of Electronic Legal Acts. In *Smart City Governance* (pp. 237–250). Elsevier. https://doi.org/10.1016/B978-0-12-816224-8.00013-3

Paulin, A. (2019d). Model for Nonmediated Governance. In *Smart City Governance* (pp. 187–201). Elsevier. https://doi.org/10.1016/B978-0-12-816224-8.00010-8

Paulin, A. (2019e). *Smart City Governance*. Elsevier. https://doi.org/10.1016/C2017-0-04241-6

Paulin, A. (2020). An Overview of Ten Years of Liquid Democracy Research. *The 21st Annual International Conference on Digital Government Research*, 116–121. https://doi.org/10.1145/3396956.3396963

Paulin, A. (2025). *CBR shapes for Draw.io* [Dataset]. https://github.com/aloispaulin/nmgov/blob/main/CBR%20Elements.xml.

Sabel, R. (2024). Israel, the ICC, and the Arrest Warrants against Netanyahu and Gallant. *Israel Journal of Foreign Affairs*, *18*(3), 320–325. https://doi.org/10.1080/23739770.2024.2440838

Valsangiacomo, C. (2021). Clarifying and Defining the Concept of Liquid Democracy. *Swiss Political Science Review*, spsr.12486. https://doi.org/10.1111/spsr.12486

Valsangiacomo, C. (2025). Six arguments in favor of liquid assemblies. *Critical Review of International Social and Political Philosophy*, 1–24. https://doi.org/10.1080/13698230.2025.2478729

Valsangiacomo, C., & Zuber, I. (2025). *Should a citizens' assembly complement the European Parliament?*. Publications Office. https://data.europa.eu/doi/10.2870/9250462

van Steen, M., & Tanenbaum, A. S. (2023). *Distributed Systems* (4th ed.). distributed-systems.net.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital government and meaningful connectivity: Opportunities and challenges for theory and practice

Manuella Maia Ribeiro [a*], *Maria Alexandra Cunha* [b], *Elsa Estevez* [c], J. Ramon Gil-Garcia[d]

[a] Regional Center for Studies on the Development of the Information Society (Cetic.br), Brazilian Network Information Center (NIC.br), São Paulo, Brazil, manuella@nic.br, https://orcid.org/0000-0002-5420-1348

[b] Escola de Administração de Empresas de São Paulo, Fundação Getulio Vargas (FGV), São Paulo, Brazil, alexandra.cunha@fgv.br, https://orcid.org/0000-0002-2022-0030

[c] Universidad Nacional del Sur, Bahía Blanca, Argentina, ecestevez@gmail.com, https://orcid.org/0000-0002-2596-4397

[d] Center for Technology in Government, University at Albany, SUNY, Albany, United States, jgil-garcia@albany.edu, https://orcid.org/0000-0002-1033-4974

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. The panel aims to explore the role of meaningful connectivity in digital government theory and practice, identify existing gaps, and propose future research directions. The meaningful connectivity perspective, which transcends binary Internet access metrics, is generally defined by the presence of infrastructure, affordability, and digital skills—dimensions considered crucial for ensuring that low-income and vulnerable populations can effectively use digital public services. The panel discussion will also showcase practical case studies of meaningful connectivity measurement in Brazil, Chile, the Dominican Republic, and Uruguay, using the methodology developed by the Regional Center for Studies on the Development of the Information Society (Cetic.br), a UNESCO Category II center located in Brazil. By engaging experts and researchers in digital government, the panel intends to provide valuable insights for academics, policymakers, and practitioners aiming to enhance the adoption of digital public services and bridge digital divides.

Keywords. Meaningful connectivity, digital government, digital services uptake.
Panel, **DOI**: https://doi.org/10.59490/dgo.2025.927

1. Theme and Objectives

The theme of the panel "Digital Government and meaningful connectivity: Opportunities and challenges for theory and practice" is related to the uptake of digital government and meaningful connectivity. It focuses on examining the role of meaningful connectivity in the theory and practice of digital government. The meaningful connectivity concept extends beyond mere Internet access, incorporating more dimensions such as infrastructure, affordability, and digital skills to ensure that digital technologies can effectively benefit all, especially vulnerable and underserved populations (Castello, 2024; Macaya, 2024). In this sense, the panel seeks to explore how meaningful connectivity can affect access to digital public services and promote the uptake of digital government.

The panel's objectives are threefold. First, it aims to debate the possibilities of integrating meaningful connectivity into digital government theory and practice, focusing on the population's access to digital public services. Second, it seeks to propose future research directions that can address existing gaps in understanding the relationship between meaningful connectivity and digital government. Third, the panel will present practical case studies of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

meaningful connectivity measurement in Latin American and Caribbean countries, including Brazil, Chile, the Dominican Republic, and Uruguay, showcasing methodologies and insights derived from these experiences.

Through these discussions, the panel intends to promote a debate about the role of meaningful connectivity perspective as a framework for addressing digital inequalities and ensuring that digital public services are accessible and inclusive. The practical cases seek to highlight innovative approaches and methodological frameworks, such as those developed by the Regional Center for Studies on the Development of the Information Society (Cetic.br), offering actionable insights for policymakers, researchers, and practitioners. By connecting theoretical debates with real-world contexts, the panel aims to provide a comprehensive perspective on the opportunities and challenges of integrating meaningful connectivity into digital government initiatives and frameworks.

2. Digital government questions and issues addressed by the panel

The panel explores the gaps in literature and practice concerning the uptake of digital government services, particularly through the lens of meaningful connectivity and its intersection with digital government from an equity perspective. Meaningful connectivity has gained prominence in recent international reports and conferences, such as the ones proposed by the International Telecommunication Union (ITU) (ITU, 2022), the Alliance for Affordable Internet (A4AI) (A4AI, n.d.), the United Nations (UN) Digital Global Compact (UN, 2024), and the discussions held during Brazil's 2024 G20 Presidency (G20, 2024).

Meaningful connectivity is understood as a threshold of connectivity quality encompassing multiple dimensions, such as infrastructure, affordability, and digital skills, rather than a binary measure of access (Alliance for Affordable Internet (A4AI), n.d.). It is proposed to be measured at the individual level, providing a granular understanding that population-wide indicators fail to capture. This construct underscores that merely having Internet access does not equate to meaningful access, especially when considering digital government services (Macaya, 2024). This is crucial for ensuring that low-income and vulnerable populations, who typically experience lower levels of connectivity, can effectively benefit from digital technologies (Belánger & Carter, 2009; Helbig et al., 2009).

The shift towards meaningful connectivity has significant implications for digital government research, policy, and practice. Despite its relevance in addressing digital inequalities, studies of meaningful connectivity through a digital government lens remain limited. Furthermore, comprehensive governmental policies addressing meaningful connectivity are still in early development. In this context, Cetic.br, a Category II UNESCO center and a department of the Brazilian Network Information Center (NIC.br) located in Brazil, developed a methodological framework for measuring meaningful connectivity based on data from its annual ICT Households survey (NIC.br, 2024). This nationally representative probabilistic study, conducted since 2005, identifies the adoption and ownership of information and communication technologies (ICT) among individuals 10 years old or older in Brazil (NIC.br, n.d.). Cetic.br´s methodological model for measuring meaningful connectivity is also being applied in Latin American and Caribbean countries, such as Chile, the Dominican Republic, and Uruguay, with plans for implementation in seven African countries, among other nations. Based on this context, the panel aims to highlight the opportunities and challenges of implementing the meaningful connectivity framework in digital government research and practice by addressing the following questions:

- What are the key dimensions and indicators of meaningful connectivity, and how do they impact the uptake of digital government services?
    - Exploring the relationship between meaningful connectivity and digital government service adoption.
    - Examining the implications of meaningful connectivity dimensions, such as infrastructure, affordability, and digital skills.
- How can meaningful connectivity be effectively measured and operationalized in diverse contexts, particularly in Latin America countries?
    - Discussing the methodological approaches and challenges in measuring meaningful connectivity.
    - Presenting case studies from Brazil, Chile, the Dominican Republic, and Uruguay.
- What policy recommendations can be derived from a meaningful connectivity approach to improve digital government services theory and practice?
    - Proposing actionable policies and scientific strategies to enhance meaningful connectivity frameworks in both literature and practice.
    - Identifying best practices and lessons learned from countries, especially Latin American initiatives.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

By addressing these questions, the panelists hope to foster a deeper understanding of meaningful connectivity's role in digital government and inspire future research and practical applications to enhance the adoption of digital public services, and bridge digital divides.

3. Benefits of discussed topics for attendees and research

Conference attendees will have the opportunity to explore the intersection of digital government and meaningful connectivity, including current debates and identifying gaps in both literature and practice. Additionally, they will be introduced to the methodology developed by Cetic.br for measuring meaningful connectivity and its results in Latin American and Caribbean countries.

The panel aligns with the conference theme "Digital government fostering social cohesion for reducing inequalities", as panelists seek to discuss strategies to enhance meaningful connectivity in the context of digital inequalities and its policy implications for ensuring equitable access to online public services. It also fits with both conference tracks 8 (Digital Government for Stronger Society) and 23 (Dialogues about Latin America).

4. Format

The panel is structured as an interactive session. The planned format is a plenary with short presentations from each expert and Q&A from the audience. The schedule is presented below:

• Session Introduction (Session moderator – up to 10 minutes)

• Short presentations from panelists (up to 10 minutes per panelist)

• Q&A from audience and moderator

• Closing comments and session summary (moderator and panelists)

3. Panel composition

The moderator is Manuella Maia Ribeiro, ICT Research Projects Coordinator from Cetic.br (Brazil). She is a digital government and public administration specialist coordinating the Brazilian ICT Electronic Government survey since 2013. She holds a PhD and Master's degree in Public Administration and Government from the Getulio Vargas Foundation (Brazil), a bachelor's degree in public policy management from the University of São Paulo (Brazil), and Law from the Mackenzie Presbyterian University (Brazil). She is a visiting expert at the United Nations University Operating Unit on Policy-Driven Electronic Governance (UNU-EGOV).

Professor Maria Alexandra Cunha, from Fundação Getulio Vargas (Brazil), brings her extensive background in digital government, ICT governance, and smart cities. Her work focuses on how governments can leverage technology to enhance public service delivery, reduce inequalities, and foster inclusive digital transformation. At FGV, she also leads the IT and Government area in the Center for Public Administration and Government (CEAPG).

The panel also features Professor Elsa Estevez, Universidad Nacional del Sur (Argentina). She is an internationally recognized researcher in digital government. She has consulted for governments, taught public managers and policymakers, and organized events about digital government in over 30, mostly developing countries. Her research interests cover structuring the information technology function in government, the digital transformation of government-citizen relationships, and the impact of such transformation on nations' and cities' capacity to pursue sustainable development. She has a PhD in Computer Science from Universidad Nacional del Sur.

The panellists include J. Ramon Gil-Garcia. Gil-Garcia is a professor at the University at Albany, SUNY, and Director of the Center for Technology in Government (CTG). His research focuses on digital government, inter-organizational collaboration, and digital inclusion. He has published extensively on smart cities, AI in public administration, and data-driven decision-making. With his experience, Professor Gil-Garcia has contributed to discussions on technology's role in public sector transformation.

Together, the panellists and the moderation will provide a multifaceted perspective on the role of meaningful connectivity in digital government, drawing from their extensive research and practical experience in many countries. Their contributions aim to bridge gaps in theory and practice, offering actionable insights for advancing inclusive and effective digital government.

Acknowledgement

- **Contributor Statement**: Manuella Maia Ribeiro was responsible for conceptualization, and writing - original draft. Maria Alexandra Cunha, Elsa Estevez and J. Ramon Gil-García were responsible for writing - review and editing.
- **Use of AI**: During the preparation of this work, the authors used Grammarly in order to correct grammatical errors. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Alliance for Affordable Internet. (n.d.). *Meaningful connectivity – unlocking the full power of Internet access*. https://a4ai.org/ meaningful-connectivity/

Bélanger, F., & Carter, L. (2009). The impact of the digital divide on e-government use. *Communications of the ACM, 52*(4), 132-135. https://doi.org/10.1145/1498765.1498801

Brazilian Network Information Center. (2024). *Meaningful connectivity: Measurement proposals and the portrait of the population in Brazil* (NIC.br Sectoral Studies). CGI.br. https://cetic.br/pt/publicacao/ meaningful-connectivity-measurement-proposals-and-the-portrait-of-the-population-in-brazil/ Brazilian Network

Brazilian Information Center. (n. d.). *ICT Households*. https://cetic.br/en/pesquisa/domicilios/

Castello, G. (2024). Meaningful connectivity in Brazil: The portrait of the population. In Brazilian Network Information Center, *Meaningful Connectivity: Measurement proposals and the portrait of the population in Brazil* (NIC.br Sectoral Studies, pp. 77-136). CGI.br. https://cetic.br/pt/publicacao/ meaningful-connectivity-measurement-proposals-and-the-portrait-of-the-population-in-brazil/

Helbig, N., Gil-García, J. R., & Ferro, E. (2009). Understanding the complexity of electronic government: implications from the digital divide literature. *Government Information Quarterly*, 26(1), 89-97. https://doi.org/10.1016/j.giq.2008.05.004

G20. (2024). *G20 Rio de Janeiro leader's declaration*. G20. https://www.gov.br/planalto/pt-br/media/18-11-2024-declaracao-de-lideres-g20.pdf

International Telecommunication Union. (2022). *Achieving universal and meaningful digital connectivity: Setting a baseline and targets for 2030*. https://www.itu.int/itu-d/meetings/statistics/wp-content/uploads/sites/8/2022/04/UniversalMeaningfulDigitalConnectivityTargets2030_BackgroundPaper.pdf

Macaya, J. F. M. (2024, October). Electronic government and meaningful connectivity levels: Who is really positioned to benefit from digital transformation in government?. In *Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance* (pp. 425-429).

United Nations. (2024). *Global digital compact*. https://www.un.org/techenvoy/global-digital-compact

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Responsible application of artificial intelligence in the Brazilian public sector: Governance and mitigation of inequalities

André Luiz Sucupira Antonio[a], Melina Ferracini de Moraes[b]

[a] Association of Public Information Technology Companies (ABEP-TIC), andre.sucupira@sp.gov.br, São Paulo, 0009-0001-6280-3146.

[b] University of Sao Paulo, melina_ferracini@sp.gov.br., São Paulo, 0000-0002-4185-3064

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 27 June 2025

Abstract. The proposed panel discusses the responsible application of artificial intelligence (AI) in the public sector, focusing on governance and the mitigation of inequalities inherent in risk, implementation, and structuring. AI presents unparalleled opportunities for enhancing efficiency and quality in public services. However, it is imperative to adopt a responsible approach to prevent exacerbating technical and social inequalities. This work examines best practices for governance in AI systems, transparency mechanisms, and inclusivity frameworks, ensuring that AI contributes to equitable and inclusive societal development.

Keywords: Artificial Intelligence, Public Sector, Governance, Inequalities, Accountability.
Panel, DOI: https://doi.org/10.59490/dgo.2025.1051

1. Introduction

The advent of artificial intelligence has profoundly transformed both public and private sectors, necessitating the establishment of robust governance structures to ensure ethical and responsible technology deployment. As public sector activities inherently aim to promote the common good, transparency, and quality in service delivery, AI systems can play a pivotal role in delivering efficient and timely services. However, disparities in access to technology across regions, coupled with the absence of well-defined governance mechanisms for developing and implementing AI, make it essential to deliberate on this subject.

The application of AI in public services introduces opportunities for modernization and efficiency, yet without adequate measures, it risks amplifying existing inequalities. Therefore, the establishment of governance structures not only aims at implementing transparent and ethical AI but also ensures equitable access to technology, thereby fostering a development model that aligns with societal objectives. This text explores the dimensions of AI governance in the public sector, emphasizing governance frameworks, mitigation of inequalities, transparency, and ethical accountability.

2. Governance in AI for the Public Sector

Governance of AI systems in the public domain has emerged as a key focus in recent debates. The ambivalence of AI—its ability to drive efficiency while exposing structural vulnerabilities—requires building frameworks of laws, norms, and policies that ensure responsible technology deployment.

Floridi (2013) aptly noted that the “infosphere” shaped by technological innovations influences societal realities and

policymaking. For the public sector, responsible AI governance involves addressing ethical, transparent, inclusive, and just dimensions. Key pillars include:

2.1 AI Governance: a) Regulation and Public Policies: Developing legal frameworks and policies that prioritize the rights of citizens, guaranteeing the safe and accountable use of AI systems; b) Ethics Committees and Oversight Bodies: Establishing committees to monitor and ensure compliance with ethical standards in AI use within the public sector.

2.2 Mitigation of Inequalities: a) AI for Public Services: Enhancing access and efficiency in health, education, and social welfare using AI-driven solutions in underserved a´reas; b) Impact Assessment Tools: Implementing AI systems to identify inequities and propose tailored interventions for effective policy outcomes.

2.3 ***Transparency and Accountability***: a) Algorithmic Explainability: Enabling citizens to understand how algorithmic decisions impact them, ensuring confidence in the system; b) Responsibility Frameworks: Clearly defining accountabilities and implementing mechanisms for addressing misuse of AI systems in public service delivery.

3. Challenges of Ethical AI in Governance

Artificial Intelligence, when implemented without adequate governance measures, risks amplifying societal inequalities. Historical biases present in training datasets can reinforce discriminatory practices. Additionally, disproportionate access to resources and AI technologies can further isolate marginalized groups. To address these challenges, the following measures are proposed:

3.1 ***Correction of Algorithmic Biases***: Identifying and mitigating biases in datasets ensures fair and equitable decision-making processes.

3.2 ***Equal Accessibility*****:** Policies promoting equitable access to AI-driven services must ensure inclusivity across racial, gender, socio-economic, and geographic diversities.

3.3 ***Social Inclusion***: AI solutions must proactively address marginalization, leveraging innovative techniques to promote empowerment and community development.

4. The Role of Governance Frameworks

Governance frameworks are integral to embedding ethical practices in AI deployment. Public sector governance includes two key dimensions:

4.1 Governance of People: Training public officials on AI use, ethical protocols, and decision- making processes to ensure effective implementation of AI systems.

4.2 Governance of Processes: Establishing standards for AI system development, operational guidelines, data integrity protocols, and societal impact evaluations. FLORIDI (2018) emphasized that socially responsible AI outcomes depend on balancing benefits against potential harm. While adherence to the law provides minimum compliance, ethical and impactful governance frameworks drive maximum societal benefits.

5. Socio-Technological Implications and Inequality Mitigation

Governance frameworks must integrate mechanisms to manage socio-technological implications. Unchecked AI deployment risks reinforcing inequalities. Algorithmic systems relying on historic datasets often replicate societal biases and exclusions. Effective mitigation strategies include: a) Scrutinizing and correcting biases in algorithmic training; b)Ensuring equal access to optimized and AI-enhanced public services; c)Promoting inclusive social advancements by designing solutions tailored to marginalized communities.

Moreover, enforcing stringent oversight mechanisms guarantees transparency in algorithmic processes and achieves accountability in service delivery. The OECD highlights technology governance as crucial to safeguarding shared values, protecting human rights, and building resilient societies. Governance structures must adapt to the socio-technological landscape to maintain their relevance and efficiency.

6. International Perspectives on AI Regulation

Globally, approaches to AI regulation vary significantly. The European Union's comprehensive AI Act

emphasizes risk mitigation but has faced criticism for restricting innovation. In contrast, the United Kingdom shifted towards prioritizing technological advancement in 2025. Similarly, the United States revised its stance by adopting innovation-centric policies under the Trump administration, eliminating pre-market AI safety protocols and emphasizing economic growth.

The divergence in international regulatory models presents both challenges and opportunities for Brazil. As a developing nation reliant on imported hardware and limited technological resources, Brazil must adopt a balanced regulatory framework that fosters innovation while safeguarding against risks. Collaborative efforts, leveraging global frameworks and addressing localized priorities, can propel Brazil toward effective and inclusive AI governance.

7. Methodology

This study employs bibliographic research under a hypothetical-deductive method, analyzing international frameworks and adapting them to public sector needs in Brazil. This methodology ensures alignment with global standards while addressing unique national challenges, building a customized governance model.

Concluding Remarks

The application of AI in the public sector demands responsible governance and practices that prioritize equity and mitigate inequalities. Governance structures must emphasize inclusivity, transparency, and accountability, ensuring AI benefits are fairly distributed while safeguarding citizens' rights. By fostering multistakeholder participation—uniting public authorities, private sectors, and civil society—Brazil can create a governance model that balances efficiency, justice, and ethical responsibility. This commitment to sustainable AI development is vital for advancing toward a more equitable and resilient society.

References:

Brazil. (2017). Decree No. 9,203, of November 22, 2017. Provides for the governance policy of the direct, autonomous, and foundational federal public administration. Available at: https://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/decreto/d9203.htm. Accessed on January 11, 2025.

Brazil. (2023). Bill No. 2,338, of May 3, 2023. Provides for the use of Artificial Intelligence in Brazil. Available at: https://www25.senado.leg.br/web/atividade/materias/-/materia/157233. Accessed on January 11, 2025.

Dafoe, A. (2018). AI Governance: A Research Agenda. Centre for the Governance of AI, Future of Humanity Institute, University of Oxford. Available at: https://www.futureofhumanityinstitute.org/. Accessed on January 23, 2025.

Floridi, L. (2013). The Ethics of Information. Oxford University Press. Available at: https://global.oup.com/academic/product/the-ethics-of-information9780198748052?cc=pl&lang=en&. Accessed January 25, 2025.

Floridi, L. (2018). Soft ethics and the governance of the digital. Philosophy & Technology, 31(1), 1–8. Available at: https://link.springer.com/article/10.1007/s13347-018-0303-9. Accessed on January 25, 2025.

Horta, R. L. (2019). Why are there cognitive biases in judicial decision-making? The contribution of psychology and neuroscience to the legal debate. Brazilian Journal of Public Policy, 9(3), 85–122. Available at: https://www.publicacoes.uniceub.br/RBPP/article/view/6089. Accessed on January 30, 2025.

Organization for Economic Cooperation and Development (OECD). (2019). Technology governance. Available at: https://www.oecd.org/en/topics/technology-governance.html. Accessed on January 29, 2025.

Track: Posters

Contents:

A Comparative Study on Judicial Visualization in the U.S. and China 1563
J. Zhou, C. Miao, and Y. Long

ARGOS: A Human-in-the-Loop ML System for Legal Aid Classification in Espírito Santo 1573
E. Pacheco

Beyond Technology: Local Authorities' Perspectives on Smart Sustainable Cities in Porto Alegre 1580
L. S. de Azambuja and R.-M. Soe

Can We Trust Open Government Data in Public Procurement? 1585
R. Fritzsche, J. Westermann, G. Klassen, M. Wyszynski, and B. Niehaves

Converging Paths? Co-creation practices in public services in Poland and Ukraine 1588
Y. Bartashevska, N. Rizun, H. Bondarovych, and N. Khairova

Cultural Observatories as Digital Platforms of Public Value in Brazil: A Comparative Analysis 1593
S. B. Ribeiro, M. A. Macadar, and F. Pinto

Cyberattacks in government organizations: A systematic literature review of attack types and mitigation strategies 1598
D. C. Ardhi, D. P. Sari, and B. Yankson

Data Report on School Dropout in a Brazilian State: Social Technologies for Preventing the Phenomenon 1603
L. A. Freires, H. M. da S. Araújo, L. F. F. Torres, T. D. Cordeiro, and G. F. C. de Macedo

Digital Dependence vs. National Performance: Preliminary Data Analysis 1608
J. Durkiewicz and T. Janowski

Digital Governance and Institutional Challenges in Rural Heritage Restoration: The Case of Caqui Hacienda in Chancay Valley, Peru 1613
O. Miranda-Hospinal, D. Valle-Cruz, and C. Cuadra

Enhancing user experience: An accessibility and usability study of an open government data portal 1621
D. P. Sari, D. C. Ardhi, D. C. Ma, and C. Dumas

Experiment Canvas: A data-driven framework for evidence-based innovation in the Judiciary 1626
W. C. do Carmo and I. C. Sá

Landscaping digital transformation in academic education programs within Europe 1630
G. Musiatowicz-Podbiał, L. Temple, F. Kleiman, and L. Bosoer

Leveraging AI Models for Automated Pattern Detection in Citizen Participation Data 1634
A. Marzouki, B. Nouri, and S. Mellouli

Leveraging Conversational AI for Adolescent Medical Financial Education.....1642
W. Chen, A. Le, P. Athota, M. Ashaduzzaman, and C.-H. Tsai

Leveraging official government data for enhanced understanding of health crisis communication topics 1648
H. Wang

Measuring the Social Impact of Digital Services: A Case of St. Petersburg, Russia 1654
R. Bolgov, O. Filatova, and D. Volkovskii

Performance Indicators Development for Public Services using an AI-based clustering approach 1659
V. de A. Xavier, F. M. G. França, P. M. V. Lima, and N. Maculan

PIX, Open Finance, and DREX: Cases of digital public infrastructure in Brazil 1664
V. da R. S. Almeida and M. A. Macadar

The evolving AI regulation space: A preliminary analysis of US state legislations addressing AI, 2024 1669
N. DePaula, L. Gao, S. Mellouli, L. F. Luna-Reyes, and T. M. Harrison

The Impact of Government Emotion-based Response Strategies on Citizens' Satisfaction 1673
R. Wang, C. K. Xu, and L. Ma

Urban Resilience and Virtual Communities: Leveraging Networking Platforms for Immigration Challenges 1678
D. M. Villegas, L. Galdino, and J. Westermann

XML as a Basis for Interoperability in Technical Education Documents.....1683
G. N. Inocêncio, and J. E. Martina

A Comparative Study on Judicial Visualization in the U.S. and China.

Jiawei Zhou [a], *Chengjie* Miao [b], *Yi* Long [c*].

[a] School of Artificial Intelligence and Law, Shanghai University of Political Science and Law, Shanghai, China, 19539476973@163.com, 0009-0005-8083-9942.

[b] School of Artificial Intelligence and Law, Shanghai University of Political Science and Law, Shanghai, China, 3358463756@qq.com, 0009-0006-3686-2245.

[c] School of Artificial Intelligence and Law, Shanghai University of Political Science and Law, Shanghai, China, longyi@shupl.edu.cn, 0000-0002-6208-9560.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 6 June 2025

Abstract. The visualization of judicial statistics is a new form of judicial openness in the era of big data, which is of great significance for the public to understand judicial dynamics and maintain judicial fairness. The study finds that neither the Supreme Court of China nor the U.S. Supreme Court provides a dashboard of judicial statistics, but the frequency of data updates in the United States is quarterly, and in China, it is updated in the form of annual reports. Among the court web portals of 35 provinces (including Hong Kong, Macao, and Taiwan) in China, only 3 courts provide visualization of judicial statistics. Among the 51 state court web portals in the United States, 18 courts conduct visualization of judicial statistics. For dg.o attendees, this research offers unique insights into how the two countries approach the challenge of making judicial data accessible and understandable to the public.

Keywords. Judicial statistics; Judicial visualization; Judicial comparison between China and the United States; Judicial openness.
Poster, DOI: https://doi.org/10.59490/dgo.2025.929

1. From judicial openness to visualization of judicial statistics

As Louis Brandeis said, "Sunlight is said to be the best of disinfectants; electric light the most efficient policeman". In modern society, judicial openness brings transparency to the system. [1]Transparency is a crucial element in the judiciary to promote citizen confidence in courts and ensure fair case administration by court staff.[2] From a perspective of common sense, visualization facilitates users to intuitively understand the content of the data, and make vertical and horizontal comparisons to enhance the transparency and the efficiency of the judicial system. Marković and Gostojić think the set of statistics included in judicial visualization should at least include the results of court decisions, case registrations, archived document records, and statistics.[3]It is known from the relevant literature that the Israeli Supreme Court database is one of the few public multi-user datasets focusing on courts and judges and is very rich in judicial statistics[4]. Besides, Germany[5], the United Kingdom[6], the Netherlands[7], France[8], Switzerland[9] and Spain[10] have created dashboards for the visualization of judicial statistics.

Judicial dashboards[11] in the United States and China might keep up with this trend. In this paper, we investigate in detail the current situation of visualization of judicial statistics on the web portals of China's supreme court and provincial courts and those of the U.S. federal supreme court and state court portals, analyzing in depth the specific differences between the two countries. Then, we put forward suggestions for enhancing the level of visualization in the two countries.

As can be seen from inquiries into the laws of the two countries, both the United States and China have laws and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

regulations at the central level that require the disclosure of judicial statistics at all levels of the courts, with the specific requirement that they be disclosed on an annual basis. In China, *the Opinions on Further Deepening Judicial Disclosure* proposes the disclosure of judicial statistics in the form of a bulletin, and in the United States, the *Disclosure of Electronic Records* provision requires government agencies to make better use of electronic processing to request information.

2. Current Status and Problems of Visualizing Judicial Statistics in China and the U.S.

The research process was as follows: in the first step, the three researchers divided their work and queried the data dashboards on the websites of the central and local courts according to a uniform standard; in the second step, a senior researcher reviewed all the data; and in the third step, the data were updated.

2.1 Overview of the central-level judicial dashboard in China and the U.S.

According to the research, China's Supreme People's Court portal makes judicial statistics public in the form of an annual report but does not provide a visual interactive function, while the website of the United States federal courts provides quarterly updated case data.

2.2 Overview of the Provincial and State-level Judicial Dashboard in China and the U.S.

Below, we compare the visualization of Chinese and U.S. court statistics through the eight most typical aspects when evaluating dashboards. Specific data are presented in Tables 1 & 2.

(1) Whether data are province-wide (state-wide) integrated

The integration of judicial statistics enables the data of courts at all levels to be displayed through a unified platform, which not only facilitates the search of judicial data by various groups of people but also accelerates horizontal comparison.

(2) Data are displayed with several dashboards

Provincial courts in China mostly use a single dashboard on the portal, while U.S. state courts mostly use a combination of multiple dashboards. The more dashboards of judicial statistics, the more detailed classification standard of the data, and the easier it is for all kinds of people to retrieve the data. However, the overly cumbersome classification standard of judicial statistics increases the difficulty of the statistical work.

(3) Whether the data comes from the local self-construction

In the author's view, the unified construction of the judicial statistics platform gives full play to the central court's function of leadership for local courts, while reducing the burden of local courts on the construction of statistical platforms, and helps to unify statistical standards to achieve comparative analysis. However, the statistical platform built by the local courts may be more flexible and innovative.

(4) Whether the data are from a single department

The advantage of multisectoral statistics over single-sector statistics is that the statistical process tends to be characterized by "objectivity, comprehensiveness, and mutual supervision". It is important to restrain the power of single-sector openness of judicial statistics, increasing the credibility of the whole system.

(5) Update Frequency

The Update frequency in China's provincial courts is significantly lower than the one in the U.S. state courts. The higher the update frequency, the more it can reflect the "dynamic" character of local judicial statistics. High-frequency updates of judicial statistical data can enhance judicial transparency and strengthen judicial authority.

(6) Lowest Court Level

The judicial data of each judge in the lowest court can be displayed to the public. The authors believe that each citizen can not only feel the importance of the local judicial system while the judge is coping with cases but also better realize justice for the people when the judicial statistics open towards the level of individual judges.

(7) Case Status

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Among provincial courts in both China and the U.S., there are differences between the divisions of case status. The classification of case statuses in judicial statistics should be tailored specifically to each country and align with the legal and judicial background of the country.

(8) Availability of Before-and-After Comparison of Data

Only one court in China (Zhejiang Province[5]) has time comparisons of judicial statistics. The provision of the comparisons of judicial statistics is conducive to the understanding of the public in the operating trends of the judicial system. It also facilitates the analysis of data compiled by professionals and makes it easier for judicial management to formulate scientific and reasonable countermeasures.

3. Suggestions for visualization of judicial statistics

Three recommendations for Chinese courts are as follows:(1) Legislating regulations on the openness of judicial statistics and establishing a standardized platform for the visualization of judicial statistics nationally. (2) Establishing a sound mechanism for disclosure upon request in the judicial system.

Three recommendations for U.S. courts are as follows: (1) Promoting the construction of visualization dashboards to popularize them nationwide. (2) Constructing a common standard for judicial data disclosure to facilitate public comparisons.

4. Conclusion

The visualization of statistical data in the courts is a new form of disclosure in the era of big data. It plays a crucial role in helping the public understand the court's operations and upholding justice. Currently, disparities exist between Chinese provincial courts and American state-level courts in terms of statistical data visualization. These differences are primarily manifested in the quantity of data dashboards, the frequency of data updates, the number of case classifications, and the case statuses presented. Both countries still have a long journey ahead in building effective dashboards for their courts.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 - Comparison of the construction of visualization dashboards of judicial statistics in China's provincial courts.

Provincial Courts	Availability of data dashboards	Whether the data integrated across the province	Number of visualization dashboards	Whether any lower courts build their data platforms	Is it a single figure for a sector	Data Sheet Showing Earliest Year	Frequency of data display	The dashboard shows the lowest court tier	Case Status	Availability of data for before and after comparisons
Macao Special Administrative Region[12]	Yes	yes	5	No	No	2000	Current year by month, previous years by year	Primary Court	Transferred from the previous month, distributed in the current month, the total number of cases, closed in the current month, transferred to the next month	No
Beijing[13]	Yes	Yes	12	No	No	2024 (current year)	Day	District People's Court	Received, Closed	No
Zhejiang Province[5]	Yes	Yes	3	No	No	2021	Indeterminate	Intermediate People's Court	Application filing, service of documents, execution node openness	Yes

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 2 - Comparison of the construction of visualization dashboards for judicial statistics in U.S. state courts.

State of the Courts	Availability of data dashboards	Whether data are integrated statewide	Number of visualization dashboards	Whether any lower courts build their data platforms	Is it a single figure for a sector	Dashboard showing earliest years	Frequency of Data Display	The dashboard shows the lowest court tier	Case Status	Whether there is a before and after comparison of the data
New York[14]	Yes	Yes	8	No	No	2019	Monthly	County	Cases filed, closed, pending, trial started	Yes
Massachusetts[15]	Yes	Yes	23	No	No	2021	Weekly	County	None	Yes
California[16]	Yes	Yes	1	No	No	2014	Annually	County	Filings, Dispositions	Yes
North Dakota[17]	Yes	Yes	5	No	Yes (Department of Corrections and Rehabilitation)	2013	Annually	County	Prison, Probation, Parole	Yes
Illinois[18]	Yes	Yes	5	Yes	No	2023	Daily	County	Investigations, Investigation w/Detainable offense, Petitions Filed, Granted, Denied, Hearings Not Completed	No
New Jersey[19]	Yes	Yes	3	No	No	2022	Monthly	County	Filings, Resolutions	Yes
Texas[20]	Yes	Yes	6	No	Yes (Bail	2023	Monthly	County	Failed To Appear,	No

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

State of the Courts	Availability of data dashboards	Whether data are integrated statewide	Number of visualization dashboards	Whether any lower courts build their data platforms	Is it a single figure for a sector	Dashboard showing earliest years	Frequency of Data Display	The dashboard shows the lowest court tier	Case Status	Whether there is a before and after comparison of the data
					Data)				Violated Condition, Committed Offense	
Oregon[21]	Yes	Yes	49	No	No	2017	Monthly	County	Incarcerated, Probation, Parole	Yes
Pennsylvania[22]	Yes	Yes	13	No	No	2011	Annually	County	Cases Pending at the Beginning of the Year, New Cases Filed, Arbitration Appeals, Cases Transferred ln, Returned to Active, Subtotal: Cases Available for Processing, Cases Processed, Cases Pending at the End of the Year	Yes
Ohio[23]	Yes	Yes	7	Yes	No	1997	Monthly or Quarterly (Probate	City, County (uploaded	Filed, on trial, closed	Yes

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

State of the Courts	Availability of data dashboards	Whether data are integrated statewide	Number of visualization dashboards	Whether any lower courts build their data platforms	Is it a single figure for a sector	Dashboard showing earliest years	Frequency of Data Display	The dashboard shows the lowest court tier	Case Status	Whether there is a before and after comparison of the data
							Court)	by individual judges)		
Georgia[24]	Yes	Yes	7	No	No	2020	Annual	County	Filed, Closed	Yes
North Carolina[25]	Yes	Yes	4	No	No	2023	Monthly	County	Filed, disposed, pending	No
Florida[26]	Yes	No	2	No	No	2019	Quarter	District	Cases Filed Last Quarter, Cases Filed YTD, Cases Disposed Last Quarter, Cases Disposed YTD	No
Arizona[27]	Yes	Yes	13	No	No	2017	Monthly	County	Filed, closed, pending	Yes
Michigan[28]	Yes	Yes	9	No	No	2006	Annually	County	Filed, closed, pending	Yes
Oklahoma[29]	Yes	Yes	1	No	Yes (child adoption only)	2023	Monthly	District	None	No
Kentucky[30]	Yes	Yes	1	No	No	2003	Monthly	County	Filed, Closed	Yes
Idaho[31]	Yes	Yes	12	No	No	2019	Monthly	County	Not Yet Disposed, Conviction, Acquittal, Dismissal,	No

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

State of the Courts	Availability of data dashboards	Whether data are integrated statewide	Number of visualization dashboards	Whether any lower courts build their data platforms	Is it a single figure for a sector	Dashboard showing earliest years	Frequency of Data Display	The dashboard shows the lowest court tier	Case Status	Whether there is a before and after comparison of the data
									Deferral, Other	

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

1. Brandeis, L. D. (2009). Other people's money and how the bankers use it. Cosimo, Inc..(pp.92).https://www.gutenberg.org/cache/epub/57819/pg57819-images.html

2. Ahmed, R. K., Ahmed, O., Pappel, I., Reitsakas, A., & Draheim, D. (2022). The role of digital transformation in fostering transparency: An e-Court system case study. In Conference on Business, e-Services and e-Society (pp. 219-230). Springer.

3. Marković, M., & Gostojić, S. (2020). Open judicial data: A comparative analysis. Social Science Computer Review, 38(3), 295-314.

4. Weinshall, K. , & Epstein, L. . (2020). Developing high-quality data infrastructure for legal analytics: introducing the Israeli supreme court database. Journal of Empirical Legal Studies(4).

5. Gerichtsportal. (n.d.). Gerichtsportal. https://www.gerichtsportal.de/. Last accessed March 29, 2025.

6. UK Government. Ministry of Justice. (n.d.). Ministry of Justice. https://www.gov.uk/government/organisations/ministry-of-justice. Last accessed March 29, 2025.

7. Rechtspraak. (n.d.). Rechtspraak: The Judiciary of the Netherlands. https://www.rechtspraak.nl/English/. Last accessed March 29, 2025.

8. Conseil supérieur de l'audiovisuel. (n.d.). Conseil supérieur de l'audiovisuel. https://www.csa.fr/. Last accessed March 29, 2025.

9. Federal Department of Justice and Police. (n.d.). Statistics. https://www.bj.admin.ch/bj/en/home/gesellschaft/statistik.html. Last accessed March 29, 2025.

10. Ministerio de Justicia. (n.d.). Ministerio de Justicia. https://www.mjusticia.gob.es/. Last accessed March 29, 2025.Zhejiang Provincial Government. (n.d.). Zhejiang judicial information. https://www.zjsfgkw.gov.cn/col/col473/index.html?time=2024. Last accessed December 5, 2024.

11. Sarikaya, A., Correll, M., Bartram, L., & al., et. (2018). What do we talk about when we talk about dashboards? IEEE Transactions on Visualization and Computer Graphics, 25(1), 682-692. https://doi.org/10.1109/TVCG.2018.2865165

12. Judiciary of Macao. (n.d.). Statistics. https://www.court.gov.mo/zh/subpage/statisticstjb. Last accessed March 30, 2025.

13. Beijing Courts. (n.d.). Court statistics. https://www.bjcourt.gov.cn/sssp/index.htm. Last accessed March 30, 2025.

14. Power BI. (n.d.). Dashboard details. https://app.powerbigov.us/view?r=eyJrIjoiYmJkM2UwYjctNmU2ZC00MzgyLThjZjQtOGM2MTA1YTBhYzVkIiwidCI6IjM0NTZmZTkyLWNiZD EtNDA2ZC1iNWEzLTUzNjRiZWMwYTgzMyJ9. Last accessed March 30, 2025.

15. Tableau. (n.d.). Data visualizations by drap4687. https://public.tableau.com/app/profile/drap4687/vizzes. Last accessed March 30, 2025.

16. California Courts. (n.d.). Court dashboard. https://www.courts.ca.gov/dashboard.htm. Last accessed March 30, 2025.

17. North Dakota Department of Corrections and Rehabilitation. (n.d.). Dashboard. https://dashboard.docr.nd.gov/us-nd. Last accessed March 30, 2025.

18. Illinois Courts. (n.d.). Pretrial resources. https://www.illinoiscourts.gov/courts/additional-resources/pretrial-resources/. Last accessed March 30, 2025.

19. New Jersey Courts. (n.d.). Public report statistics: Current filings and resolutions. https://www.njcourts.gov/public/pub-rep-stats/fil-res-current. Last accessed March 30, 2025.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

20. Texas Courts. (n.d.). Bail dashboard. https://baildashboard.txcourts.gov/. Last accessed March 30, 2025.

21. Power BI. (n.d.). Dashboard details. https://app.powerbigov.us/view?r=eyJrIjoiNDQ2NmMwYWMtNzhiZi00MWJhLWE3MjgtMjg2ZTRhNmNmMjdmIiwidCI6IjYxMzNlYzg5LWU1MWItNGExYy04YjY4LTE1ZTg2ZGU3MWY4ZiJ9. Last accessed March 30, 2025.

22. Pennsylvania Courts. (n.d.). Research and statistics: Dashboard table of contents. https://www.pacourts.us/news-and-statistics/research-and-statistics/dashboard-table-of-contents. Last accessed March 30, 2025.

23. Ohio Supreme Court. (n.d.). Court dashboards. https://www.supremecourt.ohio.gov/courts/services-to-courts/court-services/dashboards/. Last accessed March 30, 2025.

24. Georgia Courts. (n.d.). Data and statistics. https://research.georgiacourts.gov/data-and-statistics/. Last accessed March 30, 2025.

25. North Carolina Courts. (n.d.). Dashboard: Current fiscal year. https://data.nccourts.gov/pages/dashboard/#current-fiscal-year. Last accessed March 30, 2025.

26. Florida Courts. (n.d.). Publications and statistics: Statistics. https://www.flcourts.gov/Publications-Statistics/Statistics. Last accessed March 30, 2025.

27. Arizona Courts. (n.d.). Interactive data dashboards. https://www.azcourts.gov/statistics/Interactive-Data-Dashboards. Last accessed March 30, 2025.

28. Michigan Courts. (n.d.). Interactive court data dashboard. https://www.courts.michigan.gov/publications/statistics-and-reports/interactive-court-data-dashboard/. Last accessed March 30, 2025.

29. Oklahoma Department of Human Services. (n.d.). Judicial dashboard region. http://judicialdashboard.okdhs.org/judicial_dashboard_region.html. Last accessed March 30, 2025.

30. Kentucky Courts. (n.d.). Caseload monthly by category. https://www.kycourts.gov/AOC/Information-and-Technology/Analytics/Pages/Caseload-Monthly-by-Category.aspx. Last accessed March 30, 2025.

31. Idaho Court Data. (n.d.). Charge. https://courtdata.idaho.gov/Charge. Last accessed March 30, 2025.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

ARGOS: A Human-in-the-Loop ML System for Legal Aid Classification in Espírito Santo

Eduardo Pacheco[a]

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. We present the modeling of an AI system named ARGOS to classify free legal aid requests in the Court of Justice of Espírito Santo (TJES). The model replicates the decision-making pattern of a judge from the 6th Civil Court of Vila Velha, developed within Challenge 16 of PitchGovES by Atlas.IA, promoted by the State Management Laboratory of Espírito Santo (Lab.ges). The challenge proposed an automated solution to assess applicants' eligibility by cross-referencing multiple data sources to support judicial decisions. The approach consists of three key components: (i) a machine learning model for classifying requests, (ii) an information retrieval engine to support the model, and (iii) an explainability mechanism to justify decisions. A global model for TJES was initially considered but discarded due to legal and technical constraints. Instead, a judge-specific model was developed to align with the principle of Judicial Independence in Decision-Making. Model development began with analysing past judicial decisions, classifying requests as granted or denied. A significant challenge was data imbalance, as requests were not evenly distributed across classes. To address this, balancing techniques and feature selection methods were applied. Various machine learning algorithms, including decision trees and deep learning models, were tested. The final model balanced accuracy and interpretability, ensuring magistrates could understand the factors influencing decisions. The second component involved creating an information retrieval engine to supplement applicant data. Given that free legal aid assessment relies on financial capacity, the tool gathered external data. However, access to government databases was restricted, so alternative sources were used, including public income records, social assistance histories, and judicial metadata. The solution comprises four modules: applicant data capture, a dashboard, a decision interface with model training, and a recommendation system. The initial implementation achieved 81.3% balanced accuracy, surpassing the 70% target, demonstrating potential for broader judicial adoption.

Keywords. Machine Learning, Legal Decisions
Poster, DOI: https://doi.org/10.59490/dgo.2025.930

1. Introduction

The right to free legal aid is fundamental for ensuring equal access to justice, particularly for economically disadvantaged individuals. In Brazil, courts face a growing demand for legal aid requests, requiring judges to evaluate the financial conditions of applicants while maintaining efficiency and fairness. TJES is no exception, and optimizing the analysis of these requests has become a pressing issue.

To address this challenge, the PitchGovES initiative, led by the Lab.ges, launched Challenge 16, which called for innovative solutions to improve the evaluation of free legal aid requests. The core question posed was: How can access to justice be facilitated through a model that assesses whether a request should be granted, cross-referencing multiple data sources to justify its decision? The winning proposal, developed by ATLAS.IA, aimed to build an AI-powered system to support judicial decision-making in this context.

Our project ARGOS, selected as the winner of the challenge, proposed the development of an AI-powered system with Human-in-the-Loop approach capable of classifying legal aid petitions as “granted” or “denied” to facilitate decision-making in current cases based on historical judicial behavior. The system integrates a

[a] Data Scientist at Atlas.IA (www.atlasia.tech) , São Paulo, Brazil. edu@atlasia.tech. ORCID: https://orcid.org/0009-0007-9887-9189
Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

machine learning model trained on judicial decisions, an information retrieval engine to augment petitioner data, and a layer of explainability to ensure transparency and accountability. Rather than proposing a global model for the entire judiciary, we chose to replicate the decision-making logic of an individual judge from the 6th Civil Court of Vila Velha based on the rationale that each judge requires a personalized model. This design respects judicial independence, keep the judge at the center of the decision-making process aligning with legal and institutional principles while delivering practical benefits. The proposed system adheres to the guidelines for Trustworthy AI developed by the European Commission (2019), which emphasize human agency, transparency, and accountability. In line with these principles, our approach embeds a Human-in-the-Loop model that ensures judicial autonomy is maintained, while enhancing the quality and consistency of decision-making. As Bekkerman (2021) argues, HITL approaches are essential when deploying ML systems in high-stakes domains such as healthcare, finance, or law, enabling oversight and fostering trust in automated tools.

1.1 Project Scope and Objectives

We propose automating judicial decisions by replicating the individual decision patterns of each judge. This can increase efficiency in judicial services and allow judges to dedicate more time to analyzing the merits of each case. This can be addressed by a machine learning model that learns the judge's decision-making patterns and optimize public resource allocation, generating benefits for society as a whole. It is possible to avoid wasting scarce resources—such as judicial time—on tasks that could be automated. It is also possible to enhance the data available by data enrichment from external sources that either corroborate or contradict the petitioner's claims, enabling more informed decision-making. The proposed system was structured around two main components: 1. **machine learning model** trained to classify legal aid requests as granted or denied, based on historical judicial decisions. 2. An **information retrieval engine** that collects external data to supplement the analysis. This system must also enhance **explainability** and enforce transparency to help users to justify the decisions.

A key challenge in designing the system was determining whether a global model for the entire court could be developed. However, legal and technical constraints led to the decision to focus on modeling the decision-making patterns of a single judge. This approach aligns with the principle of Judicial Independence in Decision-Making, ensuring that each magistrate retains autonomy in their rulings. Judges typically rely on the information provided in the initial petition to evaluate a legal aid request. However, applicants may omit or misrepresent financial details, leading to potential inaccuracies in judicial decisions. The project aimed to expand the data sources available to judges, supplementing the petition with external financial and social data. An information retrieval engine was developed to collect relevant data, including: 1. Public salary records of federal and state executive branch employees 2. Social assistance histories, such as Bolsa Familia and Emergency Aid 3. Metadata from previous legal proceedings, including records from the Public Defender's Office. Despite efforts to access government databases, legal and technical barriers restricted direct integration with certain financial records, such as tax returns and property registries. As a result, alternative web-crawling techniques and APIs were utilized to gather publicly available data. The developed solution, ARGOS, integrates multiple components into a comprehensive decision-support system. The platform consists of four key modules: 1. Data Capture – Extracts structured information from the initial petition and external sources. 2. Dashboard – Consolidates relevant data into a user-friendly interface for judicial review. 3. Decision Interface – Enables judges to classify requests and fine-tune the AI model. 4. Recommendation System – Provides AI-generated predictions to streamline decision-making.

2 Data

At the final stage, the data from all collected sources was combined and processed to represent a legal aid request, stored in the "request" table with the following fields:

Field	Description
Total income	Sum of the applicant's declared income and external sources
Has income	Boolean indicating whether the applicant has a registered income
Has public defender	Indicates whether the applicant has been assisted by a public defender
Has social vulnerability	Self explanatory
Has debt	Self explanatory
Total Debt	Total amount of debt recorded for the applicant
Has expenses	Boolean flag indicating if the applicant has reported expenses
Has assets	Boolean flag showing if the applicant has registered assets
Total assets	Sum of the applicant's registered assets and external sources

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Occupation	The applicant's employment status or job category
Decision	Target variable, indicating whether the request was granted or denied.

Tab. 1 – Features and target label of the machine learning model

2.1 Exploratory Data Analysis

Income distribution showed a predominance of low-income petitioners, consistent with the target demographic of public legal aid policies. However, cross-variable analysis raised inconsistencies: while most applicants declared minimal income, some reported high levels of expenses or debts that seemed disproportionate. Histograms of total debt and total expense distributions highlighted this gap. While most petitioners reported low or zero debt, many also reported unusually high expenses. This discrepancy suggested either incomplete or inaccurate self-reporting, reinforcing the need for external data verification.

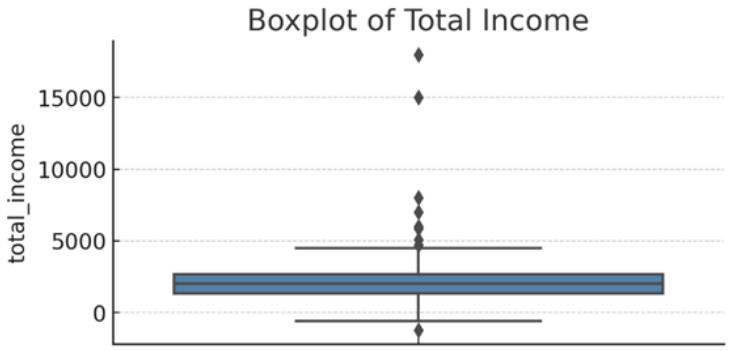


Fig. 1 - Total Income

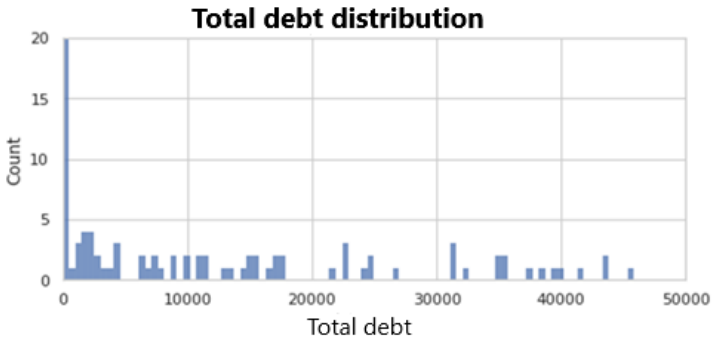


Fig. 2 - Total Debt

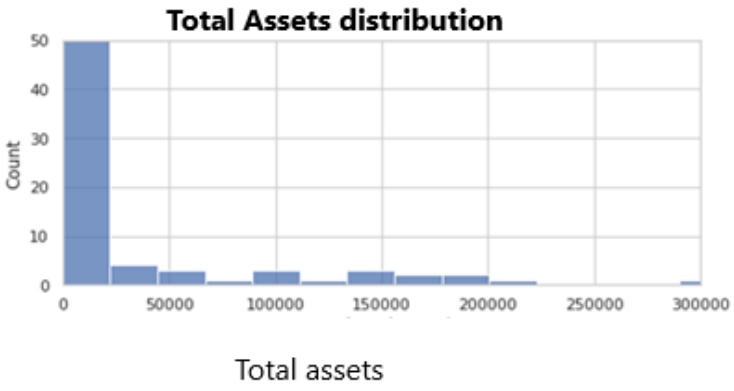


Fig. 3 - Total Assets

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

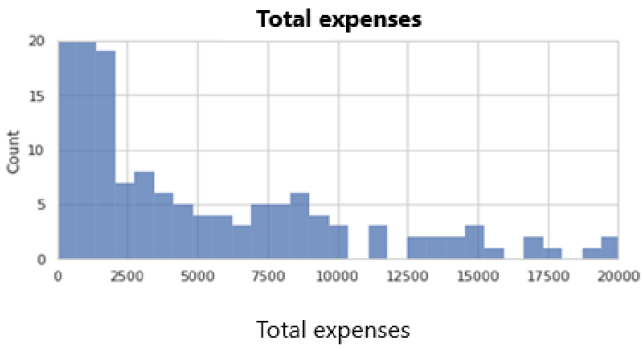


Fig. 4 - Total Expenses

Similarly, the distribution of total assets confirmed that most applicants owned few or no significant properties or financial holdings, yet there were outliers. These insights informed the feature selection process and pointed to the potential benefit of integrating external databases to validate self-declared information.

3 Modeling Approach

The modeling strategy followed a structured pipeline: 1. **Baseline Creation** – A dummy classifier always predicting the majority class ("granted") was used as a lower performance bound 2. **Preliminary Models** – Linear models such as logistic regression (Hosmer, Lemeshow, & Sturdivant, 2013), support vector machines (Cortes & Vapnik, 1995), and K-nearest neighbors (Altman, 1992) were tested to assess model fitness. 3. **Decision Tree Models** – Given their explainability, several decision tree-based (Quinlan, 1986) models were trained and fine-tuned via grid search 4. **Ensemble Models** – Random forests (Breiman, 2001) were evaluated to identify whether ensemble techniques (Breiman, 1996) improved predictive power 5. **Evaluation** – Models were evaluated using accuracy, balanced accuracy, and AUC under 10-fold cross-validation and hold-out test sets. The final training set comprised 85% of the dataset, with the remaining 15% held out for testing. Stratification ensured that class balance was preserved in both partitions.

4. Model Performance

The baseline dummy classifier achieved 63% accuracy and 50% balanced accuracy—highlighting the challenge posed by class imbalance. Logistic regression improved upon this with 71.7% test accuracy and 75.2% balanced accuracy. Support vector machines and KNN performed comparably, though KNN was more computationally intensive. Decision trees emerged as the most promising model class due to their transparency. A tree optimized via grid search (with max depth = 9 and min samples per leaf = 8) achieved 73.3% test accuracy and 77.9% balanced accuracy. Feature importance analysis revealed that income, unemployment status, and educational attainment were significant predictors.

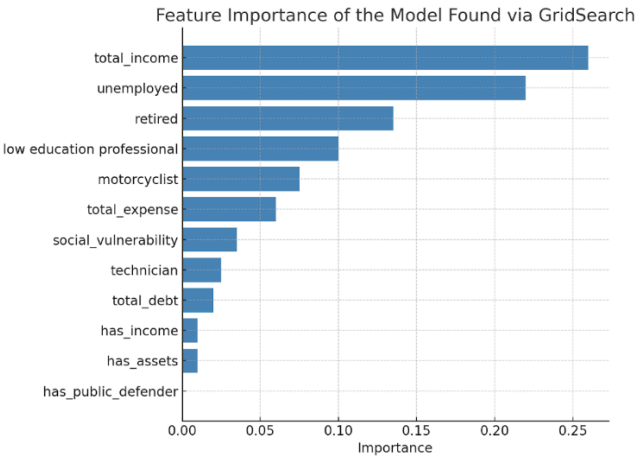


Fig. 5 - Feature importances of Decision Tree model

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Random forests slightly outperformed decision trees in certain metrics and exhibited superior performance in low false-positive regions of the ROC space. However, decision trees were favored for high true-positive rates and greater interpretability. The model's ability to identify denial cases improved markedly over the baseline.

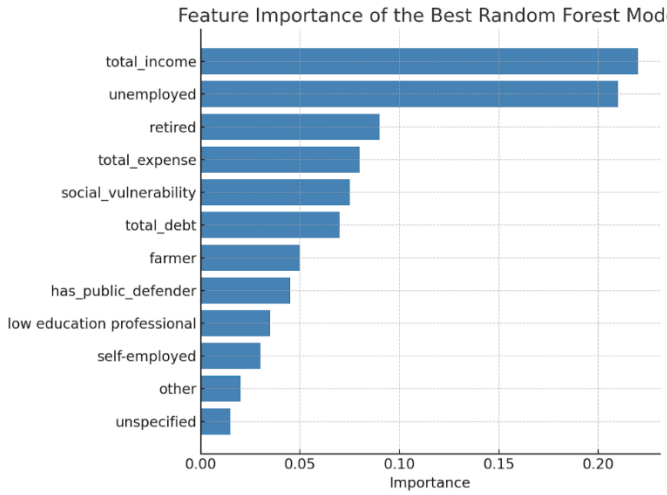


Fig. 6 - Feature importances of Random Forest model

After training all candidate models we then compared the top-performing models. The following picture shows the results.

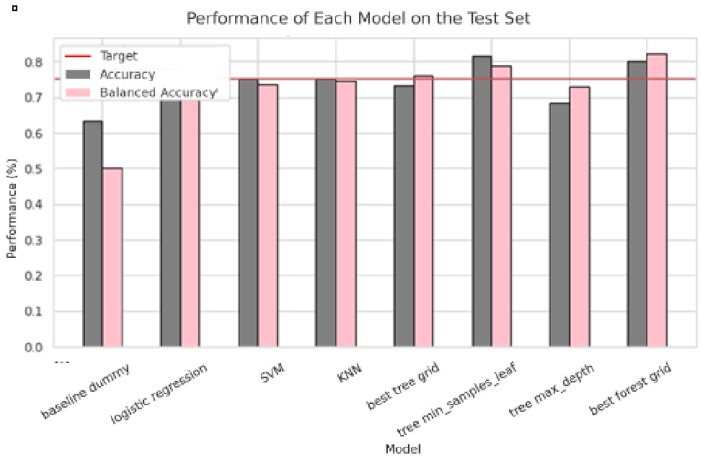


Fig 7 - Comparison of best models

ROC curves confirmed these findings, with decision trees and random forests significantly outperforming KNN.

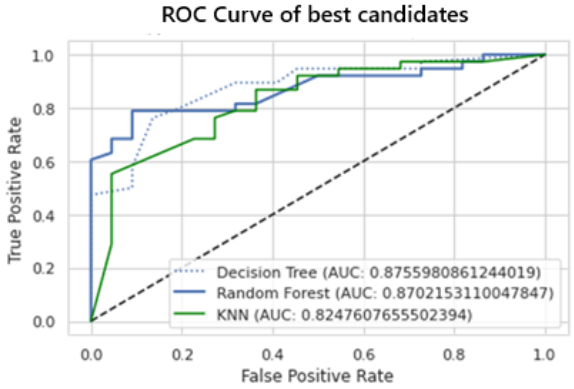


Fig 8 – ROC and AUC of best candidates

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Confusion matrices indicated that the decision tree was more conservative (favoring grants), while random forests were more effective in denying non-eligible requests.

5. Discussion

Across all evaluation metrics, decision tree and random forest models emerged as the best-performing options. Decision tree model achieved the highest balanced accuracy and was better suited for legal contexts where minimizing false negatives (wrongly denying aid) is paramount. Model performance on the test set was summarized as follows: **Decision Tree**: 81.66% acc, 78.82% balanced acc; **Random Forest**: 80% acc, 82,29% balanced acc. Slightly higher performance in low-FPR zones, better at correctly denying aid. These results confirmed the validity of the proposed approach and its potential applicability to other judges or courts.

6. Next Steps and Policy Considerations

From a technical standpoint, the system could be improved through the use of ensemble methods such as Boosting or Stacking. However, these enhancements must be weighed against the loss of interpretability. We argue that explainability can be preserved through global feature importance analysis and counterfactual explanation tools. SHAP-IQ (Fumagalli et al., 2023) methods must be explored to better-grounded explainability. Another major frontier for improvement lies in feature quality. The inclusion of more granular asset data—such as vehicle ownership and real estate—would provide stronger predictive signals. As these features were underrepresented in the current dataset, they had limited influence on model performance. Access to such data is legally possible and technically feasible via integration with existing government platforms. On the systems side, user interfaces could be optimized based on feature relevance. We also propose the development of a *decision draft generator*—a system that automatically prepares preliminary judicial decisions for review—thus saving time while maintaining final control with human judges.

7. Conclusion

This project demonstrates the feasibility and utility of modeling judicial behavior through machine learning, with direct application to legal aid classification in the Brazilian judiciary. By combining historical decision analysis, external data retrieval, and interpretability techniques, the ARGOS system provides a powerful tool for increasing efficiency and transparency in legal decision-making. More broadly, the experience highlights how AI can respect legal autonomy while delivering practical benefits to public administration. The approach taken here—replicating an individual judge's logic, rather than imposing a top-down standard—offers a scalable, ethically sound model for digital governance. As courts worldwide face growing caseloads and limited resources, systems like this one represent a compelling frontier for responsible and human-centered AI in the public sector.

Acknowledgement

- **Funding or Grant :** This work was supported by Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES), under grant TERMO DE OUTORGA DE SUBVENÇÃO ECONÔMICA No 311/2021 within EDITAL FAPES/SEGER/SEG No 05/2020.
- **Use of AI**: During the preparation of this work, the author used ChatGPT in order to translate to english. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.
- **Conflict Of Interest (COI)**: There is no conflict of interest.

References

Bekkerman, R., Bilenko, M., & Culp, M. (2021). *Human-in-the-Loop Machine Learning: Active learning and annotation for human-centered AI*. Manning Publications.

High-Level Expert Group on Artificial Intelligence. (2019). *Ethics Guidelines for Trustworthy AI*. European Commission. Available at: https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

Altman, N. S. (1992). *An introduction to kernel and nearest-neighbor nonparametric regression.* The American Statistician, 46(3), 175-185.

Breiman, L. (1996). *Bagging predictors.* Machine Learning, 24(2), 123-140.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Breiman, L. (2001). *Random forests.* Machine Learning, 45(1), 5-32.

Cortes, C., & Vapnik, V. (1995). *Support-vector networks*. Machine Learning, 20(3), 273-297.

Hosmer, D. W., Lemeshow, S., & Sturdivant, R. X. (2013). Applied Logistic Regression. John Wiley & Sons.

Quinlan, J. R. (1986). *Induction of decision trees.* Machine Learning, 1(1), 81-106.

Fumagalli, F., Muschalik, M., Kolpaczki, P., Hüllermeier, E., & Hammer, B. (2023). *SHAP-IQ: Unified Approximation of any-order Shapley Interactions.* In Advances in Neural Information Processing Systems (NeurIPS 2023).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Beyond Technology: Local Authorities' Perspectives on Smart Sustainable Cities in Porto Alegre

Luiza Schuch de Azambuja [a*], *Ralf-Martin Soe* [a]

[a]FinEst Centre for Smart Cities, Tallinn University of Technology, Tallinn, Estonia

luiza.schuch@taltech.ee, ORCID 0000-0001-7878-3875, ORCID 0000-0002-6782-1677

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19May 2025

Abstract. Smart Sustainable Cities (SSCs) integrate technology, governance, and sustainability to address urban challenges and improve citizens' quality of life. However, the understanding of SSCs varies depending on local contexts and stakeholders' perspectives and is often technocentric. This study presents preliminary findings on how local authorities in Porto Alegre (POA), Brazil, understand smart sustainable cities, analysing their perceptions and interpretations of this evolving urban model. This study addresses the following research question: What does "smart sustainable city" mean to local authorities in Porto Alegre? Using a qualitative approach, fifteen interviews with key officials from different city departments provide preliminary insights into how SSCs are framed beyond technological advancements illustrating examples of initiatives that contribute to Porto Alegre's transition towards an SSC. While technology plays a role, local authorities emphasise inclusive governance, innovation, data-driven decision-making, education, collaboration, citizen-centricity, and integration as central to their vision of a smart sustainable city.

Keywords. Smart city, smart sustainable city, urban innovation.
Poster, DOI: https://doi.org/10.59490/dgo.2025.935

1. Introduction

Smart Sustainable Cities (SSCs) is a prominent concept in urban development, aiming to leverage technology and data to improve residents' quality of life, promote economic growth, and ensure social development and environmental sustainability (Bibri & Krogstie, 2017; Höjer & Wangel, 2015; Pereira & de Azambuja, 2021). Even though many authors have sought to conceptualize the smart (sustainable) city concept, it remains it still lack a single definition (Albino et al., 2015; Dameri, 2013; Kummitha & Crutzen, 2017; Yeh, 2017).

This paper presents the preliminary findings of a case study from Latin America—Porto Alegre—using primary data collected through fifteen in-depth interviews. The aim of this study is to understand the perception of local authorities in Porto Alegre on smart sustainable cities and to identify key initiatives and projects. This study addresses the following research question: **What does "smart sustainable city" mean to local authorities in Porto Alegre?**

Local authorities are at the forefront of urban governance, responsible for planning, resource allocation, and service delivery, directly impacting the lives of citizens. Therefore, understanding their perceptions regarding SSCs is important for the successful implementation and adaptation of smart and sustainable cities. Their insights can help identify key initiatives, challenges, opportunities, and best practices, ensuring that technological advancements align with community needs and policy objectives.

2. Research Methods

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This study adopts a qualitative approach, utilizing the case study method. This approach was chosen because it is particularly effective for exploring contemporary phenomena and aims to offer a comprehensive and detailed description of a case (Yin, 2018).

2.1 Case Selection: Porto Alegre

Porto Alegre, the capital of Rio Grande do Sul, Brazil's southernmost state, boasts a rich history and a vibrant contemporary profile. While its founding dates to 1769, the official establishment is celebrated on March 26, 1772. Home to approximately 1.5 million people, it ranks as the twelfth most populous city in Brazil, with its metropolitan area encompassing a substantial 4.5 million residents. The selection of Porto Alegre as a case study is justified by the need to explore smart sustainable cities in developing countries and by the city's distinctive socio-economic and cultural characteristics. Moreover, Porto Alegre nurtures a thriving innovation ecosystem counting with renowned universities that contribute to a dynamic pool of young talent. Two major technology parks, Zenit and TECNOPUC, exemplify the commitment to innovation with TECNOPUC recognized as one of the nation's leading incubators for technological advancement. A recent report announced the city as the second most competitive capital in Brazil (Pacto Alegre, 2025). These attributes position Porto Alegre as a compelling example for studying the challenges and opportunities associated with implementing smart city frameworks in comparable contexts.

2.2 Data Collection and Analysis

The data collection of this study happened from 2022 to 2024. The first round of interviews was conducted in 2022 and additional ones in 2023 and 2024. In total, 15 interviews have been conducted in Porto Alegre, eleven in person and four online via video call. The interviews were guided following a semi-structured interview protocol. The topics included in the protocol have been selected based on the SSC drivers and barriers identified through a previous study (Azambuja, 2021). Each interview lasted between 60 and 90 minutes. All interviews were transcribed for analysis, and interviewees were assigned unique codes (INT#1–INT#15) to maintain confidentiality.

3. Preliminary Findings

3.1 Smart Sustainable Cities: Perspectives of Local Authorities

The following table presents the perspectives of local authorities in Porto Alegre on what constitutes a 'smart sustainable city' and key characteristics.

Tab. 1 Perspectives of local authorities on SSC

Perspectives on Smart Sustainable Cities	Key Characteristics	Interviewee
"… is one that can use data to identify and address issues, with agencies working together rather than in silos."	Integrated, Collaborative, Data-driven	INT#1
"… bring citizens into a place of collaboration, not just reacting to individual problems, but contributing to the city as a whole."	Citizen-centric, Collaborative	INT#2
"Coordinates public policies to manage the collective intelligence of the city, enabling people to enter a virtuous cycle of production, sharing, and well-being."	Collective intelligence, Collaborative, Citizen-centric	INT#3
“Needs to be coordinated and connected, with a clear understanding of its resources and capabilities before implementing new technologies.”	Strategic planning, Connectivity	INT#4
"It's more of a journey than a destination. Smarter cities are those that are constantly improving and becoming more sustainable."	Sustainable, Continuous improvement	INT#5
"A city that uses data, technology, and relationships to truly solve people's problems when they occur."	Citizen-centric, Data-driven, Collaborative	INT#7
"A smart city has integrated databases accessible to citizens, with easy connections, and is extremely simple for everyone to use, regardless of their level of knowledge."	Accessibility, Integrated, Inclusive	INT#8
“It starts with education and connectivity. We need to connect with citizens and understand their needs and expectations."	Education, Connectivity, Citizen-centric	INT#9
"... it should use all the tools and technology to analyse, formulate, quantify, control, and monitor the impacts of its actions."	Citizen-centric, Data-driven, technologically advanced	INT#10

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

"A smart city is a city where freedoms are respected, and the main element is the citizen, not the public authority."	Citizen-centric, Individual freedom	INT#11
"A smart city is a planned city... with continuity of planning. It uses technology to provide digital services and is less bureaucratic."	Continuous Improvement, Less bureaucracy	INT#12
"A smart city is a collaborative city... where we can exchange resources and knowledge with other cities."	Collaborative, Knowledge sharing	INT#13
"A smart city is a city that has the citizen at the centre of everything... with initiatives in health, safety, and education."	Citizen-centric	INT#14
"The first thing that comes to my mind is digital inclusion... A smart and sustainable city is one that thinks about digital inclusion."	Inclusion, Citizen-centric	INT#15

As seen, most of the interviewees mentioned the importance of a citizen-centric approach for the success of smart sustainable cities. According to the results, citizen needs are crucial for the planning of actions. Another important finding is the strong link of SSC development the of education. As mentioned by one interviewee "cities cannot be smart without smart people, because ultimately, it needs people". Furthermore, smart people are the ones able to create a "virtuous cycle of production", which is crucial for a sustainable development.

3.2 Key Initiatives contributing to Porto Alegre's transition

Porto Alegre have been developing several initiatives ranging from technology-driven solutions to community-centred projects. Table 2 outlines a summary of initiatives mentioned by the interviewees.

Tab. 2 Key Projects and Initiatives in Porto Alegre

Initiative/Project	Category	Short Description	Evidence
100% Digital Licensing	Urban Planning	Online platform for urban licensing, streamlining processes and reducing bureaucracy.	INT#7
156 and Central do Cidadão	Citizen Services, EGOV	Integrated platform for citizen service requests and information.	INT#1, INT#2, INT#3, INT#9, INT#10
Carta de Serviços (Service catalog)	Citizen Services, EGOV	Online list of all services provided by the city, with details and instructions.	INT#1
Cidades Educadoras (Educating Cities)	Education, Inclusion	International network of cities promoting education and citizen engagement.	INT#2, INT#3, INT#5
CEIC	Public Safety, Mobility	Using smart cameras for public safety and traffic control.	INT#7, INT#8
Concession of Parks and Green Spaces	Living	Ensuring maintenance and investment in parks and green spaces.	INT#8
Luz do Saber	Environment	Project using solar energy in schools.	INT#4
Open Data Portal, ObservaPOA	EGOV	Platform that makes public data available for consultation and download.	INT#2, INT#5, INT#8, INT#10
AI Optimization of Public Services	AI and Efficiency	Using AI to optimize resource allocation and improve service efficiency.	INT#8
Pacto Alegre	Economy, Education, Living	Platform for collaboration between government, universities, and businesses to promote innovation.	INT#3, INT#4, INT#5, INT#6, INT#8
Sala do Empreendedor (Entrepreneur's Room)	Economy	One-stop shop for entrepreneurs to access information and services.	INT#11, INT#15
Smart Cities Hub	AI, Urban Services, EGOV	Collaborative hub for developing and implementing AI solutions for smart cities.	INT#13, INT#14
Smart Urban Services	Urban Services	Using technology to optimize garbage collection, public lighting, and road maintenance.	INT#8

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Strategic Project Management System	Strategic Planning, EGOV	System for managing and monitoring the city's strategic projects.	INT#10
Telemedicine and Digital Health	Health	Using technology to improve healthcare access and efficiency.	INT#3, INT#5, INT#9, INT#10, INT#15
Territórios Inovadores (Innovative Territories)	Innovation and Entrepreneurship	Promoting innovation and entrepreneurship in different neighbourhoods.	INT#13
Urban Revitalization Projects	Environment, Economy	Revitalising the Historic Centre and Quarto Distrito to attract investment and improve quality of life.	INT#8, INT#11
WI-FI extension	Inclusion	Providing free Wi-Fi in vulnerable areas to promote digital inclusion.	INT#13

Among the most notable initiatives mentioned by the interviewees is the Pacto Alegre, a collaborative framework that fosters innovation and entrepreneurship by promoting collaboration between universities, companies, and the government. INT#5 highlights the importance of Pacto Alegre as a "platform for coordinating various actions," driving economic development and creating a "future-oriented" perspective. This initiative was inspired by various global examples being influenced by international experiences, particularly from cities like Barcelona, Medellín, and Israel, but was uniquely shaped by Porto Alegre's local needs and experiences, explains INT#5. The Cidades Educadoras project is part of the Pacto Alegre and focuses on educating citizens about their rights and responsibilities in urban development, promoting civic engagement through various programs.

Other key initiative is the Central do Cidadão (156web and mobile app), which is an evolution of the 156 Fala Porto Alegre which enable citizens to report urban issues such as streetlights, waste collection, and road conditions. INT#1 explains that 156 "integrates different communication channels" and "forwards demands to the responsible secretariats," making public services more accessible and efficient. Moreover, Porto Alegre has been investing in smart urban services, implementing initiatives like intelligent garbage collection (not yet in all regions) and public lighting systems. INT#8 mentions these projects as examples of how technology can be used to improve efficiency and resource management in urban services.

Urban revitalization projects like the revitalization of the Historic Centre and Quarto Distrito were also mentioned as capable of promoting economic development. INT#8 emphasizes the importance of urban revitalization for attracting and retaining talent, stating that "talents are attracted by these interesting places". Moreover, the city also counts with mobility related efforts to improve public transit systems, including smart traffic management and app-based ticketing solutions and a huge Integrated Centre of Command (CEIC). CEIC is a facility that integrates various municipal departments to monitor and manage city services. In recent years, the CEIC has expanded its capabilities by installing interactive security totems to enhance public safety.

4. Preliminary Conclusions and Future Work

This research, based on interviews with 15 key representatives from various municipal departments in Porto Alegre, has provided valuable preliminary insights into the perceptions of local authorities regarding smart sustainable cities (SSCs) within the specific context of a city in the Global South. The preliminary analysis the interviews, revealed a diverse range of definitions and key characteristics associated with SSCs, laying the groundwork for a more comprehensive understanding.

For Porto Alegre's authorities, a smart sustainable city is fundamentally citizen-centric, prioritising residents' needs, well-being, and active participation. Additionally, authorities recognise education and engagement as critical components, ensuring that citizens are informed, empowered, and involved in shaping urban development. Several initiatives illustrate Porto Alegre's commitment to this vision. Platforms such as the 156 Service and Central do Cidadão improve citizen access to information and municipal services. Pacto Alegre fosters cross-sector collaboration to drive innovation, while Cidades Educadoras promotes civic engagement through education. Urban revitalisation projects enhance public spaces for community use, and digital inclusion programmes work to bridge the digital divide. However, despite these advancements, significant challenges persist, which are going to be discussed in a future work.

In terms of contributions, this paper presents examples of key initiatives currently in place in Porto Alegre that, according to local authorities, are contributing to the city's development towards becoming a smarter and more sustainable one. Future studies could explore one of the key initiatives presented in Table 2 in greater depth to

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

investigate implementation challenges and successful practices. Further research is also encouraged to analyse public perceptions of the city's initiatives and projects, as well as to evaluate their tangible impact on citizens' lives.

Acknowledgement

- **Funding or Grant:** This research has been supported by the European Commission through the H2020 project Finest Twins (grant No. 856602).

Contributor Statement

Autor 1: conceptualization, formal analysis, investigation, methodology, writing. Author 2: supervision. Policies (tudelft.nl)

Conflict Of Interest (COI)

There is no conflict of interest

References

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

Azambuja, L. S. (2021). Drivers and Barriers for the development of Smart Sustainable Cities: *14th International Conference on Theory and Practice of Electronic Governance*, 422–428. https://doi.org/10.1145/3494193.3494250

Bibri, S. E., & Krogstie, J. (2017). On the social shaping dimensions of smart sustainable cities: A study in science, technology, and society. *Sustainable Cities and Society*, *29*, 219–246. https://doi.org/10.1016/j.scs.2016.11.004

Dameri, R. P. (2013). Searching for Smart City definition: a comprehensive proposal. *INTERNATIONAL JOURNAL OF COMPUTERS & TECHNOLOGY*, *11*(5), 2544–2551. https://doi.org/10.24297/ijct.v11i5.1142

Höjer, M., & Wangel, J. (2015). Smart Sustainable Cities: Definition and Challenges. In *Advances in Intelligent Systems and Computing* (Springer I, pp. 333–349). Springer, Cham. https://doi.org/10.1007/978-3-319-09228-7_20

Kummitha, R. K. R., & Crutzen, N. (2017). How do we understand smart cities? An evolutionary perspective. *Cities*, *67*(July 2016), 43–52. https://doi.org/10.1016/j.cities.2017.04.010

Pacto Alegre. (2025, January 21). *Porto Alegre é a 2a capital mais competitiva do Brasil*.

Pereira, G. V., & de Azambuja, L. S. (2021). Smart Sustainable City Roadmap as a Tool for Addressing Sustainability Challenges and Building Governance Capacity. *Sustainability*, *14*(1), 239. https://doi.org/10.3390/su14010239

Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. *Government Information Quarterly*, *34*(3), 556–565. https://doi.org/10.1016/j.giq.2017.05.001

Yin, R. K. (2018). *Case study research and applications: design and methods* (Sixth). SAGE Publications.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Can We Trust Open Government Data in Public Procurement?

Robin Fritzsche[a*], *Jan* Westermann[b], *Gerhard* Klassen[c], *Marc* Wyszynski[d], *Björn* Niehaves[e]

[a]AG Digital Public, University of Bremen, Bremen, Germany, robfri@uni-bremen.de, 0009-0002-8784-585X.

[b]AG Digital Public, University of Bremen, Bremen, Germany, westerma@uni-bremen.de, 0009-0009-3004-1982.

[c]AG Digital Public, University of Bremen, Bremen, Germany, gerhard.klassen@uni-bremen.de, 0000-0002-1458-6546.

[d]AG Digital Public, University of Bremen, Bremen, Germany, m.wyszynski@uni-bremen.de, 0000-0002-5292-4083.

[e]AG Digital Public, University of Bremen, Bremen, Germany, niehaves@uni-bremen.de, 0000-0002-2682-6009.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Evidence-based policy-making in public procurement depends on high-quality data. This case study evaluates 14 months (Nov 2023–Jan 2025) of procurement records from the EU's Tenders Electronic Daily (TED) to assess the reliability of this key data source. Our analysis uncovers significant anomalies in data accuracy and governance, raising concerns about the integrity of procurement processes and the policies built on them. We highlight the urgent need for improved data governance to support transparency, accountability, and innovation-driven procurement.

Keywords. e-procurement data, government data, data governance, public procurement.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1019

1. Introduction

Public procurement plays a key role in policy-making by directing demand that can drive innovation among suppliers (Amann and Essig, 2015; Bleda and Chicot, 2020). Effective and fair procurement depends on accurate assumptions about market structures and behavior, which require systematic analysis of reliable data. Open Government Data (OGD) from e-procurement portals provides a valuable basis for such analysis, offering insights into supplier participation, market dynamics, and procurement trends. Although OGD can improve transparency and efficiency, concerns about data quality may limit its usefulness (Zuiderwijk and Janssen, 2014). This study addresses the following research question: "How good is the data quality of data provided by e-procurement portals?" We analyze public procurement data from a European OGD platform, focusing on tender awards and contract notices. The aim is to assess data quality and inform evidence-based policy-making. Our findings point to the need for more consistent data maintenance, including clear standards and controls for publishing procurement data.

2. Relevant Theory & Literature

The intersection of OGD and e-procurement has attracted significant scholarly attention (Attard et al., 2015; Zhenbin et al., 2020. OGD involves the proactive release of government-held data to promote transparency, innovation, and accountability (Charalabidis et al., 2016). While its benefits are well documented — political, economic, and operational improvements (Janssen et al., 2012) — research also highlights its risks, including privacy issues, misinterpretation, and inequalities (Zuiderwijk and Janssen, 2014).
Integrating OGD with e-procurement systems can improve efficiency and reduce corruption. Adoption, however, depends on technical, organizational, and policy factors Wang and Lo, 2016). Yet, without high data

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

quality, such integration may fail to deliver set goals.
Data quality remains a central concern in OGD, with dimensions such as accuracy, completeness, consistency, timeliness, and accessibility frequently cited (Batini and Scannapieco, 2016; Heinrich et al., 2017).

3. Data and Methodology

This study combines procurement data from the TED portal and firm-level data from Moody's Orbis, covering November 2023 to January 2025. Historical exchange rates from the UN Treasury were used to standardize contract values. The TED dataset includes 1.7 million contract and award notices, of which 939,165 are unique. Winner information is available in 259,487 notices, identifying 496,445 winners (209,464 unique). Orbis provides validation and geographic details for 471,303 entities. CPV codes classify 82.1% of notices, but only 27.6% disclose winner data. Value reporting is concentrated, with 93.9% of tenders falling between €4,544 and €63,379,652. Data was retrieved via the TED Search API in JSON format.

4. Results

The dataset exhibits major anomalies in total value (Fig. 1, Fig. 2). To address these, we excluded contracts with non-positive values and conducted comparisons between the full dataset and a filtered subset limited to the interquartile range (IQR).

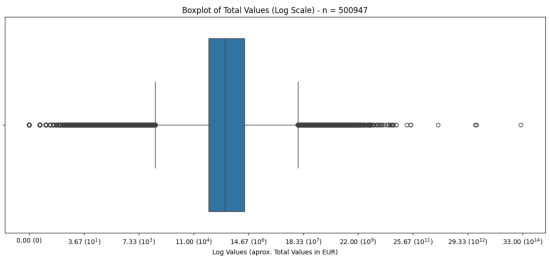


Fig. 1 – Boxplot of log scaled total values

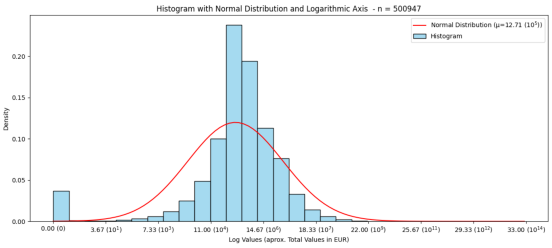


Fig. 2 – Log-transformed distribution of contract values

In the unfiltered dataset (a1, $n = 859{,}929$), Germany accounted for 19.98% of tender lots, followed by Poland (12.34%) and France (11.92%). Eastern Europe, including Poland, the Czech Republic, Romania, and Bulgaria, contributed 26.99%. After filtering out zero-value entries (a2, $n = 491{,}763$), Germany's share dropped to 9.29%, with only 45,675 of its 171,807 lots reporting a valid value. This highlights major gaps in the German data. We then compared total market volume before and after value filtering. Without restrictions (b1), the total reached €215.97 trillion, which is clearly inflated. According to the European Commission, public procurement comprises about 14% of EU GDP. Based on 2024 AMECO data (€14,122.3 billion at constant prices), this would suggest a procurement market of around €1,977.12 billion (€2,533.52 billion at current prices). Filtering to €4,544–€63,379,652 (b2) yields a revised volume of €1,256.46 billion, more aligned with expectations. Figures 1 and 2 show a right-skewed distribution with extreme outliers. Filtering changes the composition significantly. Germany's tender share drops by over 10 percentage points, and similar effects are seen in other indicators. German companies appeared as winners in 19.17% of contracts overall, but this fell to 10.92% after filtering. The average value of lots won by German firms or consortia including them was €2.51 million, dropping to €1.62 million after cleaning. These figures reflect inconsistencies due to both participation and poor data quality.

We analyzed 771,016 contracts with CPV codes across three scenarios: all classified contracts, those with positive values, and those within the filtered value range. In all cases, Division 45 (Construction Work) was dominant. The second most frequent category changed from Division 33 (Medical Equipment) in Scenario 1 to Division 71 (Engineering Services) in Scenarios 2 and 3. These shifts reflect the effect of data cleaning on sectoral distribution.

Of the 939,165 unique notices, 168,149 lacked CPV codes, indicating substantial classification gaps in the dataset.

Tab. 1 – Distribution of tender lots per CPV-Code

CPV-Division Code	Scenario 1	Scenario 2	Scenario 3
45	18.19%	7.62%	6.95%
71	10.41%	5.04%	4.77%
33	10.30%	6.76%	6.36%
90	5.95%	3.25%	3.11%
79	5.08%	3.17%	2.93%
34	4.82%	2.66%	2.54%
72	4.65%	2.96%	2.79%
50	4.43%	2.78%	2.67%
30	2.52%	1.56%	1.44%
9	2.35%	1.48%	1.36%

5. Discussion & Conclusion

A key issue is the lack of benchmarks to validate total contract values. Without a ground truth, anomalies such as zero or extremely high amounts (e.g., €1 billion) are hard to interpret, raising concerns about accuracy and intent. Our comparisons showed that outliers distort results and can lead to misleading conclusions. Missing, false, or extreme values weaken data integrity and may mask actual spending or signal fraud. Transparency requires data quality, not just quantity. TED data reveals flaws in inconsistent metadata. Better governance, oversight, and institutional capacity are needed. High-quality data is essential for accountability, policymaking, and public trust. In conclusion, TED data quality is poor. Frequent missing values and outliers limit its value for analyzing procurement and undermine the credibility of e-procurement initiatives.

Acknowledgement

- **Funding**: Research done in the frame of the research project 'Procurdat' funded by the German ministry of education and research. Funding code: 02K23A010.

References

Amann, M., & Essig, M. (2015). Public procurement of innovation: Empirical evidence from EU public authorities on barriers for the promotion of innovation. *Innovation: The European Journal of Social Science Research*, *28*(3), 282–292. DOI: https://doi.org/10.1080/13511610.2014.998641

Attard, J., Orlandi, F., Scerri, S., & Auer, S. (2015). A systematic review of open government data initiatives. *Government Information Quarterly*, *32*(4), 399–418. DOI: https://doi.org/10.1016/j.giq.2015.07.006

Batini, C., & Scannapieco, M. (2016). *Data and information quality: Dimensions, principles, and techniques*. Springer.

Bleda, M., & Chicot, J. (2020). The role of public procurement in the formation of markets for innovation. *Journal of Business Research*, *107*, 186–196. DOI: https://doi.org/10.1016/j.jbusres.2018.11.032

Charalabidis, Y., Alexopoulos, C., & Loukis, E. (2016). A taxonomy of open government data research areas and topics. *Journal of Organizational Computing and Electronic Commerce*, *26*(1-2), 41–63. DOI: https://doi.org/10.1080/10919392.2015.1124720

Heinrich, B., Hristova, D., Klier, M., Schiller, A., & Szubartowicz, M. (2017). Requirements for Data Quality Metrics. *Journal of Data and Information Quality*, *9*(2), 1–32. DOI: https://doi.org/10.1145/3148238

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, Adoption Barriers and Myths of Open Data and Open Government. *Information Systems Management*, *29*(4), 258–268. DOI: https://doi.org/10.1080/10580530.2012.716740

Wang, H.-J., & Lo, J. (2016). Adoption of open government data among government agencies. *Government Information Quarterly*, *33*(1), 80–88. DOI: https://doi.org/10.1016/j.giq.2015.11.004

Zhenbin, Y., Kankanhalli, A., Ha, S., & Tayi, G. K. (2020). What drives public agencies to participate in open government data initiatives? an innovation resource perspective. *Information & Management*, *57*(3), 103179. DOI: https://doi.org/10.1016/j.im.2019.103179

Zuiderwijk, A., & Janssen, M. (2014). The negative effects of open government data - investigating the dark side of open data. *Proceedings of the 15th Annual International Conference on Digital Government Research*, 147–152. DOI: https://doi.org/10.1145/2612733.2612761

Converging Paths? Co-creation practices in public services in Poland and Ukraine

Yuliia Bartashevska [a], *Nina* Rizun [b*], *Hanna* Bondarovych [c], *Nina* Khairova [d]

[a] Department of Information Technologies, Alfred Nobel University, Dnipro, Ukraine, bartashevska@duan.edu.ua, ORCID 0000-0002-0300-0693

[b] Gdańsk University of Technology, Gdańsk, Poland, nina.rizun@pg.edu.pl, ORCID 0000-0002-4343-9713

[c] Department of European and Oriental Languages and Translation, Alfred Nobel University, Dnipro, Ukraine, a.bondarovich@duan.edu.ua, ORCID 0009-0001-1905-5752

[d] Department of Computing Science, Umeå University, Sweden, nina.khairova@umu.se, ORCID 0000-0002-9826-0286

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. This study investigates how co-creation is being institutionalized in public service delivery in Poland and Ukraine, focusing on six domains of citizen involvement: legislative frameworks, digital platforms, public consultations, civic monitoring, local initiatives, and civic education. These neighboring countries, connected through shared regional initiatives but shaped by differing political, administrative, and civic trajectories, offer a compelling basis for comparative analysis. While both have made strides in adopting participatory practices, Poland tends to follow a more structured, policy-aligned approach, whereas Ukraine exhibits dynamic, bottom-up developments driven by ongoing decentralization reforms. Our findings indicate that co-creation is becoming more systematically integrated into governance structures, although institutionalization remains uneven across domains and administrative levels. Key challenges include institutional fragmentation, limited translation of public input into policy outcomes, and underdeveloped interdisciplinary competencies, particularly in light of digital transformation and the growing role of AI. The paper concludes with practical recommendations for strengthening co-creation ecosystems in both countries.

Keywords. Public sector, co-creation, public services, institutionalization.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1017

1. Introduction

In recent years, co-creation has emerged as a key principle in the modernization of public service delivery, aligned with broader trends in digital transformation and democratic governance (Edelmann & Mureddu, 2023). Both Poland and Ukraine have made notable advances in digital public services and citizen engagement, supported by national strategies and cross-border initiatives such as Interreg NEXT Poland–Ukraine (*Interreg NEXT Poland – Ukraine 2021-2027*, 2023). While existing literature highlights the benefits of co-creation (Mureddu & Osimo, 2020; Rodriguez Müller et al., 2021) there is limited comparative research on how different countries implement and embed participatory practices across governance domains. Poland and Ukraine offer a particularly relevant case for such an analysis: Poland as an EU member state aligning with European standards of participatory governance, and Ukraine as a country navigating decentralization, digital reform, and institutional change under complex political conditions. This study *aims* to compare the institutionalization of co-creation in Poland and Ukraine, focusing on six key domains of citizen involvement: legislative frameworks, digital platforms, public consultations, civic monitoring, local initiatives, and civic education. We apply a structured qualitative comparison *approach* based on official documents, public data, and civic programs to map and analyze institutional practices across both countries. This study *contributes* to the growing body of research on participatory public governance by providing a structured comparison of how co-creation is operationalized in Poland and Ukraine. It identifies both common patterns and country-specific differences across six domains of citizen involvement, offering insights into the extent and nature of institutionalization. It also offers practical recommendations for strengthening co-creation ecosystems and supporting more inclusive and sustainable public service delivery.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2. Comparative context

This section provides a comparative overview of the evolving digital public service landscape and mechanisms of citizen involvement in co-creation in Poland and Ukraine. It maps key policy frameworks, platforms, and practices across six domains, highlighting similarities, differences, and context-specific developments.

2.1 Digital transformation landscape

Poland and Ukraine have a strong history of digital cooperation, recently strengthened by the 2024 Memorandum of Cooperation in the Digital Sector, focusing on AI, cybersecurity, data protection, and internet infrastructure (Ministry of Digitalization, 2023). The Interreg NEXT Poland–Ukraine 2021–2027 program, co-funded by the EU, further supports joint innovation, startups, and digital solutions (*Interreg NEXT Poland – Ukraine 2021-2027*, 2023). Progress in digital transformation and co-created public services is reflected in the E-Government Development Index (EGDI) and E-Participation Index. In 2024, Ukraine scored 0.88 in EGDI and 1.0 in e-participation; Poland scored 0.86 and 0.75, respectively (*United Nations E-Government Knowledgebase*, 2023). While both countries have similar human capital levels (0.82 Ukraine, 0.83 Poland), Poland leads in telecommunications infrastructure (0.96 vs. 0.84), whereas Ukraine surpasses Poland in online service availability (0.98 vs. 0.80) (Ciepielewska-Kowalik, 2024a).

2.2 Co-creation of public services

Co-creation is increasingly recognized as a strategy to enhance the quality and efficiency of public services, while also fostering trust in government and strengthening democratic governance. In *Poland*, the concept of co-creation has gained momentum, particularly in the context of Europeanization and the shift toward knowledge-based governance (Szarek-Iwaniuk & Senetra, 2020; Ciepielewska-Kowalik, 2024b). In *Ukraine*, co-creation has evolved alongside decentralization reforms, with local authorities and citizens increasingly collaborating to address community needs (Khutkyy & Matveieva, 2024; Keudel & Huss, 2024). Table 1 presents a comparative overview of *citizen involvement mechanisms for public service co-creation* across six key domains in Poland and Ukraine: (1) *Legislative frameworks* – legal instruments and policies that guarantee citizens' rights to access information, participate in governance, and influence decision-making; (2) *Digital platforms* – government-run portals, apps, and tools that facilitate access to services and civic participation; (3) *Public consultations* – formal processes (hearings, online consultations, forums) through which citizens provide input on policies, projects, and laws; (4) *Civic monitoring* – citizen-led oversight of service quality and institutional performance via feedback tools, open data, and evaluation platforms; (5) *Local initiatives* – community-driven projects like participatory budgeting and local improvement plans supported by local authorities; (6) *Civic education* – programs that promote democratic awareness, participatory skills, and active citizenship..

Tab. 1 - Comparative overview of citizen involvement mechanisms for public service co-creation across six domains in Poland and Ukraine.

Domains	Mechanisms in Poland	Mechanisms in Ukraine
Legislative Frameworks	The Law "On Access to Public Information" (2001) (Poland, 2001) guarantees citizens the right to access information held by public institutions, as well as private entities performing public functions. PROO program (Poland, 2018) promotes the development of civil society, civic education, and volunteerism, aiming to enhance citizen participation in decision-making The Law on Participation in Local Self-Government (Poland, 1990) outlines principles of local governance and enables citizen involvement in local institutions.	The Law of Ukraine "On Citizens' Appeals" (1996) (Ukraine, 1996) allows citizens to submit suggestions, complaints, and proposals to public authorities. The Law of Ukraine "On Access to Public Information" (Ukraine, 2011), ensures citizens can access reliable information about government activities. The concept of e-government development in Ukraine (*Concept of the Development of E-Governance in Ukraine*, 2017) promotes transparency and digital access to public services in line with European standards.
Digital platforms	The mObywatel (*Portal MObywatel*, 2023) streamlines citizen-government interactions, with ~600,000 daily visits by early 2025. The mObywatel (*Mobile Application MObywatel*, 2023) provides digital access to personal documents and a wide range of public services. Gov.pl portal (*Polish Public Services Portal Gov.Pl*, 2023) offers centralized access to government services, including the dedicated platform for entrepreneurs (biznes.gov.pl) (*Portal for Entrepreneurs*, 2023).	The Diya portal (Ministry of Digital Transformation of Ukraine, 2023a) offers access to 130+ online public services, enhancing transparency and interaction, with 21 million users by January 2025. The Diya mobile app (Ministry of Digital Transformation of Ukraine, 2023b) allows mobile access to services and digital document storage, with over 10 million downloads by January 2025. The platforms "Public Budget" (DEM) (*Platform*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

		"Public Budget" (DEM), 2023), State Geocadastre (*State Geocadastre*, 2023), Public Services Portal iGov (*Public Services Portal IGov*, 2023) etc., support service access and civic engagement
Public consultations	Local governments are required to engage citizens in decision-making through consultations, hearings, and working groups (*Order on the Principles of Conducting Public Consultations of Documents Developed in the Ministry of Labour and Social Policy*, 2014), (*Ministry of Family*, *Labor and Social Policy*, 2023)	Public hearings, discussions, and consultations incorporate citizens' views into local decision-making (Ukraine, 1997a), (*Public Hearings of the Kyiv City Council*, 2023).
Civic monitoring	Citizens contribute to service transparency and efficiency by monitoring administrative services via tools like the Public Services Monitoring System (*Public Services Monitoring System*, 2023) and E-Governance platforms Public Services Monitoring System (*E-Governance Platform*, 2023).	Civic monitoring, regulated by national law (Ukraine, 1997b), allows citizens to assess service quality and oversee local government performance.
Local initiatives	Mechanisms such as participatory budgeting enable citizens to propose and implement local projects in areas like infrastructure and public space (*What Is a Local Initiative?*, 2023).	Support mechanisms, including participatory budgeting, empower citizens to propose and implement local projects, with outcomes shared via local platforms and the (*Association of Ukrainian Cities*, 2023).
Civic education	The (*The ABCs of Civic Participation*, 2023) promotes engagement from basic awareness to active involvement, while programs like (*A Conscious Citizen Program, 2023*) support civic education and public influence.	Adult education programs—supported by international and local initiatives—equip citizens with practical knowledge on governance, budgeting, and participation tools, fostering civic capacity and democratic engagement (*Decentralization. International Support*, 2023) .

Our comparative analysis reveals that both Poland and Ukraine demonstrate growing commitments to co-creation as a strategy to enhance public service quality and strengthen democratic governance. Ukraine's Diya platform exemplifies large-scale digital integration, enabling streamlined access to over 130 services, while Poland's mObywatel and Gov.pl platforms reflect steady progress toward e-participation. Legal frameworks in both contexts promote transparency and participation, yet Poland shows more structured alignment with EU-supported civic programs. Public consultations and participatory budgeting processes are increasingly present in both countries, but their impact on actual decision-making warrants further scrutiny. Mechanisms for civic monitoring and support for local initiatives are present but unevenly developed, particularly at the local level. However, its institutionalization ranges from formalized resources to project-based initiatives. Together, these observations reflect both *common patterns* and *country-specific differences* across all six domains. These trends suggest that participatory approaches are *becoming more systematically integrated if unevenly institutionalized*, across governance structures, varying not only between countries but also across thematic domains and levels of implementation.

3. Discussion and conclusions

This study examines the institutionalization of co-creation in Poland and Ukraine by comparing mechanisms of citizen involvement in public service design and delivery. Drawing from a structured comparison across six key domains – legislative frameworks, digital platforms, public consultations, civic monitoring, local initiatives, and civic education – we highlight both convergences and contextual differences in the two countries' approaches. To advance the institutionalization of co-creation in Poland and Ukraine, several *recommendations* can be derived from the comparative analysis of existing mechanisms and practices identified in our study: *First*, participation must translate into real impact – public consultations and legislative *feedback tools* should more systematically inform policy and service improvements. *Second*, civic education should embed co-creation literacy not only in community initiatives but also in *academic and professional training*. *Third*, *inclusive* access to digital co-creation tools requires improved user experience and accessibility on platforms. This involves applying *user-centered design* principles and addressing the needs of underrepresented groups through simplified services and integrated digital skills training. *Fourth*, cross-border learning communities should be fostered to support knowledge exchange. Joint academic modules, civic hackathons, and institutional partnerships can leverage existing tools for comparative learning and innovation. *Finally*, our analysis also underscores the need to build *educational ecosystems* that support co-creation competencies, especially as public services become more digitized and AI-driven (Rizun et al., 2025). Beyond administrative literacy, co-creation now requires interdisciplinary capabilities in areas such as ethics, data governance, and responsible AI.

Acknowledgement

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This work was supported by the European Union through the Erasmus+ Programme, under the project AICOSERV (AI Technologies for Sustainable Public Service Co-Creation). Project No. 101180346, funded by the European Education and Culture Executive Agency (EACEA).

References

A conscious citizen program. (2023). https://prawodoporady.pl/
Association of Ukrainian Cities. (2023). https://auc.org.ua/
Ciepielewska-Kowalik, A. (2024a). Between constraint co-production and real co-creation of public services: citizen involvement as public service innovation. Lessons from Poland. *Journal of Contemporary European Studies*, *33*(1), 198–215. https://doi.org/10.1080/14782804.2024.2363872
Ciepielewska-Kowalik, A. (2024b). Between constraint co-production and real co-creation of public services: citizen involvement as public service innovation. Lessons from Poland. *Journal of Contemporary European Studies*, *33*(1), 198–215. https://doi.org/10.1080/14782804.2024.2363872
Concept of the Development of e-Governance in Ukraine (Issue Order of the Cabinet of Ministers of Ukraine №649-p). (2017).
Decentralization. International support. (2023). https://decentralization.ua/donors
Edelmann, N., & Mureddu, F. (2023). Public Policies for Digital Co-Creation in Public Services. In *In Elgar Encyclopedia of Services. Edward Elgar Publishing Limited*.
E-Governance platform. (2023). https://icpa.pl/e-zarzadzanie
Interreg NEXT Poland – Ukraine 2021-2027. (2023). https://www.pl-ua.eu/en
Keudel, O., & Huss, O. (2024). Polycentric governance in practice: the case of Ukraine's decentralised crisis response during the Russo-Ukrainian war. *Journal of Public Finance and Public Choice*, *39*(1), 10–35. https://doi.org/10.1332/25156918Y2023D000000002
Khutkyy, D., & Matveieva, O. (2024). Sustainable Development, Digital Democracy, and Open Government: Co-Creation Synergy in Ukraine. *Comparative Southeast European Studies*, *72*(4), 436–464. https://doi.org/10.1515/soeu-2024-0036
Ministry of Digital Transformation of Ukraine. (2023a). *Diia Platform*. https://diia.gov.ua/
Ministry of Digital Transformation of Ukraine. (2023b). *Mobile Application Diia*. https://play.google.com/store/apps/details?id=ua.gov.diia.app&hl=uk
Ministry of Digitalization. (2023). *Ukraine and Poland signed a memorandum of understanding on cooperation in the field of digitalization*. https://www.gov.pl/web/cyfryzacja/ukraina-i-polska-podpisuja-memorandum-o-wspolpracy-w-zakresie-cyfryzacji
Ministry of Family, Labor and Social Policy. (2023). https://budget.e-dem.ua/howworks
Mobile application mObywatel. (2023). https://info.mobywatel.gov.pl/
Mureddu, F., & Osimo, D. (2020). CO-CREATION OF PUBLIC SERVICES Why and How? *European Review of Service Economics and Management*, *1*, 177–200.
Order on the principles of conducting public consultations of documents developed in the Ministry of Labour and Social Policy (Issue №2). (2014).
Platform "Public Budget" (DEM). (2023). https://budget.e-dem.ua/howworks
Poland. (1990). *Law of Poland on Municipal Government* (Issue №16 poz. 958).
Poland. (2001). *Law of Poland on Access to Public Information* (Issue №112 item 1198).
Poland. (2018). *Government Program for Promoting the Development of Civil Society Organizations for 2018–2030 (GDP)* (Issue Resolution №104/2018).
Polish public services portal Gov.pl. (2023). https://www.gov.pl/web/gov
Portal for entrepreneurs. (2023). https://www.biznes.gov.pl/pl
Portal mObywatel. (2023). https://www.gov.pl/web/mobywatel/mobywatel-w-przegladarce1
Public hearings of the Kyiv City Council. (2023). https://kmr.gov.ua/uk/comisii/26/public-hearings
Public Services Monitoring System. (2023). https://smup.gov.pl/
Public services portal iGov. (2023). https://igov.org.ua/subcategory/1/1
Rizun, N., Revina, A., & Edelmann, N. (2025). Text analytics for co-creation in public sector organizations: a literature review-based research framework. *Artificial Intelligence Review*, *58*(4), 1–45. https://doi.org/10.1007/s10462-025-11112-1
Rodriguez Müller, A. P., Flores, C. C., Albrecht, V., Steen, T., & Crompvoets, J. (2021). A scoping review of empirical evidence on (Digital) public services co-creation. *Administrative Sciences*, *11*(4). https://doi.org/10.3390/admsci11040130
State Geocadastre. (2023). https://e.land.gov.ua/
Szarek-Iwaniuk, P., & Senetra, A. (2020). Access to ICT in Poland and the Co-Creation of Urban Space in the Process of Modern Social Participation in a Smart City—A Case Study. *Sustainability*, *12*(5), 2136. https://doi.org/10.3390/su12052136
The ABCs of civic participation. (2023). https://partycypacjaobywatelska.pl/wp-content/uploads/2018/11/ABC-Partycypacji.pdf
Ukraine. (1996). *Law of Ukraine on Citizens' Appeals* (Issue №393/96-BP).
Ukraine. (1997a). *Law of Ukraine on Local Self-Government in Ukraine* (Issue №280/97-BP).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Ukraine. (1997b). *Law of Ukraine on Local Self-Government in Ukraine* (Issue №280/97-BP).
Ukraine. (2011). *Law of Ukraine on Access to Public Information* (Issue №2939-VI).
United Nations e-Government Knowledgebase. (2023). https://publicadministration.un.org/egovkb/en-us/Data/Compare-Countries
What is a local initiative? (2023). https://lublin.eu/mieszkancy/partycypacja/inicjatywa-lokalna/czym-jest-inicjatywa-lokalna-materialy-informacyjne/

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Cultural Observatories as Digital Platforms of Public Value in Brazil: A Comparative Analysis

Silvia B Ribeiro[a*], *Marie Anne* Macadar[b], *Fernando* Pinto[c].

[a] Phd Student at COPPEAD -Federal University of Rio de Janeiro, Rio de Janeiro, Brasil, silvia.ribeiro@coppead.ufrj.br.

[b] Faculty Member at COPPEAD -Federal University of Rio de Janeiro, Rio de Janeiro, Brasil, marie.macadar@coppead.ufrj.br, https://orcid.org/0000-0003-2744-5352

[c] Phd at COPPEAD -Federal University of Rio de Janeiro, Rio de Janeiro, Brasil, fernando.pinto@coppead.ufrj.br

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. For enhancing transparency and compliance with access to information laws, government portals provide information about investments, investing companies, and beneficiary sectors in creative economy. However, the dispersion and poor structuring of data on government investments in culture limit the understanding of the public value generated by these actions, both for public managers themselves and for society. Based on an empirical quantitative study with collected data frow digital portals of two Brazilian different subnational states, this article aims to discuss how government portals can structure their data on cultural investments in a way that translates its public value. As results, we propose directives for the structuring of culture data in government platforms that contemplates dimensions in a way thatsupports the perception of public value.

Keywords. Culture investments, electronic government, public value.
Poster, DOI: https://doi.org/10.59490/dgo.2025.934

1. Introduction

In Brazil, cultural support is structured within a complex legal framework that encompasses both federal and municipal levels, with mechanisms for tax incentives and accountability [1]. Through it, companies and individuals can allocate part of their Income Tax due to approved cultural projects in exchange for tax benefits. In accordance with Brazilian legislation, both the federal government and subnational states are required to promote transparency in public administration, which includes disclosing relevant information about cultural investments on their respective websites.

Although Brazilian legislation advocates for transparency and the availability of data regarding cultural investments, in practice, such information is not always integrated and structured appropriately on government websites. Furthermore, there is a notable absence of crucial information regarding the socioeconomic impact of cultural investments, which undermines society's perception of public value.

Seeking to address the theoretical gap—i.e. the compromised effectiveness of public value in government websites—this article presents an analytical study of two government portals from different subnational states in Brazil. The study aims to discuss how the cultural investment data available on these platforms can generate public value.

2. Theoretical background

Public value refers to the tangible and intangible benefits that government policies and services provide to society.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Therefore, creating public value is the primary responsibility of public managers, who must balance the needs and expectations of citizens with the available capacities and resources. E-government, in turn, is the use of information and communication technologies (ICTs) to transform government processes and services, increasing efficiency, accessibility, and transparency [2].

The perception of value in the creative economy is related to how individuals and companies interact with digital public services. For creative entrepreneurs, easy access to information, registration, and funding services is essential for decision-making. An efficient e-government not only reduces bureaucratic barriers but also improves user experience, increasing trust in public administration [18].

Therefore, e-government plays a crucial role in promoting the creative economy, providing the infrastructure and incentives needed for the development of this dynamic sector. Addressing the challenges of e-government implementation and investing in continuous innovation are essential steps to ensure that governments can create sustainable public value in an increasingly digitalized world [21]

3. Methodology

This study employs quantitative analysis of secondary data and documentary analysis to conduct a comparative study between the cities of Rio de Janeiro and Porto Alegre in the context of digital cultural data platforms. The research uses two main sources of data: Rio de Janeiro's "Carnival Data" reports (2022-2024), and documents from the Itaú Cultural Observatory. The main source of quantitative data is the so called Continuous National Household Sample Survey (PNADC), carried out by the Brazilian Institute of Geography and Statistics (IBGE).

The PNADC was chosen over the RAIS (Annual Social Information Report) due to its greater scope, since Around 55% of Brazilian workers in creative occupations do not have a formal work permit or are self-employed. The PNADC allows us to capture this informality, which is characteristic of the cultural sector. For this study, we used data for the period 2022-2024, focusing on the metropolitan regions of Rio de Janeiro and Porto Alegre.

Data processing involved multiple steps to ensure a comparative analysis between the two cities. Initially, after extracting the PNADC microdata, filtering was carried out to keep only the data for the capitals Rio de Janeiro and Porto Alegre for the period 2022-2024.

To operationalize this classification, three main categories of analysis were created:
1. Creative Employees in Creative Sectors - professionals who carry out creative activities in cultural/creative sectors
2. Non-Creative Employees in Creative Sectors - professionals in support roles in cultural/creative sectors
3. Creative Employees in Non-Creative Sectors - creative professionals working in traditional sectors

The creative sectors were identified using the National Classification of Economic Activities (CNAE 2.0), resulting in 10 sector groups: Fashion; Craft Activities; Publishing; Film, Music, Radio and TV; Information Technology; Architecture; Advertising; Design; Performing Arts and Visual Arts; Museums and Heritage.

4. Creative Labor Market: A Comparative Analysis Between Rio de Janeiro and Porto Alegre.

A comparative analysis between Rio de Janeiro and Porto Alegre reveals significant differences in both the structure of the creative labor market and the availability of sector-related data. While Rio de Janeiro has developed a digital platform specifically for monitoring the Carnival ("Carnaval de Dados"), Porto Alegre still lacks similar instruments for cultural data management and transparency [26][27][28].

Data from the Continuous PNAD (National Household Sample Survey) highlight significant structural differences between the two cities. Porto Alegre has a higher percentage of workers in creative occupations (10.72%) compared to Rio de Janeiro (9.94%). However, when analyzing the creative sector as a whole, Rio de Janeiro exhibits greater robustness, with 9.55% of workers, compared to 8.57% in Porto Alegre [22].

In terms of earnings, Rio de Janeiro presents higher values for professionals working simultaneously in creative occupations and sectors (R$ 6,317), whereas in Porto Alegre, this average is R$ 5,384. However, for creative occupations in non-creative sectors, Porto Alegre has a slightly higher average income (R$ 7,216 versus R$ 7,139

in Rio de Janeiro).

The most striking differences appear in the educational and racial profile of workers. In Porto Alegre, 80.94% of creative workers hold a higher education degree, a percentage that drops to 74.56% in Rio de Janeiro. The racial

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

composition also shows significant contrasts: while in Porto Alegre, 86.42% of workers are white and 13.58% are black/brown, in Rio de Janeiro, these proportions are 65.11% and 34.89%, respectively, indicating greater racial diversity in Rio's creative market.

Regarding Carnival, Rio de Janeiro exemplifies how structured data management can contribute to sectoral development. According to data from "Carnaval de Dados," the event mobilizes approximately 45,000 direct workers, including 20,000 in the Sambadrome, 18,400 municipal employees, and 10,000 licensed street vendors For 41% of these workers, Carnival represents their primary annual source of income, underscoring its economic significance [24][26][27][28].

Analyzing the structure of the cultural labor market in both cities is enriched when considering specific data from Rio de Janeiro's Carnival between 2022 and 2024. While PNAD data provide a general overview of the creative sector, Carnival data reveal how a specific cultural manifestation can significantly impact the local economy.

The profile of Carnival workers presents characteristics that differentiate it from the broader creative market. While the PNAD analysis shows high levels of formal education (74.56% with higher education in Rio) , the Carnival sector exhibits a more diversified and informal structure. The predominance of informal labor (42%) and service providers (29%) indicates a specific work dynamic within this cultural segment [26][27][28].

Carnival presents a significantly different racial profile compared to the broader creative market. While PNAD data indicate a predominance of white workers in the creative sector (65.11% in Rio), in Carnival, 67.6% of workers are black [26][27][28].

While the creative sector shows high levels of formal education (74.56% with higher education in Rio), the Carnival sector exposes significant labor precarity. The high percentage of black (67.6%) and young (51.3% under 36) workers, combined with the predominance of informal links (42%) and low wages (35.2% earning between 1 and 3 minimum wages, 33.3% earning up to 1 minimum wage), suggests patterns of labor precarization.

The employment structure analysis reveals that only 1% of Carnival workers hold formal employment contracts, while the vast majority fall into informal work and service provision. This seasonality, characteristic of the Carnival event, contributes to the economic instability of cultural sector workers. Despite high educational qualifications, these professionals rarely hold employer positions or establish stable employment relationships, perpetuating a cycle of precariousness in the cultural sector.

This scenario is particularly significant considering that 41% of these workers rely on Carnival as their primary annual income source [24] highlighting how the lack of cultural sector structuring can contribute to maintaining precarious labor conditions, even in large-scale economic events. This comparative analysis demonstrates how the availability of detailed data on a specific cultural manifestation (as in Rio de Janeiro) allows for a deeper understanding of its socioeconomic impact, reinforcing the importance of cultural data management and monitoring tools, which are currently absent in the Porto Alegre context.

5. Final Remarks

This study has explored the role of cultural observatories as digital platforms for public value generation in Brazil, particularly through a comparative analysis of the cities of Rio de Janeiro and Porto Alegre. By assessing the availability, structure, and impact of cultural investment data, we have highlighted the critical importance of well-structured digital governance mechanisms in fostering transparency, efficiency, and public engagement in the cultural sector.

One of the key contributions of this study is the identification of significant disparities in the structuring and accessibility of cultural investment data between the two cities. The presence of a structured data observatory in Rio de Janeiro, specifically for Carnival illustrates how digital platforms can enhance transparency, facilitate decision-making, and generate public value. The detailed employment and demographic data collected through the "Carnaval de Dados" initiative exemplify best practices that could be replicated in other cities to improve cultural policy management [26][27][28].

Data/Software Access Statement

The statistical software STATA was used to read and analyze the microdata from the PNADC (Pesquisa Nacional por Amostra de Domicílios Contínua - Continuous National Household Sample Survey).

Contributor Statement

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Describe properly all author contributions and all types of contributions; see Policies (tudelft.nl).

Use of AI

During the preparation of this work, the author(s) used Claude.ai in order to optimize Stata`s code. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest

References

[1] M. V. L. Lyrio, R. J. Lunkes, and E. T. Castello-Taliani, "Transparência Além Da Legislação: Uma Análise Dos Portais Eletrônicos Dos Estados Brasileiros Com Base Em Um Instrumento De Apoio À Decisão," Gestão Pública Práticas e Desafios, vol. 11, no. 2, 2019, doi: 10.51359/2177- 1243.2019.240260.
[2] P. R. Brown, L. Cherney, and S. Warner, "Understanding Public Value–Why Does It Matter?," Int. J. Public Adm., vol. 44, no. 10, pp. 803–807, 2021, doi: 10.1080/01900692.2021.1929558.
[3] J. D. Twizeyimana and A. Andersson, "The public value of E-Government – A literature review," Gov Inf. Q., vol. 36, no. 2, pp. 167–178, 2019, doi: 10.1016/j.giq.2019.01.001.
[4] I. K. Mensah, G. Zeng, and D. S. Mwakapesa, "Understanding the drivers of the public value of e- government: Validation of a public value e-government adoption model," Front. Psychol., vol. 13, 2022, doi: 10.3389/fpsyg.2022.962615.
[5] Y. Zhang and F. A. Kimathi, "Exploring the stages of E-government development from public value perspective," Technol. Soc., vol. 69, p. 101942, 2022, doi: https://doi.org/10.1016/j.techsoc.2022.101942.
[6] M. Mellouli, F. Bouaziz, and O. Bentahar, "E-government success assessment from a public value perspective," Int. Rev. Public Adm., vol. 25, no. 3, pp. 153–174, Jul. 2020, doi: 10.1080/12294659.2020.1799517.
[7] D. Valle-Cruz, "Public value of e-government services through emerging technologies," Int. J. Public Sect. Manag., vol. 32, no. 5, pp. 530–545, Jan. 2019, doi: 10.1108/IJPSM-03-2018-0072.
[8] D. MacLean and R. Titah, "A Systematic Literature Review of Empirical Research on the Impacts of e- Government: A Public Value Perspective," Public Adm. Rev., vol. 82, no. 1, pp. 23–38, Jan. 2022, doi: https://doi.org/10.1111/puar.13413.
[9] A. Bellon, "The Digitalization of Cultural Policies in France," in Digitalization of Society and Socio-political Issues 1, 2019, pp. 149–156.
[10] C. Donovan and D. O'Brien, "Governing culture: Legislators, interpreters and accountants," Crit. Perspect. Account., vol. 37, pp. 24–34, 2016, doi: https://doi.org/10.1016/j.cpa.2015.10.003.
[11] E. Belfiore, S. Hadley, B. M. Heidelberg, and C. Rosenstein, "Cultural Democracy, Cultural Equity, and Cultural Policy: Perspectives from the UK and USA," J. Arts Manag. Law Soc., vol. 53, no. 3, pp. 157– 168, 2023, doi: 10.1080/10632921.2023.2223537.
[12] M. Lettau, E. D. Otchere, and C. Y. Mtaku, Performing Sustainability in West Africa. 2022.
[13] S.-H. Kwon and J. Kim, "The cultural industry policies of the Korean government and the Korean Wave," Int. J. Cult. Policy, vol. 20, no. 4, pp. 422–439, Aug. 2014, doi: 10.1080/10286632.2013.829052.
[14] J. Roberge, L. Nantel, and A. Rousseau, "Who Needs a Plan Anyway? Digital Cultural Policymaking as the Art of Navigating through Uncertainties," J. Arts Manag. Law, Soc., vol. 47, no. 5, pp. 300–312, Oct. 2017, doi: 10.1080/10632921.2017.1366381.
[15] S. Kumar, K. Baishya, N. Sreen, P. H. Sadarangani, and H. V. Samalia, "Impact of national culture on E- government development: A longitudinal study," J. Glob. Inf. Manag., vol. 29, no. 2, pp. 23–44, 2021, doi: 10.4018/JGIM.2021030101.
[16] Y. Liang, G. Qi, X. Zhang, and G. Li, "The effects of e-Government cloud assimilation on public value creation: An empirical study of China," Gov. Inf. Q., vol. 36, no. 4, p. 101397, 2019, doi: https://doi.org/10.1016/j.giq.2019.101397.
[17] F. Bannister and R. Connolly, "ICT, public values and transformative government: A framework and programme for research," Gov. Inf. Q., vol. 31, no. 1, pp. 119–128, 2014, doi: https://doi.org/10.1016/j.giq.2013.06.002.
[18] J. A. García, M. Gómez, and A. Molina, "A destination-branding model: An empirical analysis based on stakeholders," Tour. Manag., vol. 33, no. 3, pp. 646–661, 2012, doi: https://doi.org/10.1016/j.tourman.2011.07.006.
[19] A. K. Abdulkareem and R. Mohd Ramli, "Does trust in e-government influence the performance of e- government? An integration of information system success model and public value theory," Transform. Gov. People, Process Policy, vol. 16, no. 1, pp. 1–17, Jan. 2022, doi: 10.1108/TG-01-2021-0001.
[20] P. Trein and M. Maggetti, "Patterns of Policy Integration and Administrative Coordination Reforms: A Comparative Empirical Analysis," Public Adm. Rev., vol. 80, no. 2, pp. 198–208, Mar. 2020, doi: https://doi.org/10.1111/puar.13117.
[21] N. Casemajor, G. Bellavance, and G. Sirois, "Cultural participation in digital environments: goals and stakes for Quebec cultural policies," Int. J. Cult. Policy, vol. 27, no. 5, pp. 650–666, Jul. 2021, doi: 10.1080/10286632.2020.1825403.
[22] Ribeiro, S. B. (2024). Mercado de trabalho criativo no Brasil : persistência nas ocupações e análise dos salários dos indivíduos ocupados Salários dos indivíduos ocupados [Dissertação de Mestrado, Universidade Federal do Rio Grande do Sul]. LUME Repositório Digital. http://hdl.handle.net/10183/275964
[23] IBGE (Instituto Brasileiro de Geografia e Estatística). (2024). Pesquisa Nacional por Amostra de Domicílios Contínua - PNAD Contínua.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

[24] Couri, C. (2023). Mapeamento do sistema produtivo criativo do carnaval de rua do Rio de Janeiro. Grupo de Trabalho: Gestão, Empreendedorismo e Inovação na Economia Criativa..
[25] Instituto Itaú Cultural. (2024). Painel de Dados do Observatório Itaú Cultural. https://www.itaucultural.org.br/observatorio/paineldedados/
[26] Prefeitura do Rio de Janeiro. (2024). Carnaval de Dados 2024. Observatório Econômico do Rio.
[27] Prefeitura do Rio de Janeiro. (2023). Carnaval de Dados 2023. Observatório Econômico do Rio.
[28] Prefeitura do Rio de Janeiro. (2022). Carnaval de Dados 2022. Observatório Econômico do Rio.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Cyberattacks in government organizations: A systematic literature review of attack types and mitigation strategies.

Dimaz Cahya Ardhi [a], Dwi Puspita Sari[b], Benjamin Yankson[c]*

[a] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, USA, dardhi@albany.edu, 0009-0006-9306-0820
[b] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, USA, dsari@albany.edu, 0009-0002-7451-439X
[c] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, USA, byankson@albany.edu, 0000-0003-3306-3748
Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. In the digital government era, the government must protect citizens' data from cyberattacks to gain public trust. This study aims to identify the type of cyberattack incidents in government organizations and the implementation strategies to prevent cyberattacks. In this study, we conduct the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach to answer our research questions. It performs a detailed analysis based on 50 peer-reviewed articles published in the conference proceedings and journals from January 2020 to December 2024. Those articles are retrieved from five databases: ACM Digital Library, Engineering Village, IEEE Xplore, the University at Albany Library, and Web of Science. The results revealed six types of cyberattacks in government organizations: malware, denial-of-service attacks, phishing attacks, false data injection, supply chain attacks, and advanced persistent threats. Furthermore, our review showed that four strategies have been implemented to prevent cyberattacks: 1) developing national cybersecurity strategies and frameworks, 2) building cyber defense capacity, 3) enhancing infrastructure resilience, and 4) education, training, and awareness. This study contributes to the field by providing different types of cyberattacks associated with government organizations and presenting a centralized and comprehensive analysis of research work in security, which is an excellent resource for other researchers in a similar field. Finally, this study also offers practical implications for government organizations, providing strategies to help them prevent cyberattacks.

Keywords. Cyberattack, cybersecurity, public sector, government organization.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1021

1. Introduction

It is undeniable that the use of information and communication technologies (ICTs) in government organizations has become essential as a part of the digital government and modern society. The digital government aims to expedite the administrative process in government organizations (Frandell & Feeney, 2022). Furthermore, ICT integration has become increasingly prevalent, but at the same time, it is also associated with cyber risks, including cyberattacks (Frandell & Feeney, 2022). The risk can be caused by the fact that, in the digital government, the government stores its data online or in the cloud. Cyberattacks have occurred globally in both the private and public sectors, including financial services, government administration, insurance, and other industries. The increase in cyberattack incidents has drawn the attention of many researchers to study cyberattacks in organizations.

The existing literature concentrates on the private sector due to prominent cases, including data breaches at big

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

companies such as Yahoo, Equifax, and Capital One (Khan et al., 2022). For example, Starbucks, a company with chain stores worldwide, experienced a ransomware attack that impacted 11,000 of its branches in North America, requiring employees to be scheduled manually (Watkins, 2024). However, there is scarce literature focusing on cyberattacks in government organizations. This study aims to shed light on various types of cyberattack incidents in government organizations and the strategies these organizations have implemented to prevent and address cyberattacks. Two research questions guided our study: (1) What type of cyberattacks occurred in government organizations? and (2) What strategies has the government employed to prevent cyberattacks? In order to answer these research questions, this study employed a Systematic Literature Review (SLR) approach. In particular, in this study, we apply the PRISMA approach to answer our research questions.

2. Research Design

The research design section is divided into two sub-sections: search strategies and review method. First, we describe the search strategies apply in this SLR, including the keywords used and the various sources of articles included in our search. Second, we elaborate on the steps involved in identifying the articles included in this study.

2.1 Search strategies

In our study, we include five databases for articles searches in our analysis: ACM Digital Library, Engineering Village, IEEE Xplore, the University at Albany Library, and Web of Science. In all our searches, we use the following search words: "cyber attack" OR "cyber-attack" OR "cyberattack" AND "public sector" OR "government".

2.2 Review method

In order to ensure the clarity, transparency, and quality of this systematic literature review, this study follows the SLR using the PRISMA approach to help us better understand the cyberattack types and strategies to prevent and mitigate those different attacks in government organizations (see Figure 1 below). Figure 1 below illustrates a flow diagram of the PRISMA approach, which outlines our method, divided into two main stages: identification and screening. Initially, we identified 785 articles that included the keywords. However, we excluded 735 articles because those do not meet the eligibility criteria. Finally, after reading the full text and checking the eligibility criteria, we included 50 articles for the review.

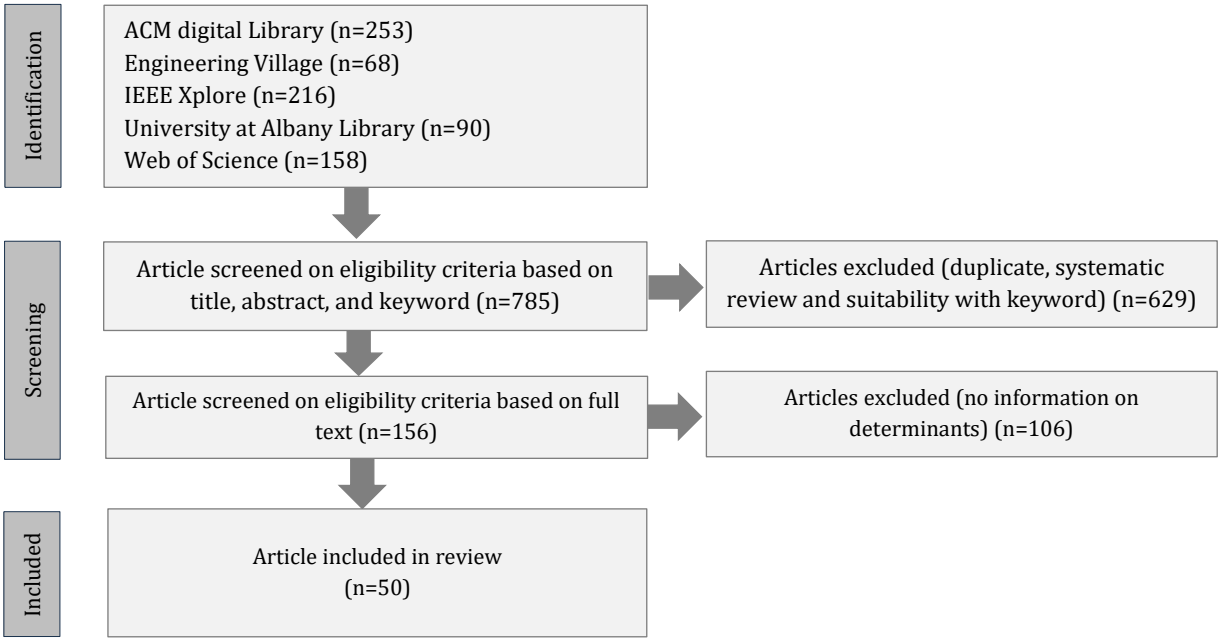


Fig. 1 – Flow diagram with PRISMA approach.

Table 1 below presents the characteristics of the included studies, which illustrate the selection of articles from five different database resources. Table 1 below shows the characteristics of the studies included in our review, including the number of articles retrieved from the database and selected for our review.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 – Sources of included studies.

Database Resource	Article Retrieved	Article Selected
ACM Digital Library	253	5
Engineering Village	68	6
IEEE Xplore	216	18
University at Albany Library	90	16
Web of Science	158	5

Table 2 below shows the characteristics of the studies included in our systematic literature review. It showcases the diversity of article publications in terms of sources, methods, and geographical regions. Out of the 50 articles included in this review, 28 were published in conference proceedings, while 22 were published in journals.

Tab. 2 – Characteristics of included studies.

		Number of publication(s)
Source	Journal	22
	Conference proceeding	28
Method	Qualitative	22
	Quantitative	13
	Mix Method	15
Geographic Region	Europe	8
	North America	10
	Central America	1
	South America	4
	East Asia	4
	Middle East Asia	1
	South Asia	1
	Southeast Asia	2
	Africa	1
	Oceania	1
	Multiple countries	8

3. Findings and Discussion

3.1 Cyberattack types

Our study indicates that the three most common government cyberattacks are malware, denial of service (DoS) and denial-of-service (DDoS), and phishing. First, ransomware attacks disrupt operations or steal sensitive data, compromising grid reliability and security (Atkins, 2021; Avraam et al., 2023). Second, DoS and DDoS attacks cause significant disruption to the government system, including communication disruption, data breaches, and attacks on the cloud service (Byeon & Suh, 2020; Aljuaid & Alshamrani, 2024). Porter and Tan (2022) in their study discuss distributed DDoS attacks as the primary method used in the first cyberattack on Estonian government organizations in 2007, targeting parliaments, banks, and ministries. Third, phishing attacks are a common cyberattack technique that targets government organizations (Drummonds et al., 2022; Park et al., 2023). In addition to these three attacks, the literature also discusses more sophisticated threats, such as code injection attacks.

Our review reveals that government organizations were vulnerable to three other types of cyberattacks: False Data Injection (FDI), supply chain attacks, and advanced persistent threats (APTs). FDI presents crucial threats to High-Voltage Direct Current (HVDC) systems under an Exchange Frequency Containment Reserve control (Avraam et al., 2023; Ramadhan et al., 2023). Furthermore, supply chain attacks indirectly target third-party vendors to infiltrate government systems. For example, the 2020 SolarWinds hack exemplifies a supply chain attack within the Orion software updates of the Texas-based IT firm SolarWinds, and government organizations, including the Department of Homeland Security and Microsoft (Porter & Tan, 2022; Wang, 2021). Attackers compromised the software build system to insert malware into legitimate Orion updates, which were then unknowingly installed by thousands of governments and corporate users. Finally, APTs, also known as national cyber-attacks, target the government in any organization and are hard to detect (Atkins, 2022; Kumar et al., 2022).

3.2 Strategies to prevent and mitigate cyberattacks

We discover four key strategies commonly implemented by governments to prevent cyberattacks. First, government organizations develop a national cybersecurity strategy. The existing literature shows that the United Kingdom government established a national cybersecurity strategy to strengthen resilience at the organizational and national levels (Klumpes, 2023). The literature mentions that national cybersecurity is updated periodically in 2011, 2016, and 2022 (Klumpes, 2023). Additionally, Swedish government organizations implemented the ISO/IEC 27001 framework for compliance in government organizations, including municipalities and regions (Magnusson

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

et al., 2023). Furthermore, Japan has implemented strategies and measures to strengthen cybersecurity, covering legal, policy, and operational aspects, starting from an action plan in 2000, the national strategy on information security since 2006, and a cyber security strategy in 2013 (Ukhanova, 2022).

Second, government organizations build a strong cyber defense capacity, which includes establishing a cyber defense unit, command, and response (Porter & Tan, 2022) or cyber response (Mahima, 2021). For example, the Estonian government established the Estonian Defense League Cyber Unit, which united computer programmers from the private and public sectors. Additionally, in 2018, Estonia established a cyber command comprising 300 military and civilian professionals, including those from the private sector. Besides developing a defense cyber unit, government organizations' action to build a strong cyber defense is creating an emergency response team (Hossain et al., 2021; Riebe et al., 2021).

Third, government organizations have started to enhance cybersecurity infrastructure by developing resilient infrastructure and implementing a detection system (Ramadhan et al., 2023; Suresh & Madhavu, 2021). For example, using sensors and normalized correlation to detect anomalies in HVDC systems effectively identifies cyberattacks, such as measurement delay, missing data, and false data injection, as demonstrated through simulations in Jeju Island, South Korea (Ramadhan et al., 2023).

Fourth, education, training, and awareness programs are essential to foster a cybersecurity-aware workforce and informed public. Keshvadi (2023) suggested the importance of specialized cybersecurity education programs designed for non-technical staff based on the results of a research survey of senior cybersecurity leaders from public and private sectors in different countries, including Australia, Europe, and the United States.

4. Conclusion

Our review shows six cyberattacks that occurred in government organizations: malware, DoS and DDoS, phishing attack, FDI, supply chain attack, and APTs. In this study, the review shows prevention strategies for cyberattacks: developing national cybersecurity strategies and frameworks, building strong cyber defense capacity, enhancing the resilience of infrastructure, and providing education, training, and awareness. Our study reveals a notable lack of empirical study examining cyberattacks and strategies to prevent and mitigate them in government organizations.

This study has two main contributions to the field. First, this study contributes to the limited literature by proposing a specific type of cyberattack explicitly associated with government organizations. Second, this study presents a centralized and comprehensive analysis of research work in security, which will serve as an excellent resource for other researchers in a similar field. Limitation of our study focuses exclusively on two primary keywords: cyber-attack/cyber attack/cyberattack and public sector/government. In the future, we need to incorporate additional keywords into our searches, like cybersecurity and cyber resilience.

Acknowledgement

- **Contributor Statement***: Author 1: conceptualization, data curation, formal analysis, investigation, and methodology, writing - original draft; Author 2: conceptualization, formal analysis, investigation, and methodology, writing - original draft; Author 3: supervision and writing - review and editing.
- **Use of AI***: During the preparation of this work, the authors used Grammarly in order to check the writing grammar. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Aldabbagh, A. M., & Ilyas, M. (2021). Smart city GIS mapping and analysis of intrusion detection. *IEEE Xplore*. https://doi.org/10.1109/ICECCT52121.2021.9616943

Aljuaid, W. H., & Alshamrani, S. S. (2024). A deep learning approach for intrusion detection systems in cloud computing environments. *Applied Sciences*, *14*(13), 5381. https://doi.org/10.3390/app14135381

Atkins, S., & Lawson, C. (2021). An improvised patchwork: Success and failure in cybersecurity policy for critical infrastructure. *Public Administration Review*, *81*(5). https://doi.org/10.1111/puar.13322

Atkins, S., & Lawson, C. (2022). Integration of effort: Securing critical infrastructure from cyberattack. *Public Administration Review*, *82*(4), 771-775. https://doi.org/10.1111/puar.13493

Avraam, C., Ceferino, L., & Dvorkin, Y. (2023). Operational and economy-wide impacts of compound cyber-attacks and extreme weather events on electric power networks. *Applied Energy*, *349*, 121577-121577. https://doi.org/10.1016/j.apenergy.2023.121577

Byeon, S., & Suh, W. (2020). A study on the government's countermeasures against cyber attacks. *IEEE Xplore.*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

https://doi.org/10.1109/BigComp48618.2020.00-17

Drummonds, A. O., Henry, J., & Mirpuri, K. (2022). An analysis of website phishing awareness in Jamaica. *IEEE Xplore*. https://doi.org/10.1109/SoutheastCon48659.2022.9764050

Frandell, A., & Feeney, M. (2022). Cybersecurity threats in local government: A sociotechnical perspective. *The American Review of Public Administration*, *52*(8), 558–572. https://doi.org/10.1177/02750740221125432

Hossain, Z., Zaman, G. K., & Taher, K. A. (2021). Cyber emergency response team for Bangladesh. *IEEE Xplore*. https://doi.org/10.1109/ICICT4SD50815.2021.9396922

Keshvadi, S. (2023). Enhancing western organizational cybersecurity resilience through tailored education for non-technical employees. *IEEE International Humanitarian Technology Conference (IHTC)*, 1-6. https://doi.org/10.1109/ihtc58960.2023.10508824

Khan, S., Kabanov, I., Hua, Y., & Madnick, S. (2022). A systematic analysis of the Capital One data breach: Critical lessons learned. *ACM Transactions on Privacy and Security*, *26*(1). https://doi.org/10.1145/3546068

Klumpes, P. (2023). Coordination of cybersecurity risk management in the U.K. insurance sector. *The Geneva Papers on Risk and Insurance - Issues and Practice*. https://doi.org/10.1057/s41288-023-00287-9

Kumar, G. K. S., Prakasha, K. K., & Muniyal, B. (2022). ACH reference model - A model of architecture to handle advanced cyberattacks. *2022 Second International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT)*. https://doi.org/10.1109/icaect54875.2022.9808076

Magnusson, L., Dalipi, F., & Elm, P. (2023). Cybersecurity compliance in the public sector: Are the best security practices properly addressed? *Communications in Computer and Information Science*, 219-226. https://doi.org/10.1007/978-3-031-36001-5_28

Mahima, D. (2021). Cyber threat in public sector: Modeling an incident response framework. *IEEE Xplore*. https://doi.org/10.1109/ICIPTM52218.2021.9388333

Park, H., Lim, K., Kim, D., Yu, D., & Koo, H. (2023). Demystifying the regional phishing landscape in South Korea. *IEEE Access*, 11, 130131-130143. https://doi.org/10.1109/access.2023.3333883

Porter, T., & Tan, N. (2022). An integrated complex adaptive governmental policy response to cyberthreats. *Journal of Economic Policy Reform*, 1-15. https://doi.org/10.1080/17487870.2022.2125390

Ramadhan, U. F., Lee, J., & Yoon, M. (2023). A comprehensive study of cyber attack mitigation with the exchange of frequency containment reserves control in a multi-infeed direct current power system. *Sensors*, *23*(4), 1964. https://doi.org/10.3390/s23041964

Riebe, T., Kaufhold, M.-A., & Reuter, C. (2021). The impact of organizational structure and technology use on collaborative practices in computer emergency response teams: An empirical study. *Proceedings of the ACM on Human-Computer Interaction*, *5*(CSCW2), 1-30. https://doi.org/10.1145/3479865

Suresh, P., & Madhavu, M. L. (2021). Insider attack: Internal cyber attack detection using machine learning. *12th International Conference on Computing Communication and Networking Technologies (ICCCNT)*. https://doi.org/10.1109/icccnt51525.2021.9579549

Ukhanova, E. (2022). Cybersecurity and cyber defence strategies of Japan. *SHS Web of Conferences*, *134*, 00159. https://doi.org/10.1051/shsconf/202213400159

Wang, X. (2021). On the feasibility of detecting software supply chain attacks. *IEEE Xplore*. https://doi.org/10.1109/MILCOM52596.2021.965290

Watkins, A. (2024). *Starbucks among companies affected by ransomware attack*. The New York Times. https://www.nytimes.com/2024/11/26/business/blue-yonder-ransomware-attack-starbucks.html

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Data Report on School Dropout in a Brazilian State: Social Technologies for Preventing the Phenomenon.

Leogildo Alves Freires[a], *Heitor Marinho da Silva Araújo* [b], *Luan Filipy Freire Torres*[c], *Thiago* Damasceno *Cordeiro*[d], *Gabriel Fortes Cavalcanti de Macedo*[e]

[a] Psychology Institute, Federal University of Alagoas, Maceió, Brazil, leogildo.freires@nees.ufal.br, 0000-0001-5149-2648.

[b] Psychology Institute, Federal University of Bahia, Salvador, Brazil, heitormrnh@gmail.com, 0000-0001-7245-9679.

[c] Psychology Department, Federal University of Pernambuco, Recife, Brazil, luan.ftorres@ufpe.br, 0000-0001-5820-2367.

[d] Psychology Institute, Federal University of Alagoas, Maceió, Brazil, thiago.cordeiro@nees.ufal.br, 0000-0003-0976-7040.

[e] Facultad de Psicologia, Universidad Alberto Hurtado, Santiago, Chile, gabriel.macedo@nees.ufal.br, 0000-0003-4997-0019.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. School dropout is a multifaceted and persistent challenge with serious implications for public health, economic development, and social equity. In Brazil, where educational disparities remain deeply rooted in structural and contextual inequalities, addressing dropout requires more than tracking attendance, academic performance, or behavior. This study presents the development and implementation of a Relational Model (RM) aimed at identifying and mitigating school dropout risks through a comprehensive, data-informed approach. Central to this model is the Alternative Instrument for Assessing School Dropout Risk Factors (IAFREE-A), which evaluates 13 interrelated risk factors across five key dimensions: Student-School, Student-School Professionals, Student-Family, Student-Community, and Student-Student. These dimensions allow for a nuanced understanding of how relational dynamics and contextual conditions shape students' engagement with schooling. A pilot study was carried out in the state of Mato Grosso, involving 624 students across 10 public schools. Data collection was conducted through physical questionnaires, digitized using Optical Character Recognition (OCR) technology, and processed via an integrated digital platform. This platform generates individual and institutional dropout risk profiles by mapping protective and risk factors, providing actionable insights for educators, school administrators, and policymakers. Results highlighted critical concerns such as inadequate school infrastructure, perceptions of insecurity, and weak family-school connections, reinforcing the need for early, context-specific interventions. The findings demonstrate that school dropout is not an isolated event, but the outcome of complex relational, institutional, and structural factors. The RM and IAFREE-A offer an innovative and culturally sensitive framework for prevention, enabling tailored interventions that respond to students' lived realities. By fostering stronger connections among students, educators, families, and communities, this approach has the potential to reduce dropout rates and promote more equitable and supportive educational environments in Brazil and beyond.

Keywords. School Dropout Prevention, Relational Model (RM), Early Warning Systems (EWS)
Poster, DOI: https://doi.org/10.59490/dgo.2025.1053

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

1. Introduction

School dropout, defined as the cessation of school attendance without re-enrolment in the formal education system, is widely recognised as both a public health concern and an economic issue, with profound implications for unemployment, poverty, crime rates, and mental health (Wood et al., 2017; Vinas-Forcade et al., 2021). The phenomenon is driven by a complex interplay of individual, familial, school-related, and community factors, including poor academic performance, lack of motivation, emotional challenges, adverse socioeconomic conditions, and insufficient family support (Witte et al., 2013; Nelson et al., 2016). These factors collectively contribute to a multifaceted problem that requires a comprehensive and nuanced approach to address effectively. To tackle this issue, a Relational Model (RM) has been proposed, which integrates protective dimensions and early warning indicators for school dropout. This model employs an Alternative Instrument for Assessing School Dropout Risk Factors (IAFREE-A), comprising 13 risk factors categorised into five dimensions: Student-School, Student-School Professionals, Student-Family, Student-Community, and Student-Student (Vasconcelos et al., 2023). The model offers a holistic perspective on the interactions influencing dropout, moving beyond conventional metrics such as attendance, behaviour, and academic performance, which, while important, do not fully capture the relational and contextual dynamics that contribute to dropout (Kearney, 2021).

The Student-School dimension focuses on the relationship between the student and the school environment, including factors such as infrastructure, safety, and the availability of educational resources. Poor infrastructure, for example, can create an unwelcoming and unsafe environment, discouraging attendance and engagement. Schools with inadequate facilities, such as lack of proper classrooms, libraries, or even basic sanitation, can significantly impact students' willingness to attend and engage in learning (Churchill et al., 2021). Additionally, the perception of safety within the school environment plays a critical role. Students who feel unsafe due to bullying, violence, or lack of supervision are more likely to disengage and eventually drop out (Vinas-Forcade et al., 2021). The Student-School Professionals dimension examines the interactions between students and school staff, including teachers, administrators, and support personnel. Positive relationships with school professionals can foster a sense of belonging and support, while negative interactions can lead to disengagement and dropout (Uekawa et al., 2010; King & Garcia, 2016). Teachers who are empathetic, approachable, and supportive can create an environment where students feel valued and motivated to succeed. Conversely, a lack of communication or negative interactions with school staff can alienate students, making them feel disconnected from the educational process (Rogers & Feller, 2016).

The Student-Family dimension considers the role of family support in a student's educational journey. A lack of parental involvement or unstable family environments can significantly impact a student's ability to remain in school (Witte et al., 2013). Families facing financial difficulties may prioritise work over education, leading students to drop out to contribute to household income. Similarly, households with high levels of conflict, neglect, or abuse can create an environment where education is not prioritised or supported. On the other hand, families that actively engage in their children's education, by attending school meetings, helping with homework, or simply showing interest in their academic progress, can significantly enhance students' motivation and commitment to staying in school (Rogers & Feller, 2016). The Student-Community dimension explores the influence of the broader community, including socioeconomic conditions, access to extracurricular activities, and community attitudes towards education. In communities where education is undervalued or where economic opportunities are limited, students may see little incentive to remain in school (Churchill et al., 2021). Conversely, communities that prioritise education and provide resources such as after-school programmes, mentorship opportunities, and safe spaces for learning can create a supportive environment that encourages students to stay in school (Vinas-Forcade et al., 2021). Finally, the Student-Student dimension looks at peer relationships and the social dynamics within the school environment, which can either support or hinder a student's educational trajectory. Positive peer relationships can provide emotional support and motivation, while negative interactions, such as bullying or social exclusion, can lead to disengagement and dropout (Nelson et al., 2016).

2. Research methods

To test the effectiveness of this model, a pilot study was conducted in a Brazilian state in partnership with the local education secretaries, involving data collection from 624 students across 10 schools. Physical questionnaires were used, which were subsequently digitised using Optical Character Recognition (OCR) technology and processed on an integrated platform. This platform generates scores that map protective dimensions and dropout risk factors, enabling data-driven decision-making. The pilot results underscored the instrument's efficacy in the early identification of at-risk students, highlighting critical issues such as inadequate school infrastructure, the perception of schools as unsafe environments, and a lack of family support (Vasconcelos et al., 2023). These findings reinforce the necessity of considering contextual and relational factors in dropout prevention strategies, as traditional metrics alone are insufficient to capture the full scope of the problem (Wood et al., 2017; Kearney, 2021).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3. Results

The study concludes that school dropout should be understood as a multifactorial and relational process, shaped by a combination of structural, institutional, and subjective elements. Structural factors include socioeconomic conditions, access to resources, and community support, while institutional factors encompass school policies, teacher-student relationships, and the overall school climate (Fuentes, 2024). Subjective factors, on the other hand, involve individual experiences, perceptions, and emotional states, which can significantly influence a student's decision to leave school (Nelson et al., 2016). The concept of protecting educational trajectories, central to this study, extends beyond merely identifying imminent risks. Instead, it focuses on creating conditions that foster student retention and academic achievement. This approach is rooted in the understanding that enhancing positive interactions among the various stakeholders in the educational ecosystem can transform schools into environments of opportunity (Fuentes, 2024).

The Relational Model (RM) and the IAFREE-A instrument represent a significant advancement in the field of dropout prevention. By integrating multiple dimensions and focusing on relational dynamics, the model provides a more comprehensive framework for understanding and addressing the root causes of dropout (Vasconcelos et al., 2023). The pilot study demonstrated the practical applicability of this model, showing that it can effectively identify at-risk students and provide actionable insights for intervention. The integrated platform, which processes and visualises the data collected through the IAFREE-A instrument, plays a crucial role in this process. It allows educators, administrators, and policymakers to access detailed information about the factors contributing to dropout risk, enabling them to tailor interventions to the specific needs of their students and schools (Vasconcelos et al., 2023).

One of the key strengths of the model is its emphasis on early intervention. By identifying at-risk students before they disengage from school, educators can implement targeted support measures that address the underlying issues contributing to dropout. This proactive approach is far more effective than reactive measures, which often come too late to make a meaningful difference (Barfield et al., 2012). The pilot study highlighted several areas where early intervention could have a significant impact, including improving school infrastructure, fostering positive relationships between students and school staff, and increasing family involvement in education. These interventions, when implemented effectively, can create a supportive and engaging school environment that encourages students to stay in school and achieve their academic potential (Perusia & Cardini, 2021).

The study also underscores the importance of evidence-based public policies in addressing school dropout. By monitoring the long-term impact of interventions and continuously refining strategies based on data, policymakers can ensure that their efforts are effective and sustainable (Fuentes, 2024). The integrated platform developed as part of this research provides a valuable tool for this purpose, offering a detailed and accessible overview of dropout risk factors and protective dimensions. This platform can be used by a wide range of stakeholders, from school administrators to national policymakers, to inform their decision-making and prioritise resources where they are needed most (Vasconcelos et al., 2023).

In addition to its practical applications, the study makes a significant theoretical contribution to the field of education. By proposing a relational model that integrates multiple dimensions of dropout risk, it challenges traditional approaches that focus narrowly on academic performance and attendance (Kearney, 2021). This broader perspective aligns with contemporary research, which increasingly recognises the importance of relational and contextual factors in shaping educational outcomes (Wood et al., 2017). The study also highlights the need for culturally sensitive and context-specific approaches to dropout prevention, as the factors contributing to dropout can vary significantly across different regions and communities (Gutiérrez-de-Rozas et al., 2022).

The Relational Model (RM) and the IAFREE-A instrument are particularly relevant in the context of Brazil, where school dropout rates remain a persistent challenge. The country's diverse socioeconomic and cultural landscape requires tailored solutions that address the unique needs of different communities (Fuentes, 2024). The pilot study conducted in the federal state of Mato Grosso demonstrated the potential of this approach to make a meaningful impact in a Brazilian context. By identifying the specific factors contributing to dropout in this region, the study provides a foundation for developing targeted interventions that can be scaled up and adapted to other parts of the country (Vasconcelos et al., 2023).

4. Conclusion

In conclusion, the study presents a robust and innovative approach to addressing the complex issue of school dropout with some limitations as being a pilot study. By integrating multiple dimensions of dropout risk and focusing on relational dynamics, the Relational Model (RM) provides a comprehensive framework for understanding and addressing the root causes of dropout. The IAFREE-A instrument and the integrated platform offer practical tools for identifying at-risk students and implementing targeted interventions. The study demonstrated the effectiveness of this approach in a Brazilian context, highlighting its potential to make a

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

meaningful impact on dropout rates and educational outcomes. The study also underscores the importance of evidence-based public policies and the need for culturally sensitive, context-specific solutions. By continuing to refine and expand this approach, it is possible to create a more equitable and inclusive education system that supports all students in achieving their full potential.

Acknowledgement

We thank the University Foundation for Extension Development and Research (Fundepes) for funding the project.

Contributor Statement

All authors have corroborated in the Conceptualization, Formal analysis, Investigation, Methodology, Resources, Writing - Original Draft and Writing - Review & Editing

References

Barfield, K. A., Hartman, J., & Knight, D. ([s.d.]). Early warning systems: It's never too early. *T. H. E. Journal*, *39*(2), 18–19.

De Vasconcelos, A. N., Freires, L. A., Loureto, G. D. L., Fortes, G., Da Costa, J. C. A., Torres, L. F. F., Bittencourt, I. I., Cordeiro, T. D., & Isotani, S. (2023). Advancing school dropout early warning systems: The IAFREE relational model for identifying at-risk students. *Frontiers in Psychology*, *14*, 1189283. https://doi.org/10.3389/fpsyg.2023.1189283

De Witte, K., Cabus, S., Thyssen, G., Groot, W., & Van Den Brink, H. M. (2013). A critical review of the literature on school dropout. *Educational Research Review*, *10*, 13–28. https://doi.org/10.1016/j.edurev.2013.05.002

Examining the Relationship Between Persistence in Attendance in an Afterschool Program and an Early Warning Index for Dropout—UNT Digital Library. ([s.d.]). Recuperado 21 de março de 2025, de https://digital.library.unt.edu/ark:/67531/metadc500218/

Gutiérrez-de-Rozas, B., López-Martín, E., & Carpintero Molina, E. (2022). Condicionantes del rendimiento académico: Revisión sistemática de 25 años de meta-análisis. *Revista de Educación*, *398*, 1–48. https://doi.org/10.4438/1988-592X-RE-2022-398-552

Improving Education Participation. ([s.d.]).

Kearney, C. A. (2021). Integrating Systemic and Analytic Approaches to School Attendance Problems: Synergistic Frameworks for Research and Policy Directions. *Child & Youth Care Forum*, *50*(4), 701–742. https://doi.org/10.1007/s10566-020-09591-0

Nelson, N. J., & Baker, S. K. (2016). *Researcher-Practitioner Partnerships:*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Pesquisas sobre políticas de proteção das trajetórias: Educação secundária na América Latina; sumário executivo—UNESCO Digital Library. ([s.d.]). Recuperado 21 de março de 2025, de https://unesdoc.unesco.org/ark:/48223/pf0000390702_por

Rogers, M., Churchill, E., & Pristawa, K. (2021). "High schoolers' and middle schoolers' connections in their schools: Relation to tardiness, absences, disciplinary referrals, and failed courses". *National Youth at Risk Journal*, *4*(2). https://doi.org/10.20429/nyarj.2021.040203

Rogers, T., & Feller, A. (2016). *Parent Beliefs and Student Absences: Large Absence-Reduction Field Experiment*. Society for Research on Educational Effectiveness. https://eric.ed.gov/?id=ED567510

Sistemas de alerta temprana en la educación secundaria: Prevenir el abandono escolar en la era del COVID-19. ([s.d.]). Recuperado 21 de março de 2025, de https://www.cippec.org/publicacion/sistemas-de-alerta-temprana-en-el-nivel-secundario/

Uekawa, K., Merola, S., Fernandez, F., & Porowski, A. (2010). *Creating an Early Warning System: Predictors of Dropout in Delaware. REL Mid-Atlantic Technical Assistance Brief. REL MA 1.2.75-10*. Regional Educational Laboratory Mid-Atlantic. https://eric.ed.gov/?id=ED565682

Vinas-Forcade, J., Mels, C., Van Houtte, M., Valcke, M., & Derluyn, I. (2021). Can failure be prevented? Using longitudinal data to identify at-risk students upon entering secondary school. *British Educational Research Journal*, *47*(1), 205–225. https://doi.org/10.1002/berj.3683

Wood, L., Kiperman, S., Esch, R. C., Leroux, A. J., & Truscott, S. D. (2017). Predicting dropout using student- and school-level factors: An ecological perspective. *School Psychology Quarterly*, *32*(1), 35–49. https://doi.org/10.1037/spq0000152

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital Dependence vs. National Performance: Preliminary Data Analysis

Jaromir Durkiewicz [a*], Tomasz Janowski[b]

[a] Gdańsk University of Technology, Gdańsk, Poland, jaromir.durkiewicz@pg.edu.pl, ORCID 0000-0002-7919-3583

[b] Gdańsk University of Technology, Gdańsk, Poland and University for Continuing Education Krems, Krems, Austria, tomasz.janowski@pg.edu.pl, ORCID 0000-0001-8950-5782

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. Countries differ in their capacity to develop and use digital technology – some build such capacity locally, others rely on foreign countries and corporations, and yet others do both. While sourcing arrangements may vary, the outcome is critical to countries' performance – their ability to pursue national goals and priorities. The paper explores the relationship between the countries' digital dependence and performance, relying on the calculation of the Spearman correlation coefficient between the Digital Dependence Index and the Online Service and E-Participation Indices, for 23 countries in 2020. The calculation established a small to moderate negative correlation between the variables, i.e. the better performance, the lower dependence, in line with theoretical assumptions, and identified cases that violate these assumptions.

Keywords. Digital technology, digital dependence, digital government, national performance
Poster, DOI: https://doi.org/10.59490/dgo.2025.936

1. Introduction

Governments around the world struggle to predict and manage the effect of digital transformation scaling up from the individual (citizens and businesses) to the system (economies and societies) level. System-level risks are particularly dangerous at the times of geopolitical tensions when the countries' capabilities to implement digital transformation is essential. For countries lacking indigeneous capabilities, it is a major risk.

In the international arena, countries' digital capabilities are represented by digital sovereignty, digital autonomy, and digital dependence. Digital sovereignty "encompasses the authority of a state to control data, infrastructure, and digital policies, ensuring that these elements reflect national laws and interests" (Bennett & Raine, 2020). Digital autonomy is "the ability of a state to shape its digital landscape, allowing for self-determination in technological adoption and policy formulation" (Mann & Wadhwa, 2019). Digital dependence is "the extent to which actors in a particular country have to rely on foreign-controlled digital technologies to perform digital activities" (Mayer & Lu, 2022a). Thus, digital sovereignty asserts the country's control over digital activities within its borders, while digital autonomy vs. dependence represents its independence vs. dependence on external entities in deciding over such activities. Stronger digital dependence weakens both sovereignty and autonomy.

Digital dependence also undermines national performance. According to Steward (1981), "technology imported from industrialized countries is often inappropriate" for developing countries, and lack of local capacity makes it more challenging to "adapt imported technology to local conditions". Fabayo (1996) contents that reliance on technology imports undermines African countries' indigenous technological development and contributes to their "distorted development or underdevelopment". Relying on import arrangements like the digital Silk Road might, in turn, entrap them "problematic digital dependence" (Seoane, 2022). Even countries like South Korea may experience "profound technological dependence" limiting their "autonomous economic growth" (Smith, 1993).

The country's performance also depends on the policy-implementation capacity of its public administration system and its digital counterpart – digital government. According to Srivastava (2007), there is a significant association between digital government and "administrative process efficiency" which in turn reduce "social divide". A

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

significant positive correlation is also present between e-government readiness and GDP (Saghafi et al., 2011) and between digital government maturity and government quality (Durkiewicz et al, 2018). How investing in digital government can produce value for countries is part of the digital government value chain (Durkiewicz et al., 2021). However, the relationship between digital dependence and digital government is largely unexplored.

To fill this gap, we explore if the relationship between the Digital Dependence Index (DDI) (Mayer & Lu, 2022a) and Online Service and E-Participation Index (United Nations, 2020) fulfils theoretical assumptions, i.e. lower dependence, higher performance. To this end, we calculate the Spearman correlation coefficients and identify countries that violate these assumptions, combining high dependency with high performance or low dependency with low performance. High or low designations represent indicator values below the first quartile or above the third quartile. The data reveals negative correlations but with several exceptions.

The paper is structured as follows. Section 2 introduces digital dependence and its measurement followed by research method in Section 3. Section 4 describes the results, followed by the discussion in Section 5 and conclusions – findings, limitations, and directions for future research – in Section 6.

2. Concept

Digital Dependence (DD) and related terms have a modest coverage in literature. On Scopus, "digital dependence" OR "digital autonomy" OR "digital sovereignty" yielded 487 results on 11 February 2025. DD is addressed from varied positions: resilience to the power of foreign corporations (Gaie & Langlois-Berthelot, 2024), troubling patterns of social behavior (Gonzales, 2024), threats to privacy and data integrity (Ilves & Osula, 2020), and geopolitical tensions (Budnitsky, 2022). Hu (2024) suggests that DD grow as a "side-effect" of foreign countries' development programs while technological sovereignty forces "difficult trade-off between taking advantage of the benefits of digital technologies and surrendering control" (Ilves & Osula, 2020).

DD is introduced in Mayer & Lu (2022a) which features "Digital Dependence Index" (DDI) that measures "the share of foreign suppliers in the total demand for certain digital technologies for each country" (Mayer & Lu, 2022b). DDI consists of hardware, software, and intellectual property subindices, ranging between 0 for countries that do not "use or consume any foreign-controlled or imported digital technologies" and 1 for countries that do not "have any domestic sources of supply for the needed digital technologies". The calculation of the index for 23 countries – G20 plus Estonia, Israel, Singapore, and Kenya in 2019 uncovered no country where "domestic digital technology is in a dominant position", one country – the USA where "domestic supply delivers majority of digital tech", two countries – China and South Korea where "global markets supply majority of digital tech", and the rest where "Foreign digital technology is in a dominant position". The latter concerns not only developing countries but also countries associated with technological advancement, like Japan, Singapore, or Australia.

3. Methods

The analysis targeted the countries' combined Digital Dependency (DD) and Digital Government (DG) performance. Two questions were formulated: 1) How does the DDI dataset appear when completed with the DG performance data? 2) Which country cases are characteristic given their performance in both areas? In particular, we look at four categories of countries with: high dependence and high performance, high dependence and low performance, low dependence and high performance, and low dependence and low performance.

To answer the first question, we built the dataset for 23 countries from the 2019 DDI study (Mayer & Lu, 2022b) including DDI's trade, infrastructure, and intellectual property subindices. The dataset was complemented with the 2020 E-Government Survey (United Nations, 2020) and its two indicators, i.e. Online Service Index (OSI) and E-Participation Index (EPI). Due to the varied distributions of data among countries, their ranks rather than index values were used. While the country selection in DDI is not a statistically-relevant sample, the Spearman rank correlation matrix was elaborated to support the supposed negative correlation between the levels of DD and DG.

To answer the second question, the 1st and 3rd quartiles for each indicator were calculated, and the countries with performance above the 3rd quartile were marked with "+" while those below the 1st quartile were marked with "-". A country was considered interesting if it belonged to either categories for any DD and DG indicators. The results were then analyzed with respect to the cases that represent (1) high dependence and high performance, or (2) low dependence and low performance. These cases were identified as possibly worth further exploration.

4. Findings

The Spearman correlation matrix between the DD and DG indicators in the created dataset is presented in Table 1. According to this, there is a small to moderate negative correlation between DD and DG, confirming the assumption that the better DG performance, the lower DD, and the other way round. We did not provide p-values since this is

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

not meant to be a statistically representative dataset: the data refers to a specific point and range of measurement.

Tab 1. Spearman rank correlation coefficient values between the 2019 Digital Dependency Index and its Trade, Infrastructure and Patents subindices vs. the 2020 Online Service Index and e-Participation Indices

	DDI	TRADE	INFRASTRUCTURE	PATENTS
OSI	-0.32	-0.39	-0.14	-0.34
EPI	-0.34	-0.35	-0.21	-0.38

Table 2 contains the dataset for 23 countries in the DD study (Mayer & Lu, 2022b). Each country's performance is described in thirteen columns. The first six contain the DDI ranks (DDI-2019) and its three subindices – trade (TRADE-2019), infrastructure (INFRASTRUCTURE-2019) and patents (PATENTS-2019), and two columns representing Online Service Index (OSI-2020) and e-Participation Index (EPI-2020). The following six columns indicate whether the previous indices' values are above the 3rd ("+") or below the 1st quartile ("-") of all values in that index. The final column indicates whether, following the logic of this research, a case is "interesting".

According to Table 2, there are three cases (Germany, Israel, Kenya) where either of the dependence indicators is very low at the same time as one of the digital government indicators. Also, there are cases – USA and Korea, with low dependence and high performance, and the other way round – Indonesia and Saudi Arabia.

Tab 2. Rank data for G20, Estonia, Israel, Singapore, and Kenya for the 2019 DDI and its Trade, Infrastructure and Patents subindices vs. the 2020 OSI and EPI, with particularly low (-) or high (+) values.

Country	Index rankings						Best-worst analysis						Interesting?
	DDI-2019	TRADE-2019	INFRASTRUCTURE-2019	PATENTS-2019	OSI-2020	EPI-2020	DDI-2019	TRADE-2019	INFRASTRUCTURE-2019	PATENTS-2019	OSI-2020	EPI-2020	
Argentina	6	5	5	7	13	15		+					
Australia	3	4	2	3	6	8	+	+	+	+			
Brazil	1	1	2	1	10	11	+	+	+	+			
Canada	10	12	5	10	14	9							
China	22	23	22	22	8	8	-	-	-	-			
Estonia	17	19	15	14	2	2		-			+	+	
France	10	11	9	14	9	11							
Germany	13	15	12	19	20	19				-	-		yes
India	17	17	18	14	12	15							
Indonesia	4	3	9	3	22	19	+	+		+	-		
Israel	20	21	18	18	19	22	-	-				-	yes
Italy	8	10	5	7	15	17							
Japan	17	9	16	21	8	4				-		+	
Kenya	17	13	20	14	23	23			-		-	-	yes
Korea, Rep.	21	21	21	20	1	2	-	-	-	-	+	+	
Mexico	17	17	15	14	16	17							
Russian Federation	11	8	20	10	17	13			-				
Saudi Arabia	3	2	3	3	21	22	+	+	+	+	-	-	
Singapore	14	17	12	14	3	6					+		
South Africa	6	6	9	7	19	19							
Turkey	8	8	12	7	11	12							
United Kingdom	13	15	9	14	4	6					+		
United States	23	21	23	23	6	2	-	-	-	-		+	

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Fig. 1 visualizes how the data is scattered. Digital Dependence Index values are plotted against Digital Government performance (average of OSI and EPI). For readability, particular country points are labeled with respective ISO alpha-3 codes. Notice the distinct separateness of three countries, the United States, China, and Korea.

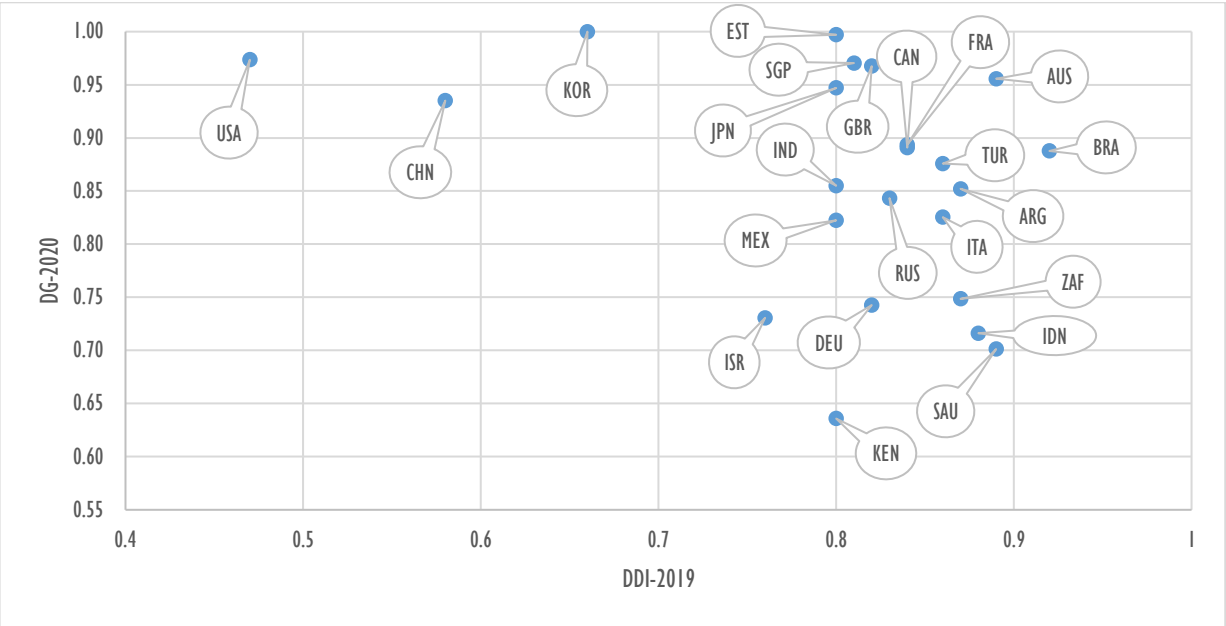


Fig. 1. DDI and DG performance data scatterplot with country labels.

5. Discussion

Today's global digital landscape is dominated by one or two countries, the second trying to catch up with the first (Mayer & Lu, 2022a). Most countries seem to surrender to this dichotomy despite the enormous impact of digital technologies on them. As noted, the most capable and committed countries "are keen to exploit their 'cyberpower'" employing "companies under their jurisdiction and control as their agents" (Ilves & Osula, 2020, p. 26).

This study pursued the ambition to start defining a new direction in DG studies: exploring the relationship between countries' DG and DD. To our knowledge, it is a pioneering effort of this kind. We brought conceptual recognition and theoretical soundness to this problem, revealed some discrepancies between DD and DG performance, and identified countries that need policy analysis. We learned that DD is a highly relevant and timely concept, beyond unequal distribution of economic power. However, conceptual clarification is first needed, starting with definitions of "sovereignty", "autonomy" and "dependence", and their digital counterparts, and how they affect governments and countries. Then, the concepts should be mapped to the elements of the national or international public policy.

6. Conclusions

This study was built upon the premise that "digital dependence" affects the countries' digital policies and their capacity to pursue national development. While terms like "digital sovereignty" or "digital autonomy" have already settled in the academic and policy discourse, "digital dependence" remains elusive. With this paper, we intend to address this gap and reveal some insights emerging from the official international data.

Since this study is based on (Mayer & Lu, 2022a), which itself is limited, our observations may not exactly reflect the global state of affairs, although we would be surprised if they are refuted by a more comprehensive study. We identified countries with problematic relationships between DD and DG but all need in-depth studies. Also, the theoretical constructs provided should lead to more sophisticated models, providing a nuanced analysis of DD.

We plan to further develop our insights into DD. A formal model is a work in progress. We also intend to enhance the DD concept aimed at spotting its causes, including the unprecedented power of global technology corporations.

References

Bennett, C. J., & Raine, M. (2020). "Digital Sovereignty: The New Frontier in International Relations." Global Policy.

Budnitsky, S. (2022). A Relational Approach to Digital Sovereignty: e-Estonia Between Russia and the West. *International Journal of Communication*, *16*, 1918–1939.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Durkiewicz, J., & Janowski, T. (2018). Is digitalization improving governance quality? Correlating analog and digital benchmarks. In *Proceedings of the 18th European Conference on Digital Government ECDG* (pp. 48-56).

Durkiewicz, J., & Janowski, T. (2021). Chain Action - How Do Countries Add Value Through Digital Government? 54th Hawaii International Conference on System Sciences (HICSS), 5-8 January 2021, Hawaii, USA. IEEE, http://hdl.handle.net/10125/70897

Fabayo, J. A. (1996). Technological dependence in Africa: its nature, causes, consequences and policy derivatives. *Technovation*, *16*(7), 357-370.

Gaie, C., & Langlois-Berthelot, J. (2024). Is the dependence of governments on digital giants a problem? *Polytechnique Insights. A Review by Institut Polytechnique de Paris*. https://www.polytechnique-insights.com/en/braincamps/digital/

Gonzales, A. (2024). What is 21st-Century Digital Autonomy? *International Journal of Communication*, *18*, 1326–1328. https://doi.org/1932–8036/2024FRM0002

Hu, H. (2024). Digitalization and Dependence: Evaluating the Impact of the Belt and Road Initiative on Achieving Sustainable Development Goals 8 and 9 and Shaping Digital Autonomy. *Journal of Economic Integration*. https://doi.org/10.11130/jei.2024024

Ilves, L., & Osula, A.-M. (2020). The Technological Sovereignty Dilemma - and How New Technology Can Offer a Way Out. *European Cybersecurity Journal*.

Mann, R., & Wadhwa, V. (2019). "Digital Autonomy: A New Paradigm for National Security." Journal of International Affairs.

Mayer, M., & Lu, Y.-C. (2022a). *Digital Autonomy? Measuring the Global Digital Dependence Structure*. https://ecfr.eu/publication/geo-tech-politics-why-technology-shapes-european-power/.

Mayer, M., & Lu, Y.-C. (2022b). *Digital Dependence Index: Methodology*. https://digitaldependence.eu/wp-content/uploads/2022/05/DDI_Methodology.pdf

Saghafi, F., Zarei, B., Abadi, A. K. D., & Shahkooh, K. A. (2013). An integrated strategic framework for e-government initiatives. In *Managing Information Resources and Technology: Emerging Applications and Theories* (pp. 67-79). IGI Global Scientific Publishing.

Seoane, M. F. V. (2022). Alibaba's discourse for the digital Silk Road: the electronic World Trade Platform and 'inclusive globalization'. In *China's Globalizing Internet* (pp. 67-82). Routledge.

Smith, D. A. (1993). Technology and the modern world-system: Some reflections. *Science, Technology, & Human Values*, *18*(2), 186-195.

Srivastava, S. C., & Teo, T. S. (2007). E-government payoffs: Evidence from cross-country data. *Journal of Global Information Management (JGIM)*, *15*(4), 20-40.

United Nations. (2020). UN E-Government Survey 2020. https://publicadministration.un.org/egovkb/en-us/Reports/UN-E-Government-Survey-2020

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Digital Governance and Institutional Challenges in Rural Heritage Restoration: The Case of Caqui Hacienda in Chancay Valley, Peru

Oscar Miranda-Hospinal [a], *David Valle-Cruz* [b], *Carlos* Cuadra [c]

[a] Faculty of Civil Engineering, National University of Engineering, Lima, Perú, omiranda@uni.edu.pe .

[b] Unidad Académica Profesional Tianguistenco, Universidad Autónoma del Estado de México, davacr@uaemex.mx.

[c] Faculty of System Science and Technology, Akita Prefectural University, Yurihonjo, Japan, carlos@akita-pu.ac.jp.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract: This study aims to analyze the challenges faced by local governments in the preservation and restoration of rural historical buildings in Peru, using the Caqui Hacienda in the Chancay Valley as a representative case. It is proposed that the rigidity of Peruvian regulations on cultural heritage, combined with the limited technical and budgetary capacity of local administrations, represents a significant obstacle to the recovery of these properties. Additionally, other barriers are identified, such as the weak implementation of digital governance, lack of institutional coordination, and limited availability of accessible digital platforms for citizens. Through an exploratory qualitative approach that combines historical analysis, regulatory review, field observation, and surveys of public works professionals, the study seeks to evaluate how the adoption of technological tools and the modernization of public policies could contribute to a more efficient, transparent, and sustainable management of cultural heritage. The expected results aim to provide evidence on the need for regulatory reforms and institutional strengthening and to propose the use of emerging technologies, such as artificial intelligence, in the monitoring and restoration processes of historical heritage in rural contexts.

Keywords: Digital governance, cultural heritage, historical buildings, transparency, restoration, public sector.
Poster, DOI: https://doi.org/10.59490/dgo.2025.938

1. Introduction

The preservation of rural historical buildings is closely linked to the effectiveness of digital governance in the management of cultural heritage. The implementation of digital tools can enhance transparency and efficiency in decision-making, particularly in public projects involving heritage conservation. However, in rural areas such as the Chancay Valley, the low level of digitalization in local government processes may hinder initiatives aimed at restoration and protection. Studies on e-government adoption indicate that insufficient digital infrastructure, budget constraints, and limited institutional capacity negatively affect the ability of public administration to effectively manage historical sites (Buyannemekh, Gil-Garcia, & Gascó-Hernández, 2023).

In this context, the role of artificial intelligence (AI) and digital monitoring systems could be explored as potential enablers to enhance heritage conservation efforts. AI-driven platforms have been successfully integrated into public works management, improving project oversight and reducing inefficiencies (Miranda-Hospinal et al., 2023). By leveraging AI and digital platforms, local governments in Peru could establish data-driven strategies to monitor and prioritize the restoration of historical sites. Nevertheless, achieving such advancements requires not only technological investment but also policy alignment and capacity-building programs to ensure effective governance in heritage preservation (Goos & Savona, 2024).

In the Chancay River Valley in Peru, there are several rural historical buildings that are abandoned and, as a result,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

undergoing deterioration. The Caqui country house or hacienda, located in the district of Aucallama, was selected as a representative example to analyze the reasons behind the lack of building's maintenance and to propose a research project to recover this historical structure. The property legal status is a critical issue that prevents intervention to recover and protect this cultural heritage. However, it is also considered that the level of digital governance implemented in the local administration could be a contributing factor to this situation.

The current state of the old historical constructions in the lower Chancay Valley is critical due to the lack of maintenance and attention they have received, as they represent the former model of production under the control of a landowner—a model in which, today, production is managed in some cases through a cooperative system and in others by individual farmers. In this territory, it is possible to find unique human settlements with emblematic cultural traditions and historical buildings that are undergoing deterioration and face latent extinction. Near the town of Caqui, the old landowner's country house, which still stands, is distinguished not only by its architecture but also by the artistic expression that can still be seen in the wall paintings and inside a small chapel.

The historical structure restoration of Caqui requires a detailed study of its original architecture, as well as the recovery of the paintings. As a reference, there is a replica of this building in Japan. It was built in a theme park called Little World, which features representative constructions from different parts of the world. The old Caqui farmhouse was selected as a typical Peruvian building, and the replica has dimensions similar to those of the original located in Caqui. The paintings were also reproduced; however, some of them are not exactly the same as those found in Caqui. Additionally, some of the furniture displayed in the theme park corresponds to the original furniture from the old Caqui farmhouse. Therefore, this replica is considered a potential model for reconstructing the original building.

The national government of Peru has given due importance to the implementation of digital government through a plan called the Digital Policy for Digital Transformation. Peru's e-government development index improved, reaching position 59 out of 193 evaluated economies. However, it is considered that differences still exist within the country, especially in small districts or localities where the level of digital government implementation remains low. Therefore, improving this implementation will primarily benefit citizens and will also support the management of other areas, such as the conservation of historical buildings.

2. The old Caqui Farmhouse

2.1 Construction Characteristics

The farmhouse analyzed in this study is in the village of Caqui, in the district of Aucallama, province of Lima, Peru. Figure 1 shows the location of Caqui on a Google map. The Caqui hacienda is situated on the left bank of the lower Chancay River valley, at an approximate altitude of 246 meters above sea level. It is built on a rocky outcrop that emerges from the geological formation known as La Bóveda Hill. The hacienda was managed by the Mujica family at the time of the Agrarian Reform implemented in 1968, which brought an end to the hacienda system and gave way to the cooperative system and, in some cases, the subdivision and distribution of land.

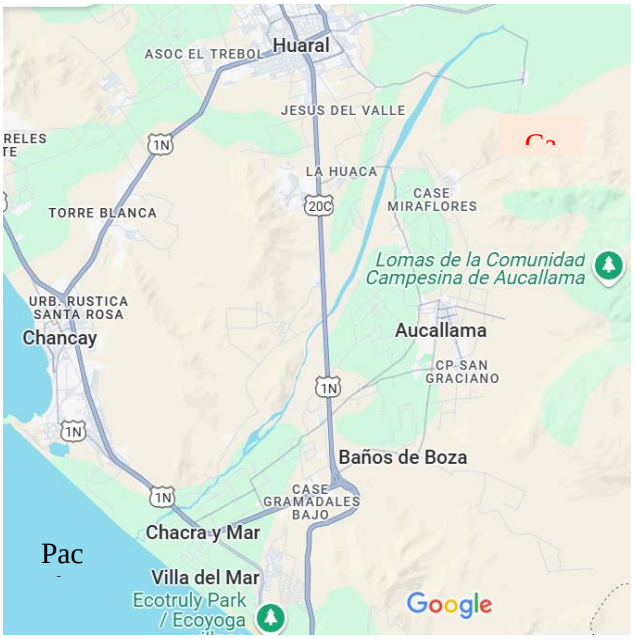


Fig. 1 – Location of Caqui (Google Map)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The architectural typology of the Caqui hacienda building corresponds mainly to a domestic residence (kitchen, dining room, bathrooms, etc.), in which the spaces are arranged around a central courtyard that provides light and ventilation and allows for the independence of each area. The house, being intended to accommodate the landowner and his family during their visits, includes spaces that facilitate the management of the hacienda, such as offices and reception rooms. Accordingly, it features a vestibule, a main courtyard, an entrance atrium, and a chapel—spaces that possess special infrastructure and in which particular attention was given to design and decoration. Figure 2 shows the floor plan of the Caqui hacienda.

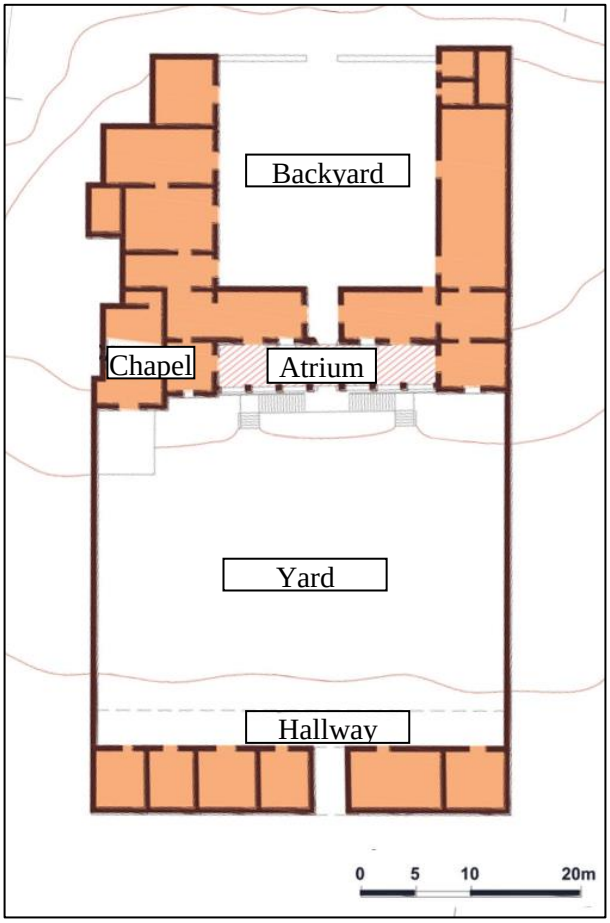


Fig. 2 – Plan view of the Caqui hacienda.

2.2 Comparison with the replica

A full-scale replica of the Caqui farmhouse can be found at the Little World theme park in Aichi Prefecture, Japan, as part of the World Buildings exhibition. This replica is considered a potential model for the reconstruction and restoration of the original Caqui farmhouse. Figures 3 to 6 below show a comparison of photographic details between the two buildings.





Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Fig. 3 – General view from hallway entrance (left replica, right Caqui farmhouse)



Fig. 4 – Detail of the exterior of Chapel (left replica, right Caqui farmhouse)



Fig. 5 – Detail inside the Chapel (left replica, right Caqui farmhouse)



Fig. 6 – Detail of the backyard (left replica, right Caqui farmhouse)

When comparing the replica with the current structure of the Caqui farmhouse, it can be observed the severe deterioration of both the building itself and the artwork on the walls, especially inside the chapel. It is therefore clear that the well-preserved replica can be used as a model to propose the repair and/or restoration of this historical structure.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

3. The role of the local government

The building analyzed in this study is managed by the local municipal government of the Aucallama district. Figure 7 shows the municipal building. The district of Aucallama has an area of 717 km^2 and a population of 19,464 inhabitants (2017).



Fig. 7 – Municipal building of Aucallama district.

According to the government's website, digital governance has been implemented and users can access care and services online. In addition, information is available to ensure or verify governmental transparency. However, information about cultural heritage or historical buildings is more difficult to obtain. This information should be available not only to researchers or individuals interested in such buildings, but it could also help promote tourism in the area by showcasing not only recreational facilities but also the cultural aspects of the district. On the other hand, the development of proposals for the reconstruction or restoration of historical buildings can be carried out in collaboration with institutions such as universities, which engage in activities that include social outreach

4. Final comments and Future directions

This poster outlines insights into the role of digital government and AI governance in addressing institutional challenges within heritage restoration projects, specifically in rural contexts like the Caqui Hacienda case in Peru.

Firstly, it highlights the potential gap between national-level digital transformation initiatives and their practical implementation at the local government level. Although Peru's national digital transformation policies have significantly advanced, achieving noticeable global recognition, local disparities persist, particularly in rural areas. This disconnect exposes that digital government efforts should go beyond mere policy formulation, actively engaging in the capacitation and technological empowerment of local governments to warrant coherent and inclusive digital progress. Secondly, the research emphasizes that robust digital governance frameworks and AI-driven platforms can profoundly enhance heritage management processes. By integrating AI tools into public administration, local governments could foster decision-making transparency, enhance monitoring efficiency, and strengthen public participation and accountability in heritage preservation efforts. Moreover, this poster highlights the importance of regulatory flexibility and institutional collaboration as critical enabling factors for digital and AI governance in the heritage sector.

Future research should further explore the specific mechanisms through which digital governance and AI can be more effectively implemented at the grassroots level, suggesting models that can be replicated and adapted to various rural and resource-constrained settings globally. For this reason, future work will explore this phenomenon through empirical analysis, beginning with a survey (See Appendix A).

5. Acknowledgements

Use of AI*: During the preparation of this work, the authors used ChatGPT to assist in the design of a survey to iterate and refine the questions (See Appendix A). After using this tool, the authors reviewed, edited, adapted the content as their own, and validated the outcome as needed, and take full responsibility for the content of the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

publication.

6. References

Alvino, J., & Guzman, M. (2016). Archeology, architecture and art in Caqui, province of Huaral, Lima. *Devenir*, 3(6), 143–162. Universidad Nacional de Ingeniería. https://doi.org/10.15381/dev.v3i6.11676

Buyannemekh, B., Gil-Garcia, J. R., & Gascó-Hernández, M. (2023). Exploring emergent collaborations for digital transformation in local governments: The engagement of public libraries in the development of smart cities. *Public Policy and Administration*, 09520767231197600.

Goos, M., & Savona, M. (2024). The governance of artificial intelligence: Harnessing opportunities and mitigating challenges. *Research Policy*, *53*(3), 104928.

Miranda, O., Valle-Cruz, D., & Yrivarren-Lazo, J. (2023). Perceptions of civil engineers on the development and adoption of AI in the Peruvian public sector. In *Handbook of Research on Applied Artificial Intelligence and Robotics for Government Processes* (pp. 173–193). IGI Global. https://doi.org/10.4018/978-1-6684-5624-8.ch009

Presidencia del Consejo de Ministros, Secretaría de Gobierno y Transformación Digital, Perú. (2023). *Política Nacional de Transformación Digital*. https://www.gob.pe/ciudadaniadigital

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Appendix A

1. Perception of the current situation and the role of digital government

- **To what extent do you agree that digital government could improve the management and conservation of historical heritage?**
  (Scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree)
- **Do you believe that the use of digital technologies can help prevent the deterioration of historical heritage?**
  (Options: Yes / No / Not sure)

---

2. Institutional capacities and training

- **Do you consider it necessary for the Ministry of Culture to provide training to local governments on the use of digital technologies for managing and restoring historical heritage?**
  (Scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree)
- **What level of knowledge do you have regarding artificial intelligence (AI) and digital tools applied to heritage conservation?**
  (Options: Basic / Intermediate / Advanced / I have no knowledge)

---

3. Technical and operational barriers

- **What do you consider to be the main barriers to implementing technologies such as AI in the management and restoration of historical heritage? (Select all that apply)**
  - Lack of funding
  - Lack of training
  - Lack of digital infrastructure
  - Lack of clear regulations
  - Other: _____

---

4. Regulations and the deteriorated state of heritage

- **Do you consider that the current regulations in Peru for intervening in heritage properties are too rigid in relation to the technical, economic, and operational capacity of local governments?**
  (Scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree)
- **Do you believe that the lack of modernization in heritage regulations has contributed to the abandonment, deterioration, or inability to restore numerous heritage buildings in the country?**
  (Scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree)
- **Considering international experiences like that of Japan—where preserving the façade and updating the interior is allowed—do you believe it is necessary to rethink and modernize Peru's heritage regulations to enable more sustainable and contextual restoration practices?**
  (Scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree)
- **What aspects of the current regulations do you think should be modernized to allow for more efficient, sustainable, and feasible restoration of historical heritage? (Select at least 3 options)**

  - Excessive or costly technical requirements
  - Extensive bureaucratic procedures
  - Inefficient authorization processes
  - Lack of differentiated criteria based on the value or type of property
  - Lack of integration with digital government and urban planning regulations
  - Little consideration of the local economic context
  - Other: _____

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5. Transparency and access to heritage information

- **Do you believe that the process by which a site is declared historical heritage is accessible and transparent?**
  (Options: Yes / No / Not sure)
- **Do you think citizens and local authorities should have open access to the protocols, criteria, and resolutions used to declare a site as historical heritage?**
  (Scale from 1 to 7, where 1 is strongly disagree and 7 is strongly agree)

---

6. Expectations and opportunities of digital government

- **What benefits do you expect from the adoption of digital government in the management of historical heritage? (Select at least 3 options)**

  - Mayor transparencia en la asignación de fondos
  - Greater transparency in the allocation of funds
  - Reduction of bureaucracy in permit processes
  - Better access to heritage information
  - Improved planning and monitoring of restoration projects
  - More informed citizen participation

- **How likely do you think it is that AI will be implemented in heritage management in the next five years?**
  (Escala de 1 a 7, donde 1 es totalmente en desacuerdo y 7 totalmente de acuerdo)

---

7. Key stakeholders and citizen participation

- **Who should lead the implementation of digital government in the protection of historical heritage? (Select at least 3 options)**

  - Ministerio de Cultura
  - Ministry of Culture
  - Local governments
  - Academic institutions
  - Technology companies
  - International organizations

- **Do you believe citizens should have access to digital platforms to check the status of heritage properties and report their deterioration?**
  (Options: Yes, absolutely / Yes, with restrictions / No / Not sure)

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Enhancing user experience: An accessibility and usability study of an open government data portal.

Dwi Puspita Sari [a*], *Dimaz Cahya Ardhi* [b], *Derick Chungcheh Ma* [c], *Catherine Dumas* [d]

[a] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, USA, dsari@albany.edu, 0009-0002-7451-439X

[b] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, USA, dardhi@albany.edu, 0009-0006-9306-0820

[c] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, USA, cma3@albany.edu, 0000-0002-2888-5109

[d] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, USA, cdumas@albany.edu, 0000-0002-7859-0763

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Government organizations initiate digital transformation by using online platforms to facilitate the dissemination of open government data (OGD) to the public. Despite the government's effort to increase citizens' willingness to participate in the OGD initiative, there is a possibility that citizens may encounter challenges accessing the OGD through open government data portals (OGDP). This study aims to assess the effectiveness of user interface (UI) and user experience (UX) design in Satu Data Indonesia (SDI), the Indonesian national OGDP. The research question guiding this study is "How does user experience influence willingness to use OGDP?" We follow a quantitative approach to gain an understanding of the OGDP usability and users' willingness to engage with the OGD. First, an experiment will examine participants' access to SDI portal. Second, a survey will investigate whether the participants are willing to use OGD based on their experience engaging with OGDP. This study will enhance our understanding of OGDP usability within the context of developing countries and evaluate whether user experience influences future usage willingness. Ultimately, the findings will benefit governmental entities in improving their OGDPs' usability and user experience.

Keywords. open government data, open government data portal, OGDP, UI/UX design, accessibility, usability.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1015

1. Introduction

Open government data (OGD) comprises two components: open data, which is characterized as data freely available for use, repurposing, and dissemination (Open Knowledge Foundation, 2012), and government data, which is defined as data generated by government organizations (Ubaldi, 2013). By providing access to government data, the government promotes and enacts a participatory and collaborative policy process (Soegiono, 2018). The OGD movement aims at increasing the availability and accessibility of government data, encouraging government organizations to publicly disseminate their data on open government data portals (OGDP). This movement was initiated in the United States in 2009, with the issuing of the Open Government Directive, mandating federal agencies to open government data for openness, participation, and collaboration (The White House, 2009). Later, it became a global trend among governmental entities. Using OGDPs illustrates the actualization of both open government initiatives and digitization for disseminating government data and information with technology (Sari et al., 2024).

Previous studies have discussed OGDP in different regions, including Asia (Saxena, 2019; Shao et al., 2021; Wang et al., 2023; Warraich & Rasool, 2023), Europe (de Juana-Espinosa & Luján-Mora, 2019; Kapoor et al., 2015), America (Begany et al., 2021; Oliveira et al., 2016; Paige & Freund, 2019), and combinations among different

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

regions (Máchová et al., 2018; Molodtsov & Nikiforova, 2024; Mutambik et al., 2021; Nikiforova, & McBride, 2021; Sheoran et al., 2023). However, few studies examining OGDP from the user interface (UI) and user experience (UX) design perspective in emerging countries. This study, focusing on Indonesia, addresses this literature gap by using a quantitative approach to answer the following research question, "How does user experience influence willingness to use OGDP?"

This study deepens the understanding of OGDP usability and users' challenges of OGDP access. Moreover, it enriches current literature on OGD in developing countries. Finally, the findings can guide government organizations to improve OGDP usability and ultimately increase the willingness to use OGD. This study is structured as follows: the following section provides a literature review, the third section describes the methods, and the last section discusses the conclusion and future work.

2. Literature Review

2.1 Usability and the adoption of OGDPs

OGD initiative is characterized by free government data access and use. This initiative has attracted many scholars' interest in the adoption, challenges, and impact of using it. The existing literature has addressed OGDP adoption and its association with usability. For example, Shao and colleagues (2021) shows that the perceived utility and ease of use deterine user's intention to use an OGDP. It indicates a willingness to engage with OGDPs when its use is beneficial and user-friendly. Similarly, Kapoor and colleagues (2015) shows that the less complicated an OGDP is to use, the easier it is to adopt, which can be assessed by the time required for searching OGD datasets. In short, the willingness to engage with OGDPs is positively associated with its benefits and user-friendliness.

2.2 Usability features of OGDPs

Previous studies discuss various OGDP usability features. First, numerous studies emphasize dataset access, including searching and filtering capabilities on OGDPs for dataset discoverability (Máchová et al., 2018; Oliveira et al., 2016). Additionally, when users cannot locate the needed OGD, OGDP must offer adequate assistance to contact government employees; otherwise, it may hinder OGDP usage. The government can enhance the assistance features, such as incorporating online functions (Wang et al., 2023). Second, readability is crucial. Indeed, as indicated by Warraich and Rasool's (2023) assessment of the Pakistan OGDP, poor readability impedes users' ability to read and comprehend OGDP content.

Third, visualization and analytic tools on OGDPs are necessary (Máchová et al., 2018; Mutambik et al., 2021; Saxena, 2019). Lastly, active interactions and communications with users and stakeholders are crucial since government's capacity to facilitate interactivity on OGDPs affects the ease of use (Sheoran et al., 2023). Users would use OGDPs when the government provides sufficient channels for interactions and gives feedback (Shao et al., 2021). Indeed, Nikiforova and McBride (2021) discovered that the most deficient OGDP usability characteristic includes lacking capabilities for interactions between OGD users and providers. Interactions can be strengthened by providing feedback forms features, including forums, contact forms, ratings and comments, and dataset requests (Mutambik et al., 2021). Various variables can measure OGDP interactivity, such as pageviews, number of sessions, and the duration of user interaction with the portal (Begany et al., 2021).

2.3 UTAUT model and the research framework

This study evaluates the usability of SDI (https://data.go.id/), the Indonesian national OGDP, and the factors of user experience influencing behavioral intentions to use OGDPs. The previous study indicated that behavioral intention to utilize technology may influence the use of OGD (Sari & Gascó-Hernández, 2024). Since the OGDP is considered an assisting technological platform, we employed the Unified Theory of Acceptance and Use of Technology (UTAUT) model to inform our research. In addition to four key determinants of UTAUT (effort expectancy, performance expectancy, social influence, and facilitating conditions), this study also examines moderating factors: gender, age, and education, which are defined as demographic characteristics of the participants (See Figure 1).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

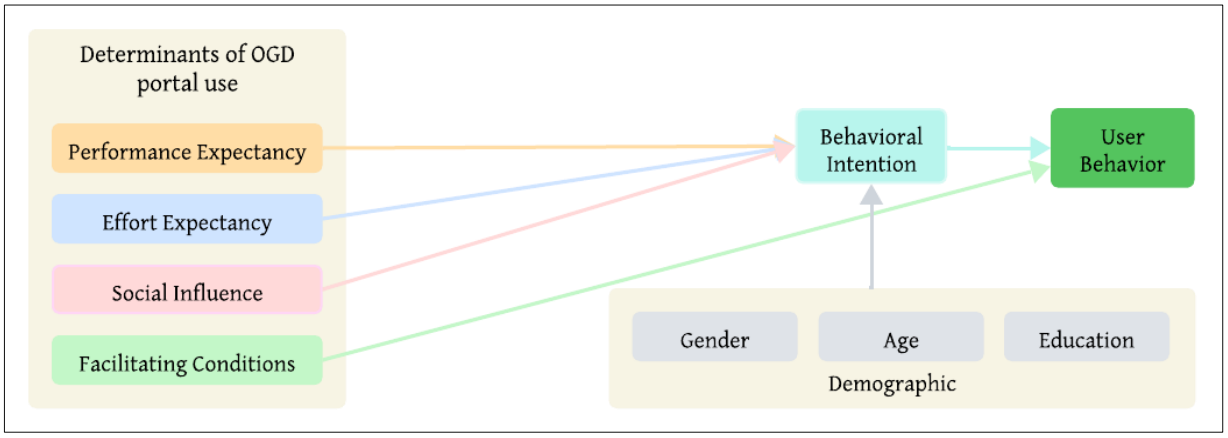


Fig. 1 – Research Framework extending the UTAUT model (Venkatesh et al., 2003)

3. Methods

3.1 Case study

The Indonesian government launched its OGD initiative in recent years. In June 2019, the President of Indonesia issued Presidential Regulation Number 39 of 2019 on Satu Data Indonesia, which requires all levels (national, provincial, and local) of Indonesian government organizations to release current, accurate, and accountable data through SDI. Since the launch of SDI portal in December 2022 (Iman, 2022), the new policy has trickled down to regional governments. Following the implementation of OGD initiatives at the national level, government organizations at various levels followed suit and launched their regional OGDPs (Sari, 2020).

3.2 Research Design

We employ two methodologies to address our research question (See Figure 2). First, a usability experiment requires the participants to follow the provided instructions and access SDI portal. Participants will play the researchers seeking OGD datasets across three provinces in Indonesia to support their research. One type of OGD users are students (Crusoe et al., 2019; Davies, 2010; Lassinantti et al., 2019; Talukder et al., 2019; Zainal et al., 2019). This study will recruit participants from graduate schools, as graduate students are more likely to possess the data literacy necessary for effective OGD use, aligning with the target population of this study. Participants will access the OGD datasets on SDI portal and answer questions in a session lasting for one hour.

After the experiment, a survey questionnaire will measure participants' willingness to use OGD based on their experiences with the portal. The survey consists of five sections, with 25 questions assessing participants' attitude to the statements with a 4-point Likert scale (strongly agree to strongly disagree). The performance expectancy inquiries assess whether utilizing OGDP assist with finding needed datasets. The effort expectancy questions evaluate the ease of use of SDI portal. The social influence section investigates whether social networks promote participants' use of OGDP. Finally, the facilitating conditions section investigates whether participants need the knowledge and guidance for utilizing SDI portal.

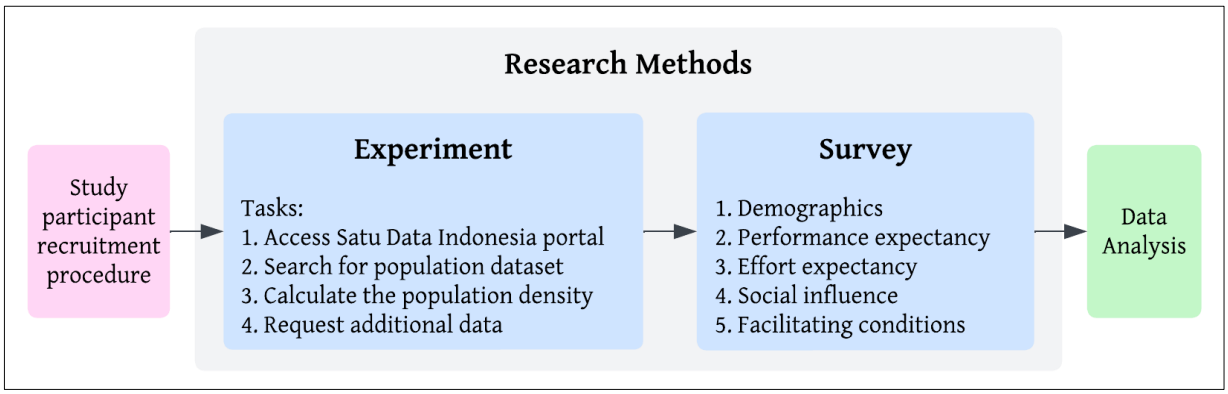


Fig. 2 – Procedure

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

4. Conclusion and future work

Limited OGD research analysed the situations in emerging countries when studying OGDP usability and the effect of user experience on the willingness to use OGDPs. This study addresses this gap by starting to focus on emerging countries with a case study on SDI portal. The OGDP usage experiment and the user experience survey in the subsequent phase seek to determine whether the experienced accessibility and usability influence future willingness to use OGDPs. Ultimately, the findings will provide empirical insights informing OGDP designing guidelines, enhancing OGDP UI/UX, thereby improving user experience and engagement, which boost the willingness of OGD use.

Acknowledgement

- **Contributor Statement***: Author 1: Conceptualization, methodology, visualization, writing - original draft, Author 2: Methodology and writing – review and editing, Author 3: Methodology and writing – review and editing, and Author 4: Supervision and writing – review and editing.
- **Use of AI***: During the preparation of this work, the authors used Grammarly in order to check the writing grammar. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Begany, G. M., Martin, E. G., & Yuan, X. (2021). Open government data portals: Predictors of site engagement among early users of health data NY. *Government Information Quarterly*, *38*, 101614. https://doi.org/10.1016/j.giq.2021.101614

Crusoe, J., Simonofski, A., Clarinval, A., & Gebka, E. (2019). The impact of impediments on open government data use: Insights from users. *2019 13th International Conference on Research Challenges in Information Science (RCIS)*. https://doi.org/10.1109/rcis.2019.8877055

Davies, T. (2010). *Open data, democracy and public sector reform: A look at open government data use from data.gov.uk* (724819880) [MSc Dissertation, University of Oxford].

de Juana-Espinosa, S., & Luján-Mora, S. (2019). Open government data portals in the European union: Considerations, development, and expectations. *Technological Foecasting and Social Change*, *149*, 119767. https://doi.org/10.1016/j.techfore.2019.119769

Iman. (2022, December 23). *Bappenas Luncurkan Portal "Satu Data Indonesia."* Lembaga Penyiaran Publik Radio Republik Indonesia. https://www.rri.co.id/iptek/119530/pro3-bappenas-meluncurkan-portal-satu-data-indonesia

Kapoor, K., Weerakkody, V., & Sivarajah, U. (2015). Open data platforms and their usability: Proposing a framework for evaluating citizen intentions. In M. Janssen et al. (Eds.). *IFIP International Federation for Information Processing 2015* (pp. 261-271). https://doi.org/10.1007/978-3-319-25013-7_21

Lassinantti, J., Ståhlbröstm A., & Runardotter, M. (2019). Relevant social groups for open data use and engagement. *Government Information Quarterly*, *36*(1), 98-111. https://doi.org/10.1016/j.giq.2018.11.001

Máchová, R., Hub, M., & Lnenicka, M. (2018). Usability evaluation of open data portals: Evaluating data discoverability, accessibility, and reusability from a stakeholders' perspective. *Aslib Journal of Information Management*, *70*(3), 252-268. https://doi.org/10.1108/AJIM-02-2018-0026

Molodtsov, F., & Nikiforova, A. (2024). An integrated usability framework for evaluating open government data portals: Comparative analysis of EU and GCC countries. *dg.o '24: Proceedings of the 25th Annual International Conference on Digital Government Research*, 899-908. https://doi.org/10.1145/3657054.3657159

Mutambik, I., Almuqrin, A., Lee, J., Zhang, J. Z., Alomran, A., Omar, T., Floos, A., & Homadi, A. (2021). Usability of the G7 open government data portals and lessons learned. *Sustainability*, *13*, 13740. https://doi.org/10.3390/su132413740

Nikiforova, A., & McBride, K. (2021). Open government data portal usability: A user-centered usability analysis of 41 open government data portals. *Telematics and Informatics*, *58*, 101539. https://doi.org/10.1016/j.tele.2020.101539

Oliveira, M. S., de Oliveira, H. R., Oliveira, L. A., & Lóscio, B. F. (2016). Open government data portals analysis: The Brazilian case. *17th Annual International Conference on Digital Government Research*. http://dx.doi.org/10.1145/2912160.2912163

Open Knowledge Foundation. (2012). What is open data?. In: Open Data Handbook [online]. https://opendatahandbook.org/guide/en/what-is-open-data

Paige, B., & Freund, L. (2019). A case study of New England open data portals. *eJournal of eDemocracy & Open Government*, *11*(1), 59-80. https://doi.org/10.29379/jedem.v11i1.541

Sari, D. P. (2020). *Kajian Portal Open Data Pemerintah Dalam Negeri*. Dinas Komunikasi, Informatika dan Statistik Provinsi DKI Jakarta.

Sari, D.P. & Gascó-Hernández, M. (2024). The use of open data: Challenges and good practices from a user's

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

perspective. *Hawaii International Conference on System Sciences 2024 (HICSS-57).* https://hdl.handle.net/10125/106648

Sari, D. P., Ardhi, D., Santiago, M., & Jatmiko, B. (2024). Assessing open government data quality using machine learning: The case of Satu Data Indonesia. *Proceedings of Ongoing Research, Practitioners, Posters, Workshops, and Projects of the International Conference EGOV-CeDEM-EPart 2024*. https://ceur-ws.org/Vol-3737/paper56.pdf

Saxena, S. (2019). Evaluation of the national open government data (OGD) portal of Saudi Arabia. In Visvizi, A. & Lytras, M. D., *Politics and Technology in the Post-Truth Era* (pp.221-235). https://doi.org/10.1108/978-1-78756-983-620191015

Shao, T., Cui, X., Jiang, H., & Huang, X. (2021). Understanding users' response to open government data portal: An exploratory study. *WHICEB 2021 Proceedings*. https://aisel.aisnet.org/whiceb2021/12

Sheoran, S., Mohanasundaram, S., Kasilingam, R., & Vij, S. (2023). Usability and accessibility of open government data portals of countries worldwide: An application of TOPSIS and entropy weight method. *Internation Journal of Electronic Government Research*, *19*(1), 1-25. https://doi.org/10.4018/IJEGR.322307

Soegiono, A. N. (2018). Investigating digital (dis)engagement of open government: Case study of One Data Indonesia. *Jurnal Kebijakan dan Administrasi Publik*, *22*(1), 36-51. https://doi.org/10.22146/jkap.31848

Talukder, M. S., Shen, L., Talukder, M. F. H., & Bao, Y. (2019). Determinants of user acceptance and use of open government data (OGD): An empirical investigation in Bangladesh. *Technology in Society*, *56*, 147-156. https://doi.org/10.1016/j.techsoc.2018.09.013

The White House. (2009). About open government. *The White House President Barack Obama*. https://obamawhitehouse.archives.gov/open/about

Ubaldi. B. (2013). Open government data: Towards empirical analysis of open government data. *OECD Working Papers on Public Governance*, *22*, 1-60. https://doi.org/10.1787/5k46bj4f03s7-en

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *27* (3), 425-478. https://doi.org/10.2307/30036540

Wang, D., Richards, D., Bilgin, A. A., & Chen. C. (2023). Advancing open government data portals: A comparative usability evaluation study. *Library Hi Tech*, *41*(4), 1189-1213. https://doi.org/10.1108/LHT-10-2020-0250

Warraich, N. F., & Rasool, T. (2023). Assessing the readability of open data portals: A case study of Open Data Pakistan. *Malaysian Journal of Library and Information Science*, *28*(3), 81-93, https://doi.org/10.22452/mjlis.vol28no3.5

Zainal, N. Z., Hussin, H., Rahim, N. H. A., Nazri, M. N. M., & Suhaimi, M. A. (2019). Open government data use by Malaysian researchers: Some empirical evidence. *6th International Conference on Research and Innovation in Information Systems (ICRIIS)*. https://doi.org/10.1109/ICRIIS48246.2019.9073640

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Experiment Canvas: A data-driven framework for evidence-based innovation in the Judiciary

Welkey Costa do Carmo[a*] and *Iago* Capistrano Sá[b]

[a] LabLuz, Ceará State Court of Justice, Brazil. OrcID: 0009-0009-3151-5000. E-mail: welkey.carmo@tjce.jus.br.

[b] LabLuz, Ceará State Court of Justice, Brazil. OrcID: 0000-0002-3100-8828. E-mail: iago.capistrano@insightlab.ufc.br.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 25 July 2025

Abstract. This paper presents the Canvas of the Experiment, an innovative tool developed by the Innovation Laboratory of the Court of Justice of the State of Ceará (LabLuz) to structure, implement, and evaluate innovation within the Brazilian judiciary. By employing a data-driven approach, the Canvas aims to enhance efficiency, accessibility, and inclusion in judicial processes. The study describes the methodology, structure, and impact of the Canvas through various case studies, demonstrating its effectiveness in generating measurable results and promoting evidence-based decision-making. The results reveal the potential of the Canvas to transform innovative ideas into practical solutions, offering a valuable model for other public institutions.

Keywords. Data-driven Innovation, Evidence-based policy, Impact measurement, Legal Innovation Framework, Experiment Canvas.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1070

1. Introduction

The Brazilian judiciary faces persistent challenges in improving efficiency, ensuring accessibility, and fostering social inclusion. Traditional approaches often struggle to integrate data into decision-making, leading to inefficiencies and limited impact (Lunardi & Clementino, 2021). To address this vulnerability in public sector innovation, the Innovation Laboratory of the Judiciary of Ceará (LabLuz) developed the Canvas of the Experiment to tackle these issues. This tool provides a framework for designing, implementing, and evaluating innovative practices within the judicial system. It facilitates the creation of evidence-based solutions, ensuring that new initiatives are rigorously tested and validated before broader implementation. This article explores the Canvas's structure, methodological foundations, and the impact of its application.

2. The Experiment Canvas methodology and structure

The Brazilian judicial system requires a shift toward evidence-based approaches to overcome obstacles such as high rates of criminal recidivism, complex legal language, and operational inefficiencies. These challenges are further exacerbated by the low educational level of those interacting with the judicial system. The Canvas of the Experiment was designed to help overcome these barriers. It serves as a practical guide for innovation professionals to formulate clear objectives, develop actionable plans, and systematically test innovative solutions. By integrating data collection and analysis into the innovation process, the Canvas enables effective measurement and validation of new practices before their large-scale implementation.

All LabLuz initiatives are conducted experimentally, with well-defined planning and outcome indicators. Only after data collection and verification of the initiative's success is the knowledge generated in the laboratory transferred to operational teams, and the practice is scaled as an institutional project.

Thus, completing the Canvas is the initial and essential step in structuring the development of an experiment, ensuring that all participants understand their roles and project objectives.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license



Figure 1 – Experiment Canvas

The Canvas integrates principles of action research, Design Thinking, and strategic management to offer a pragmatic, data-oriented approach to innovation. Its methodology is rooted in the works of Kurt Lewin and William Foote Whyte, emphasizing the iterative and collaborative nature of the innovation process (Elden, 1992).

The framework is structured around the following key components:

1) **Strategic alignment**: ensures that innovative projects align with the judiciary's overall strategic objectives. This includes alignment with the judiciary's strategic map and international frameworks such as the UN's 2030 Agenda and the Sustainable Development Goals (SDGs).

2) **Objectives**: clearly defines tactical and operational goals, establishing measurable targets for the project. This step ensures that all parties share a unified vision of the project.

3) **Data-driven approach**: emphasizes the use of data to track innovation progress and evaluate its effectiveness. This includes identifying necessary data, defining collection methods, and assigning responsibilities for data collection.

4) **Hypothesis testing**: formulates a central hypothesis about the expected impact of the experiment, which is then rigorously tested using selected data.

5) **Iterative process**: Designed to be used iteratively, allowing continuous adjustments, refinements, and improvements.

The Canvas helps structure experiments by guiding teams through essential steps, including defining strategic alignment to ensure the experiment contributes to broader institutional objectives. Its use also promotes contextualization within larger frameworks such as the UN's 2030 Agenda. Additionally, the Canvas assists teams in defining data collection methods and specifying responsibilities.

Formulating a testable hypothesis, which the experiment seeks to validate or refute, is a guiding step throughout the innovation cycle. The Canvas aids in establishing methods for tracking progress and analyzing results to enable informed decision-making. Ultimately, it ensures the use of structured data collection methods and assignment of responsibilities, guaranteeing that data is collected reliably and ethically. This process fosters a culture of experimentation and evidence-based decision-making.

3. Case studies and impact

The effectiveness of the Canvas of the Experiment is demonstrated through several case studies conducted by LabLuz, such as reducing penal regressions.

A fundamental study focused on simplifying legal language used in communications with prisoners transitioning to a more lenient regime. Carmo & Sá (2024) show that using clear and accessible language alongside visual resources led to a **31.54% reduction in penal regressions due to negligence**, demonstrating how language

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

simplification directly impacts compliance and reintegration. The Canvas proves its value when, at the end of an experiment, the team can measure the prototype's impact in reality and compare it with the initial projection.

Another successful application of the Canvas was in Family Courts, where the use of plain language in summonses led to an increase in attendance at conciliation hearings. This initiative highlighted the importance of clear communication in increasing public engagement with the judiciary. Once again, at the end of the efforts, the impact was traceable.

Additionally, a chatbot is being used to provide information and support to victims of domestic violence, improving decision-making security regarding protective measures and reducing the demand for court officers (Vieira, 2020). Data already support the hypothesis of this experiment, highlighting the Canvas's versatility across various contexts.

LabLuz is also testing simplified communication strategies to facilitate understanding and compliance with protective orders by aggressors, aiming to reduce violations of urgent protective measures.

Another ongoing experiment seeks to test whether a language-based approach improves the effectiveness of search and seizure warrants in the jurisdiction of Boa Viagem, Ceará.

These cases illustrate how the Canvas facilitates the transition from innovative ideas to measurable and impactful results. The emphasis on data collection ensures that decisions are based on evidence rather than assumptions.

4. Conclusion

The Canvas of the Experiment represents a significant advancement in how the Brazilian judiciary approaches innovation. By providing a framework for developing, implementing, and evaluating new practices, it promotes a culture of evidence-based decision-making and continuous improvement. The Canvas facilitates the translation of innovative ideas into tangible results, leading to increased efficiency, accessibility, and inclusion within the judicial system. It offers a valuable model for public institutions seeking to adopt data-driven approaches to enhance their services and promote social impact.

The application of the Canvas of the Experiment has generated several significant findings:

1) Simplified legal language significantly improves comprehension among individuals interacting with the legal system, particularly those with lower educational levels (Mayer, 2021).

2) Visual resources enhance clarity and information retention, complementing simplified language and aiding in overcoming information absorption barriers.

3) A data-driven approach enables evidence-based decision-making, leading to more effective improvements in judicial policies and processes (Monte, 2023).

4) Structured experimentation provides a replicable methodology for other institutions, promoting systematic innovation in the public sector.

5) The use of the Canvas ensures that each solution is validated before wider application, promoting efficiency, accountability, and measurable impact.

These findings highlight the importance of integrating data and user-centered design into the public sector innovation process.

Ultimately, the Experiment Canvas serves as a replicable model for governments seeking to develop innovation strategies that are not just exploratory but empirically validated, results-driven, and deeply aligned with societal needs. By embedding data and evidence at the core of policy experimentation, public institutions can enhance trust, legitimacy, and effectiveness, paving the way for a more transparent, accountable, and responsive governance ecosystem.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5. References

Carmo, W. C., & Sá, I. J. C. (2024). The impact of plain language and visual law techniques on regression rates in the criminal execution system: An experiment by LabLuz - Judiciary Innovation Laboratory of the State of Ceará. ENAJUS 2024, 1-16.

Elden, M. (1992). Review of Social Theory for Action: How Individuals and Organizations Learn to Change, by W. F. Whyte. Administrative Science Quarterly, 37(1), 152–155.

Lunardi, F. C., & Clementino, M. B. M. (2021). Judicial innovation: Fundamentals and practices for high-impact jurisdiction. National School of Training and Improvement of Magistrates (Enfam).

Mayer, G. (2021). Diversity and innovation in the Judiciary. Revista da Enfam, 6(1), 45-62.

Monte, J. P. P. (2023). Technology and innovation in the Judiciary: Concepts, differences, and impacts on judicial activity. CCSA/UFRN Research Seminar.

Vieira, T. G. (2020). Open innovation and digital justice: Disruptive transformation in the Brazilian Judiciary [Doctoral dissertation, Universidade Nove de Julho].

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Landscaping digital transformation in academic education programmes within Europe.

Grażyna Musiatowicz-Podbiał [a*], *Lucy* Temple [b], *Fernando* Kleiman [c], *Lucía* Bosoer [d]

[a] Department of Informatics in Management, Faculty of Management and Economics, Gdańsk University of Technology, Gdańsk, Poland, grazyna.podbial@pg.edu.pl, ORCID 0000-0002-9343-1883

[b] Department for e-Governance and Administration, Faculty of Business and Globalization, University for Continuing Education Krems, Austria, lucy.temple@donau-uni.ac.at, ORCID 0000-0003-4131-7648

[c] Department Engineering Systems and Services, Faculty of Technology, Policy and Management, Delft University of Technology, The Netherlands, f.kleiman@tudelft.nl, ORCID 0000-0003-3336-3484

[d] Chair AI and Democracy, Florence School of Transnational Governance, European University Institute, Italy, lucia.bosoer@eui.eu, ORCID 0009-0004-0967-7445

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. This paper aims to recognize content and trends with topics related to Digital Transformation (DT) in educational offers in Higher Education Institutions (HEI), in four EU countries: Austria, Italy, the Netherlands, and Poland. Research is based on benchmarking, recognizing keywords in courses and programmes offered by European universities. The main findings indicate that DT is an essential element of EU education curricula.. The second observation shows DT education as frequently located at the intersection between technology and society. The third finding demonstrates the growing inclusion of DT topics in non-technical disciplines. This research also has practical implications, as its findings on educational portfolios can be applied globally.

Keywords. digital transformation, HEI education, EU courses, digital skills development, digital competencies.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1054

1. Introduction

This template was set-up as a word document. The document is based on A4 size and contains a left and right margin of 24 mm, the top margin is 23.3 mm while the bottom margin is 19 mm.

Digital Transformation (DT) can be defined as a multidimensional transformation that results in new developments and redefines practices and relationships between various stakeholders, in the way they offer services and products (Zaoui and Souissi, 2020). In recent decades, the pressure on businesses and governments has increased, leading them to adopt these new ways of working (Kraus et al., 2021, Tangi et al., 2020) and therefore requires essential capacity building. It has been recognized that in Europe, more than 90% of professional roles require a basic level of digital knowledge. On the other hand, it was noticed that around 42% of Europeans still lack basic digital skills, including 37% of those in the workforce (EU 2022a). According to Cedefop (2022) 45% of adult workers acknowledge that they need new knowledge and skills to work with digital technologies. Developing digital skills becomes a top priority, ensuring that people are well-versed in digital skills, which in turn not only boosts the competitiveness of businesses but also empowers individuals to play an active role in shaping the digital future. The future demand for skills will drive increased digitalization, leading to task re-engineering with a strong focus on upskilling and reskilling, particularly in digital competencies. Bearing this in mind, the main research question is as follows: **RQ: What are the essential content elements of educational initiatives driving digital transformation capacity building by HEIs in Europe?**

This paper reveals the findings from state-of-the-art research on educational programmes related to DT available

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

at HEIs, in four EU Member States: Austria, Italy, the Netherlands and Poland, focused on common trends in the educational agenda for higher education.

2. Methodology

Benchmarking in European HEI's helps to determine learning and promotion strategies, improving the teaching process and curriculum development, to have a positive impact at the educational institution level (Nugroho and Jaqin, 2021). The educational processes are knowledge-oriented and knowledge-intensive (Godfrey and Godfrey, 1999) and therefore justify using a four step benchmark method as described by Spendolini (1992).

The first step of this process was an analysis of the courses and training programmes in four European countries on the topic of DT capacity building. The study focuses on four European countries: Austria, The Netherlands, Italy and Poland. The main activity performed was focused on web-based research in each country, targeting higher education initiatives in the field of DT. Besides course search, a snowballing technique was performed to deepen the information based on the initial findings.

The scope of this research was to find HEIs courses and programmes that would fit training or teaching knowledge and skills for DT in a variety of fields and took place between April and June 2023 and resulted in analysis of 148 courses/programmes.The mapping focused on understanding the main topics (content) offered, the length of programmes (duration), workload (ECTS), and the approach (delivery method) used. To enable subject analysis, each course has been assigned keywords describing its main content for better course differentiation, based on digital transformation characteristics found in n research articles (Phuong, et al,, 2023; Morakanyane, Grace, & O'Reilly, 2017; Morze & Strutynska, 2021).

The coding of courses and programmes has been done assigning a maximum of three keywords to each learning item. The major trends can be identified and deliver insights on DT education in Europe. After listing, analysing, and labelling the courses, a simple count was performed, identifying commonalities and repetitions. The most frequently mentioned keywords were indicated by researchers based on analysis of course topics and content. Independently of recurring in the first, second, or third keyword slot, using the repetition as proxy was a first attempt to formulate the trends.

3. Findings

The state-of-the-art overview has shown that digital transformation is a key element in HEI curricula. To answer the research question, the content of the courses was analysed without upfront selection criteria. The courses represent a wide range of potential training programmes, ranging from entry-level positions (employees) through middle managers to management staff. A total of 55 keywords were listed, and the courses were labelled according to the course description. Within the total of 148 courses identified, 25.7% explicitly mention DT in their programmes, indicating a trend towards creating a specific field in education.

A recurring topic, gaining momentum throughout these countries, is Artificial Intelligence (AI), which is emerging as a key aspect of DT, with several academic programmes dedicated exclusively to it. AI, Data Science, Digital Technology, Technology ethics and Regulation and Governance came next with 12.8% of occurrences (**Tab. 1**). The prominence of AI, data science, and digital ethics within HEI curricula aligns with the 2030 Digital Compass's (EU 2021) vision for a digitally skilled population and the digital transformation of businesses and public services.

Digital Business, Digital Leadership, Machine Learning (ML), Digital Innovation, IT infrastructure, Social Impact and Change management build the next group of keywords, slightly above 7% of occurrences. In this case, more humanities are included (management, social, business), expanding the understanding of digital transformation to its opportunities and consequences.

Tab. 1. Most frequently present focus area of courses (keyword occurring more than 10% of cases)

Keyword	Area	Occurrence	%
Digital Transformation	Economic aspects	38	25,70%
Artificial Intelligence (AI)	Technological aspects	19	12,80%
Data Science	Technological aspects	19	12,80%
Digital technology	Economic aspects	19	12,80%
Technology ethics	Managerial aspects	19	12,80%
Regulation and governance	Economic aspects	18	12,20%

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

While the EU's overarching DT agenda provides a unified framework, the specific educational responses vary significantly across member states. Each country exhibits unique educational focuses. A discernible trend emerges, emphasizing social impact as a pivotal aspect of digital transformation, highlighting its potential effects on society. These variations reflect the importance of a flexible and context-specific approach when addressing educational offerings.

4. Conclusions

Firstly, the most popular elements of DT curricula are AI, Data Science and Digital Engineering. In addition, emerging elements are: technology ethics, regulation and governance, and digital leadership. This suggests that technological aspects are currently balanced with business and management aspects.
The second observation is that several programmes are located at the intersection between technology and society. While in the past, technological advances were mainly studied in scientific academic programmes, today we increasingly see undergraduate and postgraduate programmes in social sciences, including courses on the impact of emerging technologies and digitalization in government, industries, markets, and society in general.
Additionally, observations revealed that EU's Digital Skills Agenda (EU 2020) is reflected in the wide array of DT programmes offered by HEIs at various educational levels. The interdisciplinary nature of these programmes, which span from technical to social sciences, ensures that digital skills are integrated across diverse fields, promoting accessible and inclusive digital education.

Funding or Grant

This research was funded by the Project UNI UEAR - "Alianza Universitaria Argentina Europea para la Transformación Digital" - Grant Contract: NDICI HR INTPA/2022/437-643—OPSYS: PC-20191

Contributor Statement

Conceptualisation; Methodology; Funding, Writing, Editing: All Authors.

Use of AI

During the preparation of this work, the author(s) used AI tools for proofreading and language correction of the proposal. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest

References

Cedefop (2022). Setting Europe on course for a human digital transition: new evidence from Cedefop's second European skills and jobs survey. Luxembourg: Publications Office. Cedefop reference series; No 123, http://data.europa.eu/doi/10.2801/253954

(EU 2010) European Commission (2010, 19 May). A Digital Agenda for Europe. Brussels: European Commission COM(2010)245 final

(EU 2013). European Commission 2013, December. Horizon 2020 – the Framework Program for Research and Innovation for 2014-2020, https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-2020_en

(EU 2018a). European Commision (2018). Regulation of the European Parliament and of the counsil establishing the Digital Europe programme for the period 2021-2027, https://digital-strategy.ec.europa.eu/en/activities/digital-programme

(EU 2018b) European Commission (2018) COUNCIL RECOMMENDATION of 22 May 2018 on key competences for lifelong learning (Text with EEA relevance) (2018/C 189/01)., https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)

(EU 2020) European Commission. (2020). European skills agenda for sustainable competitiveness, social fairness and resilience. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 1 July 2020 .https://ec.europa.eu/social/main.jsp?catId=1223&langId=en

(EU 2021) European Commission (2021). 2030 Digital Compass: the European way for the Digital Decade,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

9.03.2021, https://eufordigital.eu/wp-content/uploads/2021/03/2030-Digital-Compass-the-European-way-for-the-Digital-Decade.pdf

(EU 2022) Joint Employment Report 2022 – European Commission, Directorate-General for Employment, Social Affairs and Inclusion, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2767/342787)

Godfrey, J.M. & Godfrey, P.J. (1999), Benchmarking quality management: how does it apply to the university alumni office?, Benchmarking: An International Journal, Vol. 6 No. 1, pp. 40-59

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., & Roig-Tierno, N. (2021). Digital transformation: An overview of the current state of the art of research. *Sage Open*, *11*(3), 21582440211047576.

Morakanyane, R., Grace, A. A., & O'Reilly, P. (2017). Conceptualizing digital transformation in business organizations: A systematic review of literature. https://www.academia.edu/download/97223124/301373698.pdf

Morze, N. V., & Strutynska, O. V. (2021, June). Digital transformation in society: key aspects for model development. In Journal of physics: Conference series (Vol. 1946, No. 1, p. 012021). IOP Publishing

Nugroho, B. H., & Jaqin, C. (2021). Implementation of benchmarking method for higher education institution: A literature review. IJIEM (Indonesian Journal of Industrial Engineering & Management), 2(2)

OECD (2019). Going Digital: Shaping Policies, Improving Lives, OECD Publishing, Paris, https://doi.org/10.1787/9789264312012-en

Phuong, T. T. T., Nguyen, T. T., Danh, N. N., Van, D. N., Luong, H. D., & Tran, T. (2023). Digital transformation in education: a bibliometric analysis using Scopus. European Science Editing, 49, e107138, https://doi.org/10.3897/ese.2023.e107138

Spendolini, M.J. (1992). The Benchmarking Book, American Management Association, New York, NY

Tangi, L., Janssen, M., Benedetti, M., & Noci, G. (2020). Barriers and drivers of digital transformation in public organizations: Results from a survey in the Netherlands. In *Electronic Government: 19th IFIP WG 8.5 International Conference, EGOV 2020, Linköping, Sweden, August 31–September 2, 2020, Proceedings 19* (pp. 42-56). Springer International Publishing, https://doi.org/10.1007/978-3-030-57599-1_4

Zaoui, F. & Souissi, N. (2020). Roadmap for digital transformation: A literature review. *Procedia Computer Science* 175: 621-628, https://doi.org/10.1016/j.procs.2020.07.090

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Leveraging AI Models for Automated Pattern Detection in Citizen Participation Data

Amal Marzouki[a*], *Boutheyna* Nouri[b], *Sehl* Mellouli[c]

[a]Department of Information Systems, Université du Québec à Rimouski, Campus de Lévis 1595 Boulevard Alphonse-Desjardins, Lévis, QC G6V 0A6, Canada; amal_marzouki@uqar.ca; ORCID:0009-0002-9931-1564

[b]Department of Information Systems, Université du Québec à Rimouski, Campus de Lévis 1595 Boulevard Alphonse-Desjardins, Lévis, QC G6V 0A6, Canada; Boutheyna.Nouri@uqar.ca; ORCID: 0009-0007-1339-1564

[c]Department of Information Systems, Université Laval, 2325, rue de la Terrasse, Québec, QC G1V 0A6, Canada; sehl.mellouli@fsa.ulaval.ca; ORCID: 0000-0003-0977-4603

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 10 July 2025

Abstract. Citizen Participation (CP) is essential for urban projects, traditionally done through face-to-face meetings. Information Technologies (IT) have introduced electronic participation (e-Participation), enhancing inclusivity and engagement. CPPs generate valuable data for decision-making, but processing large volumes of unstructured data is challenging. Traditional methods are inefficient. AI algorithms can improve data analysis, automate classification, detect patterns, and extract relevant information, reducing the workload for decision-makers. This research explores how AI can detect and classify patterns in CPP data, contributing to best practices in applying AI to government operations.

Keywords. Citizen participation, Artificial Intelligence models, Data analysis, Pattern detection, Semantic, spatial and temporal analysis.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1068

1. Introduction

Citizen Participation (CP) integrates citizens into decision-making for urban and community projects. Historically, CP was facilitated through face-to-face meetings, allowing stakeholders to share their perspectives. The advent of Information Technologies (IT) has introduced electronic participation (e-Participation), leveraging tools like blogs and social networks to enhance inclusivity and engagement. CPPs generate valuable data that must be meticulously analyzed to aid decision-making and improve service delivery (Marzouki et al., 2022b). However, processing large volumes of unstructured data is challenging. Traditional manual methods are inefficient and limit scalability. AI algorithms can automate the classification of citizen posts, detect patterns, and extract relevant information, reducing the workload for facilitators and edecision-makers (Bonsón et al., 2015; Marzouki et al., 2022a). This research explores how AI can enhance CPP data analysis, contributing to better decision-making and government service delivery. By leveraging AI, governments can gain deeper insights into citizens' needs and preferences, ensuring that actions are aligned with community demands (Burgess-Allen & Owen-Smith, 2010; Sanford & Rose, 2007).

2. Theoretical background

To integrate Artificial Intelligence (AI) into participatory platforms, we focus on the analysis of participation data derived from these platforms. At the core of this conceptualization, we propose a systemic approach in which the human aspect is represented by citizens, facilitators, and decision-makers. This model integrates

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

AI techniques for faster, more efficient, and responsive interactions to citizens' needs.
Key concepts include textual data analysis (TDA) and the semantic, spatial, and temporal contextualization of participation data. TDA examines textual data to extract meaningful patterns using natural language processing (NLP) techniques like Named Entity Recognition (NER) and text classification. AI models such as LDA, CNN, LSTM, and RBFN are considered for text classification. NER identifies key entities in text, classifying results into spatial, semantic, and temporal dimensions (Marrero et al., 2013).
The anticipated results aim to extract knowledge about citizens' living contexts, classify this knowledge into distinct patterns, and inform decision-makers. This approach promotes better decisions aligned with citizens' needs, generating valuable insights to refine policies, improve services, and foster stronger engagement between decision-makers and communities. Anchoring decisions in citizen-centered data strengthens trust and governance effectiveness.

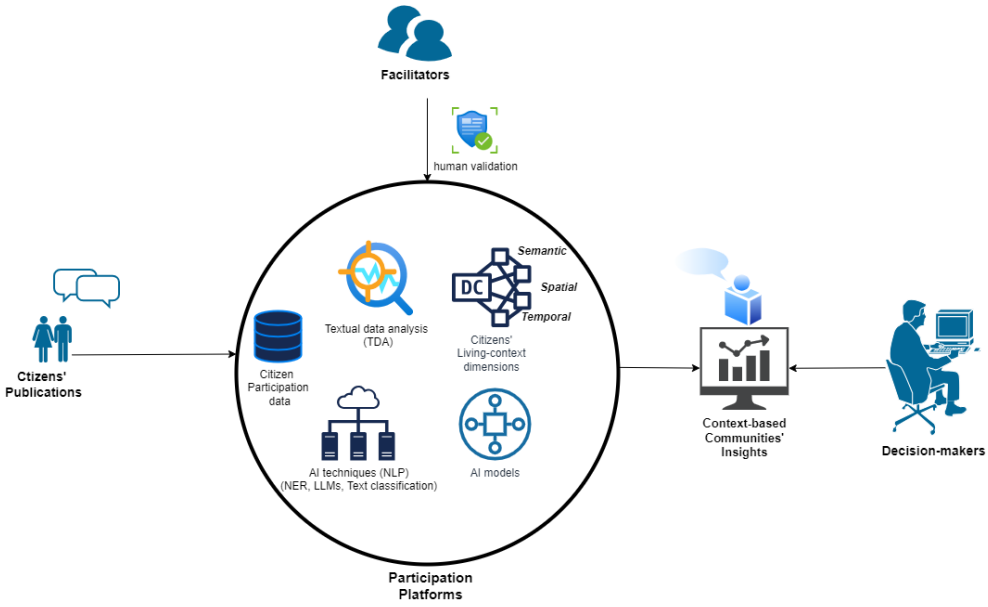


Fig. 1 – A conceptual model for AI models integration in citizens' living context identification in citizen participation data (authors main contribution)

2.1. Textual Data Analysis (TDA)

TDA systematically examines textual data to extract meaningful patterns, isnsights, or classifications using techniques like natural language processing (NLP), text mining, sentiment analysis, and topic modeling. In our study, TDA allows qualitative assessment and automatic classification of citizens' posts, reducing the workload for facilitators and improving decision-making (Feldman & Sanger, 2007; Mohit, 2014).

2.2. Semantic, Spatial, and Temporal Contextualization

After collecting citizens' opinions and feedback, data analysis and information extraction processes are necessary. Patterns capturing stakeholders' living contexts are classified into three dimensions (Marzouki et al., 2022a; Meersman, 1997):

1. **Semantic Dimension:** Represents the meaning of information provided by citizens, including issues, suggestions, lived experiences, metrics, governing entities, references, questions, compliments, links, tags, hashtags, and emoticons (Marzouki et al., 2022a).
2. **Spatial Dimension:** Addresses the question "Where," representing objects in geographical space, including internal and external spatial entities, similar organizations, hypothetical and approximated positions, cities, provinces, countries, hashtags, and location stamps (Lafrance et al., 2019; Marzouki et al., 2022a).
3. **Temporal Dimension:** Addresses the question "When," including past and future calendar expressions, deictic and anaphoric expressions, founded calendar expressions, and temporal hashtags (Lafrance et al., 2019; Marzouki et al., 2022a).

2.3. Named Entity Recognition (NER)

NER identifies and categorizes important names and proper nouns in text, enabling information extraction of Named Entities (NE) (Marrero et al., 2013). We will use pre-trained models due to their high accuracy:

1. **Spacy:** Utilizes deep learning for NLP, processing text from tokenization to annotation (Dasagrandhi, 2021; Partalidou et al., 2019).
2. **Stanford CoreNLP:** Java-based tool with feature extractors for named entities, using a sequence of annotations (Bondielli et al., 2018).
3. **OpenNLP:** Contains components for a complete NLP system, including sentence detection, tokenization, and parsing (Mohanan & Samuel, 2016).
4. **Gate:** Open-source tool with multilingual support, providing reusable processing resources for NLP tasks (Cunningham et al., 2014; Elsherif et al., 2019).
5. **NLTK:** Python library for NLP tasks, analyzing data programmatically (Siva Rama Rao et al., 2022).

This approach aims to extract knowledge about citizens' living contexts, classifying this knowledge into distinct patterns, and informing decision-makers in their decision-making processes. By anchoring decisions in citizen-centered data, this approach strengthens trust and the overall effectiveness of governance .

2.4. Large Language Models (LLMs)

LLMs are a category of deep learning models designed to understand and generate human language. These models are built on transformer architectures, which enable them to learn complex patterns in text data by processing input sequences in parallel and capturing long-range dependencies between words. LLMs are pre-trained on massive corpora of text and can be fine-tuned for specific tasks such as text classification, named entity recognition (NER), and text generation (Brown et al., 2020). Below, we discuss some of the most prominent LLMs: GPT-4, BERT, RoBERTa, DistilBERT, and T5.

1. **GPT-4 (Generative Pre-trained Transformer 4):** GPT-4 is a state-of-the-art generative language model developed by OpenAI. It has been trained on a vast corpus, which enables it to perform well on a wide range of natural language processing (NLP) tasks (Brown et al., 2020).
2. **BERT (Bidirectional Encoder Representations from Transformers):** BERT, developed by Google, is a transformer-based model designed to understand the contextual relationships between words in a sentence. It is primarily used for tasks like named entity recognition (NER), question answering, and sentence classification (Devlin et al., 2019).
3. **RoBERTa (A Robustly Optimized BERT Pretraining Approach):** RoBERTa is an optimized version of BERT developed by Facebook AI. The improvements result in better performance on a range of NLP tasks, particularly for tasks that require understanding the relationship between words within large text corpora (Liu et al., 2019)
4. **DistilBERT (Distilled Version of BERT):** DistilBERT is a smaller, more efficient version of BERT that retains 97% of BERT's language understanding while being 60% faster and using 60% less memory (Sanh et al., 2019)
5. **T5 (Text-to-Text Transfer Transformer):** T5, developed by Google Research, is a transformer-based model that treats every NLP task as a text-to-text problem. It is highly versatile and can perform a wide variety of NLP tasks by leveraging a unified architecture and large-scale pretraining (Raffel et al., 2020)

2.5. Text Classification

Text classification assigns a document to a predefined category. It can be binary or multi-class, where binary classification can also be used for multi-label classification (Anis, 2022).

2.6. Artificial Intelligence Algorithms

AI algorithms, inspired by human intelligence, perform tasks like learning, reasoning, and problem-solving. They process and analyze complex data, including natural language (Russell & Norvig, 2016). Effective algorithms for text data analysis include:

1. **LDA:** Probabilistic model for discrete data clusters, identifying hidden topics (Sayadi, 2017).
2. **CNN:** Network using minimal preprocessing, useful for detecting named entities (Widiastuti, 2019).
3. **LSTM:** Extends memory of RNNs, storing states of each cell for sequential processing (Schmidhuber & Hochreiter, 1997).
4. **RBFN:** Neural network for curve-fitting in high-dimensional space, useful for classifying participation data into semantic, spatial, or temporal patterns (Zhang et al., 2011).

3. Methodology

This paper explores the integration of AI models for semantic, spatial, and temporal analysis of citizen participation data on digital platforms. The methodology involves several steps:

- **Exploration of Citizen Participation Platforms:** Establish foundational understanding of functionalities and data generated.
- **Framework for CPP Data Contextualization:** Analyze data based on semantic, spatial, and temporal dimensions.
- **Review of Textual Data Analysis Techniques:** Identify key dimensions for analysis.
- **Search for Appropriate AI Architectures:** Design AI models tailored to each dimension.
- **Evaluation of AI Model Designs:** Assess accuracy scores for models like Named Entity Recognition (NER) and Entity Classification.
- **Selection and Integration of Models:** Choose the best models for each dimension and analyze results to understand citizen participation patterns.

3.1. Choice of Pre-trained NER Model:

We selected a pre-trained NER model based on performance, corpus size, and integration environment. After comparing several models, including SpaCy, Stanford Core NLP, OpenNLP, Gate, and NLTK, we excluded Java-based models due to integration constraints. Between SpaCy and NLTK, SpaCy was preferred for its larger corpus size and better performance. After evaluating the available SpaCy models, we chose `fr-core-news-sm` for its smaller size and efficiency in identifying patterns in citizen participation texts.

4. Proposed AI Models for Semantic, spatial and temporal Analysis of citizen participation data on digital government platforms

4.1. The proposed Semantic Dimension Model

- **Design of Solution 1 of the Semantic Model**

This solution is based on the pre-trained SpaCy model with custom entity recognition. The goal is to detect and classify semantic patterns from a given text. Semantic patterns include: Question, Governing Entity, Reference, Number/Metric, Link or document/file, Tag, Hashtag, Emoticon.
Figure 2 shows the semantic patterns detected by Solution 1 (using the NER model) and Solution 2 (using the LLM model) in the text.

- **Design of Solution 2 of the Semantic Model**

In this solution, we will employ Large Language Models (LLMs) to enhance the detection and classification of semantic patterns within citizen participation data. The model is pre-trained on vast amounts of textual data and by fine-tuning it, we can detect and classify complex semantic entities which are listed in the solution 1 of the semantic model. By integrating LLMs, the model strengthens the decision-making framework by offering a comprehensive understanding of citizen engagement and by improving the data processing on digital government platforms. The illustrative diagram for this solution is similar to Solution 1, as it shares the same inputs and outputs; however, the model used will be different to detect specific semantic patterns.

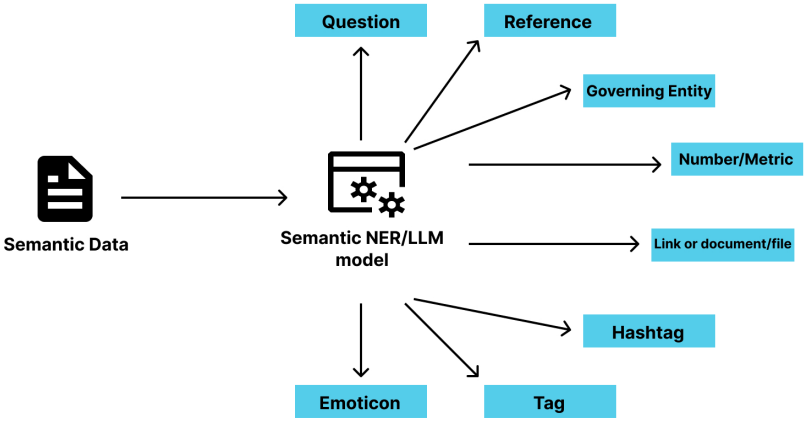


Fig. 2 – Illustrative diagram of the Semantic Dimension Model using NER/LLM

4.2. The proposed Spatial dimension Model

One essential dimension in data analysis is the extraction of spatial data. Two solutions are proposed: one using the SpaCy NER model with a neural classification model, and one using the pre-trained SpaCy NER model combined with a geolocation API and an algorithmic classification process.

- **Design of Solution 1 of the Spatial Model** This solution involves implementing two complementary models:

- Spatial NER Model: Similar to the semantic dimension, input data is prepared, annotated, and divided into training and testing corpora. This model extracts spatial patterns without classifying them. Figure 3 shows the spatial entity that this model is designed to detect in the text. **- Spatial Entity Classification Model:** This

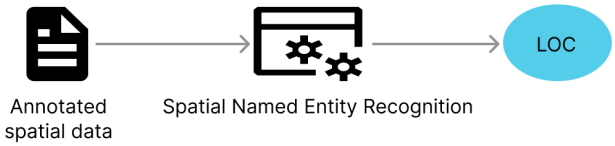


Fig. 3 – Illustrative diagram of the Spatial NER model

model classifies the spatial patterns detected by the first Spatial NER model, processing the annotated corpus and outputting six class categories using a Feed Forward network. Figure 4 shows the spatial patterns that this model is designed to classify.

- **Design of Solution 2 of the Spatial Model**
  This solution uses the pre-trained SpaCy model to identify location and organization entities (Loc, Org), then prepares an NER model to detect classes like Cities_provinces_Countries, Spatial entity approximated position, and Hashtag. The entity results are then classified according to logical constraints. Figure 5 illustrates the second solution as well as the spatial patterns that this solution is designed to classify.

4.3. The proposed Temporal dimension Model

- Design of Solution 1 of the Temporal Model: This solution includes two complementary models: a Temporal NER model, similar to the semantic dimension and the first spatial solution, which detects

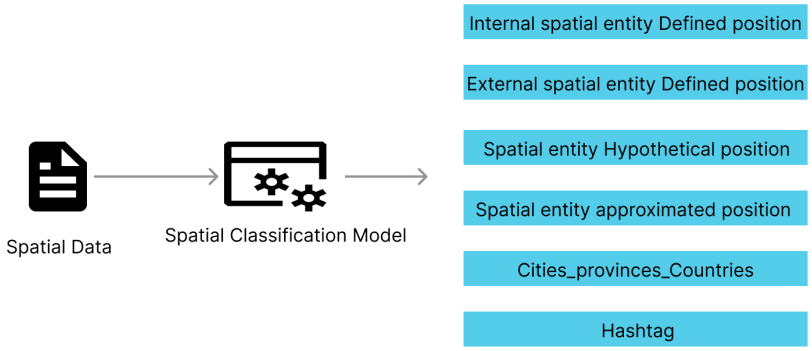


Fig. 4 – Illustrative diagram of the first spatial classification model

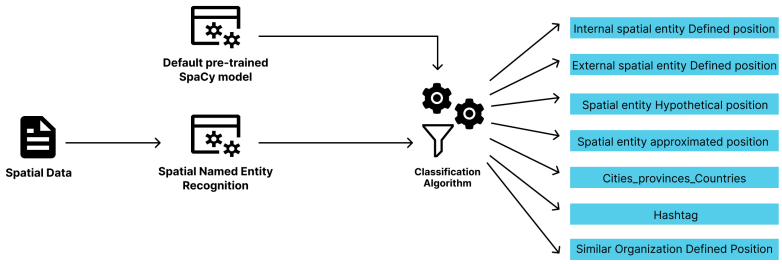


Fig. 5 – Illustrative diagram of the second spatial classification solution

temporal patterns from the annotated corpus, and a Temporal Entity Classification model that automatically classifies the temporal entities detected by the Temporal NER model. Figure 6 shows the temporal entity that this model is designed to detect in the text. Figure 7 shows the temporal patterns that this model is designed to classify.

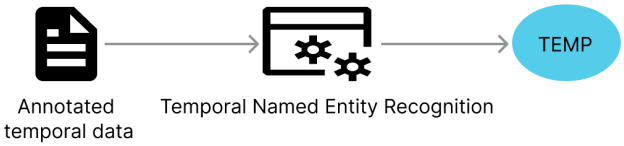


Fig. 6 – Illustrative diagram of the Temporal NER model

- Design of Solution 2 of the Temporal Model: This solution uses the pre-trained SpaCy model to detect the date from the (DATE) entity after translation, then applies the NER model trained with collected temporal data to identify deictic expressions and temporal hashtags. The extracted information is processed through a classification algorithm based on logical classification rules. Figure 8 illustrates the second solution as well as the temporal patterns that this solution is designed to classify.

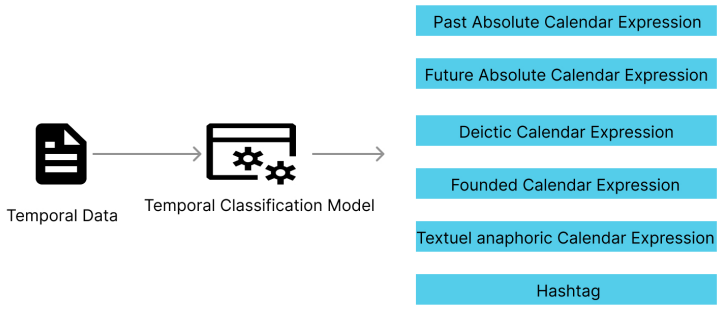


Fig. 7 – Illustrative diagram of the temporal classification model

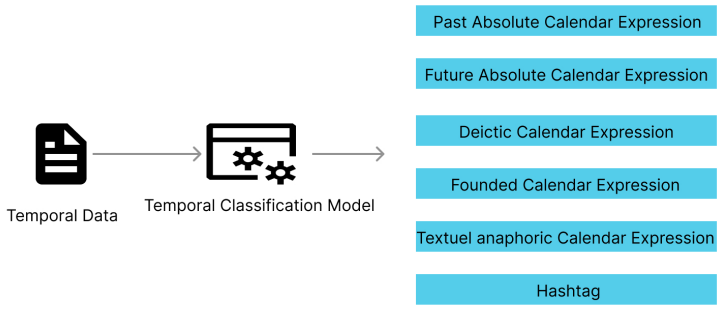


Fig. 8 – Illustrative diagram of the temporal classification model

5. Discussion and Conclusion

This study explores the integration of AI models for semantic, spatial, and temporal analysis in citizen participation data on digital platforms . Automating data analysis through AI enhances the ability to identify nuanced patterns, supporting scalable and efficient decision-making processes tailored to citizen needs (Marzouki et al., 2022a). Semantic analysis captures stakeholders' experiences and concerns, spatial analysis further contributes by mapping out the geographic dimensions of citizen inputs, thereby aligning community needs with spatial strategies in urban planning (Lafrance et al., 2019), and temporal analysis tracks changes over time (Andrienko et al., 2010), fostering proactive governance (Marzouki et al., 2022b).
The integration of AI-driven methodologies represents a significant advance in the transformation of digital citizen participation platforms. This approach addresses data scalability and complexity, improving decision-making processes in urban governance. By bridging the gap between citizen data and actionable insights, it fosters more inclusive and data-informed policy-making.
Our research aims at automating the analysis of large volumes of textual data, in order to provide actionable insights for city decision-makers. Future work will include collecting real citizen participation data, testing the proposed models, and developing a participatory platform integrated with decision support mechanisms. Further refinement of these AI models will enhance the effectiveness of citizen participation platforms, including the analysis of other data types, like images and videos, to provide a comprehensive understanding of citizens' living contexts.

References

Andrienko, G., Andrienko, N., Demsar, U., Dransch, D., Dykes, J., Fabrikant, S. I., & Tominski, C. (2010). Space, time and visual analytics. *International Journal of Geographical Information Science*, *24*(10), 1577–1600.

Anis, A. (2022, March). Pytorch lstm: The definitive guide. https://cnvrg.io/pytorch-lstm

Bondielli, A., Passaro, L., & Lenci, A. (2018). Corenlp-it: A ud pipeline for italian based on stanford corenlp. *Proceedings of the Fifth Italian Conference on Computational Linguistics CLiC-it 2018*, 57–61.

Bonsón, E., Royo, S., & Ratkai, M. (2015). Citizens' engagement on local governments' facebook sites. an empirical analysis: The impact of different media and content types in western europe. *Gov. Inf. Q.*, *32*, 52–62.

Brown, T., Mann, B., Ryder, N., Subbiah, M., Kaplan, J. D., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell, A., et al. (2020). Language models are few-shot learners. *Advances in neural information processing systems*, *33*, 1877–1901.

Burgess-Allen, J., & Owen-Smith, V. (2010). Using mind mapping techniques for rapid qualitative data analysis in public participation processes. *Health Expectations*, *13*(4), 406–415. DOI: https://doi.org/10.1111/j.1369-7625.2010.00594.x.

Cunningham, H., Maynard, D., Bontcheva, K., Tablan, V., Aswani, N., Roberts, I., & Derczynski, L. (2014). *Developing language processing components with gate version 8*. University of Sheffield Department of Computer Science.

Dasagrandhi. (2021). Understanding named entity recognition pre-trained models. https://blog.vsoftconsulting.com/blog/understanding-named-entity-recognition-pre-trained-models#:~:text=Stanford%5C%20NER

Devlin, J., Chang, M.-W., Lee, K., & Toutanova, K. (2019). Bert: Pre-training of deep bidirectional transformers for language understanding. *Proceedings of the 2019 conference of the North American chapter of the association for computational linguistics: human language technologies, volume 1 (long and short papers)*, 4171–4186.

Elsherif, H. M., Alomari, K. M., AlHamad, A. Q. M., & Shaalan, K. (2019). Arabic rule-based named entity recognition system using gate. *MLDM (1)*, 1–15.

Feldman, R., & Sanger, J. (2007). *The text mining handbook: Advanced approaches in analyzing unstructured data*. Cambridge University Press.

Lafrance, F., Daniel, S., & Dragićević, S. (2019). Multidimensional web gis approach for citizen participation in urban evolution. *ISPRS International Journal of Geo-Information*, *8*(6), 253.

Liu, Y., Ott, M., Goyal, N., Du, J., Joshi, M., Chen, D., Levy, O., Lewis, M., Zettlemoyer, L., & Stoyanov, V. (2019). Roberta: A robustly optimized bert pretraining approach. *arXiv preprint arXiv:1907.11692*.

Marrero, M., et al. (2013). Named entity recognition: Fallacies, challenges and opportunities. *Computer Standards Interfaces*, *35*(5), 482–489.

Marzouki, A., Mellouli, S., & Daniel, S. (2022a). The identification of stakeholders' living contexts in stakeholder participation data: A semantic, spatial, and temporal analysis. *Land*, *11*(6), 798.

Marzouki, A., Mellouli, S., & Daniel, S. (2022b). Understanding issues with stakeholders participation processes: A conceptual model of spps' dimensions of issues. *Government Information Quarterly*, *39*(2), 101668.

Meersman, R. (1997). Introduction: An essay on the role and evolution of data(base) semantics. In *Database applications semantics* (pp. 1–7).

Mohanan, M., & Samuel, P. (2016). Open nlp based refinement of software requirements. *International Journal of Computer Information Systems and Industrial Management Applications*, 293–300.

Mohit. (2014). Named entity recognition. In *Natural language processing of semitic languages* (pp. 221–245).

Partalidou, E., Spyromitros-Xioufis, E., Doropoulos, S., Vologiannidis, S., & Diamantaras, K. (2019). Design and implementation of an open source greek pos tagger and entity recognizer using spacy. *IEEE/WIC/ACM International Conference on Web Intelligence*, 337–341. DOI: https://doi.org/10.1145/3350546.3352543.

Raffel, C., Shazeer, N., Roberts, A., Lee, K., Narang, S., Matena, M., Zhou, Y., Li, W., & Liu, P. J. (2020). Exploring the limits of transfer learning with a unified text-to-text transformer. *Journal of machine learning research*, *21*(140), 1–67.

Russell, S. J., & Norvig, P. (2016). *Artificial intelligence: A modern approach*. Pearson.

Sanford, C., & Rose, J. (2007). Characterizing eparticipation. *International Journal Of Information Management*, *27*(6), 406–421. DOI: https://doi.org/10.1016/j.ijinfomgt.2007.08.002.

Sanh, V., Debut, L., Chaumond, J., & Wolf, T. (2019). Distilbert, a distilled version of bert: Smaller, faster, cheaper and lighter. *arXiv preprint arXiv:1910.01108*.

Sayadi, K. (2017). *Classification du texte numérique et numérisé. approche fondée sur les algorithmes d'apprentissage automatique* [Doctoral dissertation, Université Pierre et Marie Curie-Paris VI].

Schmidhuber, J., & Hochreiter, S. (1997). Long short-term memory. *Neural Comput*, *9*(8), 1735–1780.

Siva Rama Rao, A. V., Vamsi, P. V. V., Rashmika, N., Hemanth, K., & Aditya Kumar, K. (2022). Named entity recognition using stanford classes and nltk. *Proceedings of Second International Conference on Sustainable Expert Systems: ICSES 2021*, 583–597.

Widiastuti, N. I. (2019). Convolution neural network for text mining and natural language processing. *IOP Conference Series: Materials Science and Engineering*, *662*(5), 052010.

Zhang, M., Wang, K., Zhang, C., Chen, H., Liu, H., Yue, Y., & Qi, X. (2011). Using the radial basis function network model to assess rocky desertification in northwest guangxi, china. *Environmental Earth Sciences*, *62*, 69–76.

Leveraging Conversational AI for Adolescent Medical Financial Education

Wesley Chen[a*], *Anthony* Le[b], *Pavan* Athota[b], *Md* Ashaduzzaman[c], *Chun-Hua* Tsai[c].

[a]Millard North High School, Omaha, Nebraska, USA, wesleychen127@gmail.com.

[b]Millard North High School, Omaha, Nebraska, USA.

[c]College of Information Science & Technology, University of Nebraska Omaha, Omaha, Nebraska, USA.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Medical financial literacy is essential to make smart decisions in healthcare settings and prevent unanticipated financial hardships. Existing literature has shown that young adults often struggle to understand information associated with health insurance and the financial planning necessary for health-related costs. AI-driven chatbots are emerging as educational tools that have the potential to address this issue. This exploratory study examined an AI chatbot aimed at enhancing medical financial literacy among high school students. Participants engaged with the chatbot's responses to medical financial questions while also rating the clarity, ease of use, trustworthiness, and educational value of the chatbot engagement. Our experiment results supported that the chatbot increased students' understanding of the financial aspect of healthcare - 76.9 percent of students reported a high degree of understanding, 80.8 percent rated the chatbot's responses as clear, and 73.1 percent reported they would recommend it to a peer. The responses indicated that students found the chatbot helpful, but suggested that interactive features be added and/or real-world finance features be incorporated into the chatbot.

Keywords. Conversational AI, Medical financial literacy, Young adults, Chatbot, exploratory study.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1020

1. Introduction

Medical financial literacy refers to the ability to understand and manage healthcare-related finances. Achieving medical financial literacy allows a person to make informed healthcare decisions and avoid unexpected financial burdens. Although important, many do not know much about health insurance before an emergency or treatment. Most patients reported learning about health insurance through trial and error during treatment (Waters et al., 2022). These gaps in medical financial literacy may have caused people to be unprepared to navigate the intricacy of healthcare costs. According to the Kaiser Family Foundation (KFF)'s 2023 report, AIAN and Hispanic US citizens under 65 have high uninsured rates at 18.7 percent and 17.9 percent. This is double their white counterparts at 6.5 percent.

Medical financial literacy education is one of the solutions to alleviate such financial burden. Financial literacy among young people today is increasingly important as finances become more complex. The financial landscape is evolving, showing the need for the early introduction of financial education so that the youth today can make informed financial decisions. Many states have recognized this need by incorporating financial literacy courses into their curriculum, showing the importance of giving students resources that better equip them for the future (Mancone et al., 2024). Most 18-year-olds are held financially responsible for their healthcare (Cruz et al., 2024). Many graduating high school students are likely to be unaware of the unexpected financial costs in the American healthcare system. Several studies have underscored the misunderstandings and obstacles that young adults face in navigating the costs associated with the healthcare system (Cruz et al.,

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2024; Mancone et al., 2024; Waters et al., 2022). For example, studies depict that adolescent and young adult cancer survivors tend to have difficulty comprehending health insurance, which makes them more vulnerable to financial risk (Vaca Lopez et al., 2023; Waters et al., 2022).

One solution to this problem is AI. AI is a useful educational tool, and studies support the idea that chatbots can enhance understanding of complex topics (Cruz et al., 2024; Nur Azlina Mohamed Mokmin, 2021; Reshawn Ramjattan, 2022). Chatbot technology has been successful in increasing the ease of use of educational software in healthcare (Nur Azlina Mohamed Mokmin, 2021; Reshawn Ramjattan, 2022). By extending the argument to the digital native generation, an AI chatbot would be effective in helping high schoolers further comprehend medical finances. Another study further supports the idea that chatbots can be a useful tool in health literacy. The overall assessment showed that the developed chatbot has significant potential to be used as a bridge to increase health literacy among students and young adults (Nur Azlina Mohamed Mokmin, 2021).

This study aims to address the existing gap in knowledge regarding the potential of AI chatbots to improve medical financial literacy, thereby contributing to the use of digital technologies to tackle a significant societal issue. This study evaluates the effectiveness of an AI chatbot in enhancing high school students' understanding of medical financial concepts. The chatbot was designed to tailor responses based on the user's location and grade level, ensuring relevance. As a team of student researchers, we identified five commonly asked questions related to medical financial literacy as five prompts for the AI chatbot. We invited high school students (N=26) to review the chatbot-generated responses to these prompts. Participants were shown prompts to answer and the chatbot's responses. Students then completed a survey that assessed various aspects of the chatbot's performance, including understandability, clarity, ease of use, reliability, and the knowledge gained (Naamati-Schneider, 2024). This process allowed us to assess students' perceptions of the chatbot's educational value and identify areas for improvement.

This study demonstrates how an AI-based chatbot can effectively improve high school students' medical financial literacy by providing clear, accessible, and relevant information regarding healthcare costs, highlighting AI's ability to simplify complex ideas for young learners.

2. Literature Review

Improving medical financial literacy requires new tools, with AI-powered chatbots emerging as a viable solution. They provide real-time explanations that simplify complex insurance concepts. Studies have found that adolescent and young adult cancer survivors lack understanding of insurance coverage, leaving them at greater risk of financial hardship (Waters et al., 2022). Another study finds students largely unaware of key insurance concepts like out-of-pocket costs and coverage limits (Cruz et al., 2024). These findings suggest conventional education methods are insufficient, underscoring the need for alternatives like AI-driven learning.

AI chatbots are increasingly used in education for personalized, interactive learning. Evidence shows chatbots improve student engagement and comprehension in healthcare topics (Vaca Lopez et al., 2023). They simulate real financial scenarios, enabling active learning over passive consumption. One study showed chatbots improved understanding of complex topics via immediate, personalized feedback (Naamati-Schneider, 2024). This is proof of the incorporation of chatbots in medical financial literacy education. Their effectiveness depends on providing accurate, trustworthy, and engaging content. Users find chatbots helpful for healthcare learning, though trust depends on transparency and accuracy (Vaca Lopez et al., 2023). Another study established that interventions using chatbots enhanced financial and health literacy, and individuals indicated that they were more confident in making fully informed decisions following AI-supported tools (Mancone et al., 2024). Some limitations remain, though, including the lack of personalization and interactive engagement elements, potentially impacting long-term retention and user trust (Reshawn Ramjattan, 2022). This paper aims to incorporate user feedback to enhance learning outcomes and promote increased participation.

3. Methodology

3.1. Medical Financial Literacy Chatbot

The AI chatbot, developed using the Dify platform (see Figure 1), is designed to educate high school students transitioning to college about medical financial literacy. Tailored to their grade level, it delivers clear, engaging

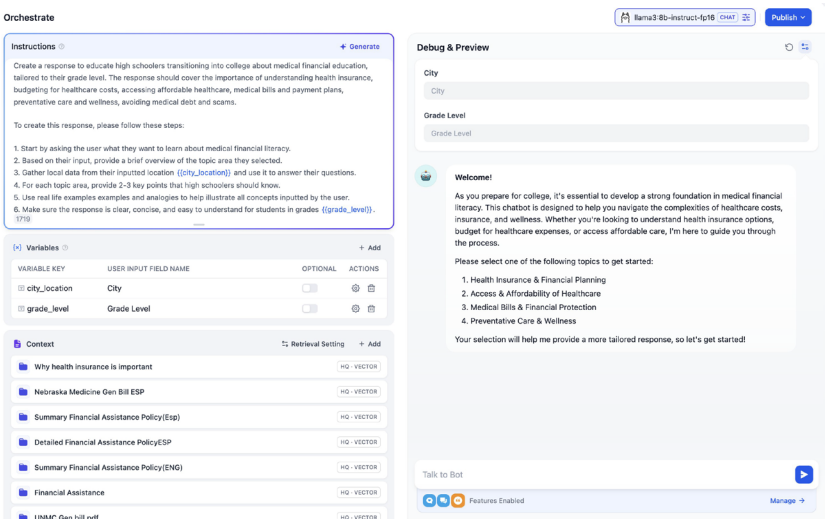


Fig. 1 – System Design for AI Chatbot.

responses on topics such as health insurance, budgeting for healthcare, accessing affordable care, managing medical bills, and avoiding debt or scams. The chatbot uses a structured approach: users choose a topic, receive an overview, and get localized answers based on their city. Real-life examples aid understanding, while a vectorized knowledge base with resources like Nebraska Medicine bills and student insurance guides ensures accurate, location-specific insights. Hosted on Dify's open-source framework, the chatbot combines ease of deployment with robust LLM-driven (llama3:8b-instruct-fp16) capabilities, making it an effective educational tool for young adults navigating healthcare finances.

3.2. Study Design

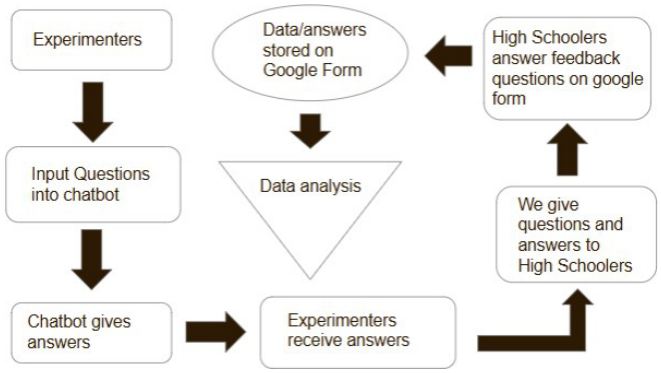


Fig. 2 – The participant-driven data collection process using the chatbot.

This study employed a survey-based, cross-sectional design to evaluate the effectiveness of a conversational AI chatbot in enhancing medical financial literacy among high school students. Due to the school's AI usage policy, students were not permitted to interact directly with the chatbot on campus. To address this limitation, we identified the five most frequently asked questions related to medical financial literacy and obtained responses from the AI chatbot. These responses were then shared with the high school students using Google Slides to collect quantitative data on their understanding, trust, and perceived educational value. Figure 2 illustrates the participant-driven data collection process using the chatbot. 26 high school participants were asked to go step by step through the provided answers to ensure exposure to the content covered by the chatbot. Afterward, the participants took a feedback survey on Google Forms via QR code. The feedback survey consisted of quantitative Likert-scale questions regarding the interpretation of clarity, perceived usefulness, and areas for improvement in the chatbot's learning content for grades 9-12, who participated in our experiment. We showed them 5 commonly asked prompts directed to the chatbot, that addressed concepts about health insurance that are most relevant to young adults, copays, deductibles, private vs public insurance, and handling unaffordable medical bills, which were answered by the chatbot (e.g. Figure 3). The experiment has been approved by the high school supervisor to protect the students' well-being and privacy. No identifiable data was shared outside of the high school research team.

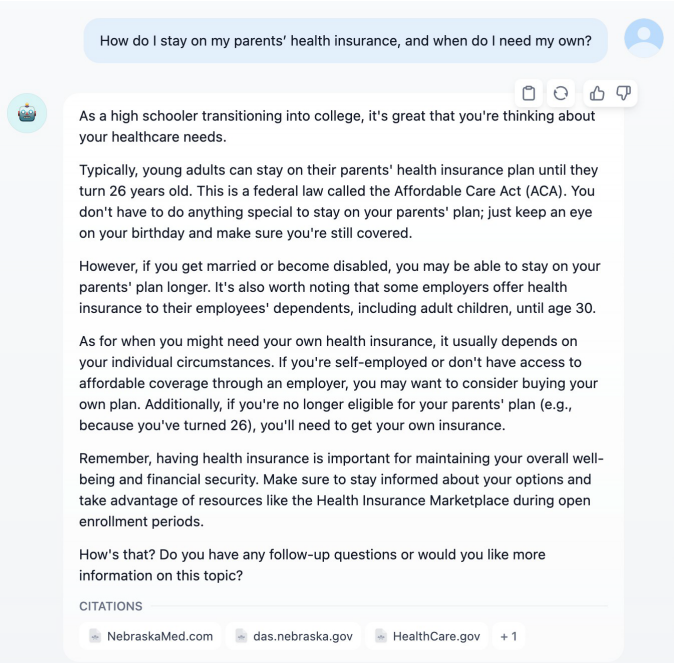


Fig. 3 – AI chatbot explains how to stay on parents' health insurance and when to get your own, with clear guidance.

4. Findings

We generated these findings from our research on the perceived learning of medical finances through an AI-powered chatbot. (see Table 1).

Tab. 1 – Participant responses categorized by pre-existing knowledge, learning outcomes, perceived accuracy, and overall impact of the medical finance chatbot.

Categories	Questions	Mean of Likert Scale (1-5)	Percentage over 3 on Likert Scale (1-5)
Pre-Existing Knowledge & Familiarity	2. On a scale of 1-5, how familiar are you with medical financial concepts (e.g., insurance, medical billing, healthcare costs)?	2.35 ±0.94	7.7%
	5. Before seeing the chatbot's responses, how would you rate your understanding of medical financial concepts?	2.58 ±1.17	19.2%
Learning & Comprehension	3. On a scale of 1-5, to what extent did you learn from the chatbot?	3.81 ±1.23	73.1%
	4. On a scale of 1-5, how clear and understandable were the explanations?	4 ±1.06	80.8%
	6. After seeing the chatbot's responses, how would you rate your understanding of the medical financial concepts in the questions?	3.61 ±0.94	65.3%
Appropriateness & Accuracy	7. On a scale of 1-5, was the chatbot's explanation appropriate for your grade level?	4 ±1.26	69.2%
	8. Did you feel confident that the chatbot was providing accurate and reliable information?	4.12 ±1.14	80.8%
Impact & Recommendation	9. Do you feel more prepared to handle medical financial situations after using the chatbot?	3.54 ±1.20	61.5%
	10. Would you recommend this chatbot to other students?	3.96 ±1.22	73.1%

First, our chatbot was perceived as a valuable educational resource in educating about healthcare expenses. We used a Likert scale for this, and we found that 80.8 percent of students scored clarity as 4 or 5, and 69.2 percent of students scored the explanation as being appropriate for their grade level as a 4 or 5 as well. This indicates that the chatbot effectively simplified topics like insurance, deductibles, and medical billing. That being said, some participants did suggest that interactive features (quizzes or real-world finance scenarios) would further enhance engagement. Second, our data suggested that the chatbot significantly improved high school students' comprehension of medical financial concepts. Still using the Likert scale, we found that before engaging with the chatbot, 50 percent of students rated their understanding as low (1-2). After interacting with the chatbot, 76.9 percent of students rated their understanding high (4-5). This shows that students learned from the chatbot and that the chatbot's ability to simplify complex concepts into easy explanations is remarkable. Some students did note that topics such as insurance comparisons and handling unaffordable medical bills needed further explanation. Furthermore, 80.0 percent of students ranked their confidence in accurate responses as high on the Likert scale (4-5). 73.1 percent of students said that they would recommend it to their peers. These results show that students found the chatbot credible and useful as a learning tool. User feedback highlighted the accurate responses, but one way we could improve is by improving conciseness and adding real-life examples. Overall, these findings demonstrate that AI-powered chatbots can serve as effective tools for improving medical financial literacy among high school students. By enhancing clarity, comprehension, and trust, such tools have the potential to bridge knowledge gaps and empower young individuals with essential healthcare financial knowledge.

5. Conclusion

Our findings show that our AI chatbot can be an effective educational tool for improving medical financial literacy among high school students. The chatbot was successful in enhancing perceived educational value, comprehension, and fostering confidence. Our exploratory research and experiment demonstrate the potential of AI educational tools to bridge the gap between youth and complex medical and financial concepts. The study faces limitations due to its sample size, which may not be generalizable to all high school demographics. Our data collection relies on self-reporting, which introduces potential biases into the responses obtained from participants. A better approach for future studies would be to administer pre-tests and post-tests to measure knowledge gain. Additionally, there was a lack of live chatbot interaction, as responses were displayed rather than allowing people to interact with the chatbot directly. Future research should examine more diverse demographics of participants, incorporate interactive functionalities and real-world tasks, and utilize pre- and post-assessments of understanding to increase the robustness of the findings.

Acknowledgement

- **Funding or Grant**: This material is based upon work supported by the National Science Foundation under Grant No. 2153509.

References

Cruz, B. L., Rosales, D., Chuang, J., Cruz, R., & Huang, J. S. (2024). Cross-sectional evaluation of health insurance knowledge and self-efficacy in adolescents and young adults with inflammatory bowel disease. *The Journal of Pediatrics*, *275*, 114244.

Mancone, S., Tosti, B., Corrado, S., Spica, G., Zanon, A., & Diotaiuti, P. (2024). Youth, money, and behavior: The impact of financial literacy programs. *Frontiers in Education*, *9*, 1397060.

Naamati-Schneider, L. (2024). Enhancing ai competence in health management: Students' experiences with chatgpt as a learning tool. *BMC Medical Education*.

Nur Azlina Mohamed Mokmin, N. A. I. (2021). The evaluation of chatbot as a tool for health literacy education among undergraduate students. *Education and Information Technologies*, *5*, 6033–6049.

Reshawn Ramjattan, N. H., Patrick Hosein. (2022). Using chatbot technologies to help individuals make sound personalized financial decisions.

Vaca Lopez, P. L., Warner, E. L., Waters, A. R., van Thiel Berghuijs, K. M., Anderson, J. S., Ray, N., Tsukamoto, T., Kaddas, H. K., Fair, D., Lewis, M., et al. (2023). Adaptation and development of a health insurance education program for adolescent and young adult cancer patients. *Journal of Adolescent and Young Adult Oncology*, *12*(5), 692–700.

Waters, A. R., Mann, K., Warner, E. L., Vaca Lopez, P. L., Kaddas, H. K., Ray, N., Tsukamoto, T., Fair, D. B., Lewis, M. A., Perez, G. K., et al. (2022). “i thought there would be more i understood”: Health insurance literacy among adolescent and young adult cancer survivors. *Supportive Care in Cancer*, *30*(5), 4457–4464.

Leveraging official government data for enhanced understanding of health crisis communication topics.

Houcai Wang [a*]

[a] School of Management, Shanghai University, Shanghai, China, email address [wanghoucai@shu.edu.cn], ORCID number [0000-0003-1671-6479].

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Taking full advantage of multiple official government data sources is crucial for government emergency management agencies and authorities to formulate scientific and feasible crisis communication policies and measures. The current study examined the case of the public health emergency to explore the association between government microblog activities and the evolution of the public health emergency. Moreover, the present research utilized latent Dirichlet allocation (LDA) topic modeling to detect dominant pandemic-related themes in the government microblog dataset and the government press release conference dataset. Research results indicate that the evolution of government microblog activities is generally similar to that of the pandemic outbreak. The current research also found that government microblog messages and press releases had consistent pandemic-related themes (medical treatments, nucleic acid testing, pandemic statistics, pandemic updates, press conferences, and material support). These results can assistant government agencies and stakeholders obtain a comprehensive understanding of the evolution of public health emergencies and public feelings, concerns, and issues, which will further improve their crisis communication ability.

Keywords. government microblog, government website, government press release conferences, crisis communication, topic modelling
Poster, DOI: https://doi.org/10.59490/dgo.2025.1018

1. Introduction

Public health emergencies such as Western Africa Ebola, Zika, and COVID-19 pandemic have posed an enormous threat to human life and health in the past decade. Owing to the high infectivity, uncertainty, and unpredictability of epidemics, many countries have implemented strict social distancing initiatives to restrict its spread, resulting in difficulties in face-to-face communication between stakeholders and a move to online communication (Wang & Xiong, 2022). The main goals of online crisis communication in public health emergencies are to share pandemic-related information and boost the situational awareness of stakeholders.

Compared with traditional media, government social media accounts have become a pivotal crisis communication medium for public sectors to disseminate crisis information and interact with citizens during public health emergencies (Zeemering, 2021). Government emergency management agencies proactively use government social media accounts for the timely release of pandemic-related information, policies, and measures to meet citizens' information needs (Tang et al., 2021). Meanwhile, citizens increasingly use government social media accounts in a proactive manner to obtain relatively authentic and authoritative pandemic-related information and express their opinions, attitudes, and suggestions regarding the performance of the government in epidemic response (Wang et al., 2023). In addition, many studies have revealed a correlation between disaster severity and the degree of social media users' online participation (Fang et al., 2019). Wong and Jensen (2020) reported that increases in new cases lead to higher levels of online communication among Twitter users during emergencies.

COVID-19 as the novel coronavirus continues to mutate, the risk of epidemic transmission is ever-present, and the pressure of the epidemic response in various countries remains high. However, the COVID-19 outbreak attracted significant attention and caused great social panic. As a measure to alleviate the impact of the pandemic on physical and mental health and regulate misinformation and rumors, government agencies should release prevention policies in a timely manner via their official social media accounts (Dong & Lian, 2022). Hence, to improve the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

efficiency of public health crisis communication, it is warrant to conduct more comprehensive investigation of the topics released by government social media accounts and netizen attitudes during public health crises.

Although scholars have investigated government social media accounts regarding their users' behavior during public health emergencies (Tang et al., 2021; Wang et al., 2023), most such research has adopted traditional research methods such as questionnaire surveys with a limited sample, which makes it difficult to comprehensively understand the entire scope of major topics associated with the pandemic released by government social media accounts and track communication across each public health crisis stage. To better understand how government social media account for crisis communication information during public health emergencies, this study utilized text-mining technologies and natural language processing methods to analyze government social media messages posted by government agencies during the pandemic in depth.

2. Research methods

This study collected three primary types of data: pandemic-related statistics, government microblog data, and government press release conference data. pandemic-related statistics collected from "website of the Shanghai Municipal Health Commission" during the period from March 1 to May 31, 2022, were used to demonstrate the evolution of the pandemic. Government microblog data were obtained from Sina Weibo "Released in Shanghai". We employed the Weibo Search API to download related government microblog messages from March 1 to May 31, 2022, resulting in the collection of 1330 government microblog messages. Government press releases conferences data related to the epidemic were obtained from government website "The State Council Information Office of the People's Republic of China" during the period from March 1 to May 31, 2022, and compiled into a Microsoft Word file containing 92 documents.

The framework and approach applied in this manuscript for pandemic-related topic identification from various official government data sources is schematically shown in Fig. 1, consisting of three phases: data collection, data processing, and data analysis. The data collection and preprocessing procedures were demonstrated in the previous section. Then, using the filtered government microblog data, the amount of government microblog activity (number of messages, likes, forwards, and comments) was calculated for each week. These were compared with weekly epidemiological updates on pandemic (number of deaths, confirmed cases, asymptomatic cases, and new cases) to present the evolution of the pandemic and government microblog activities.

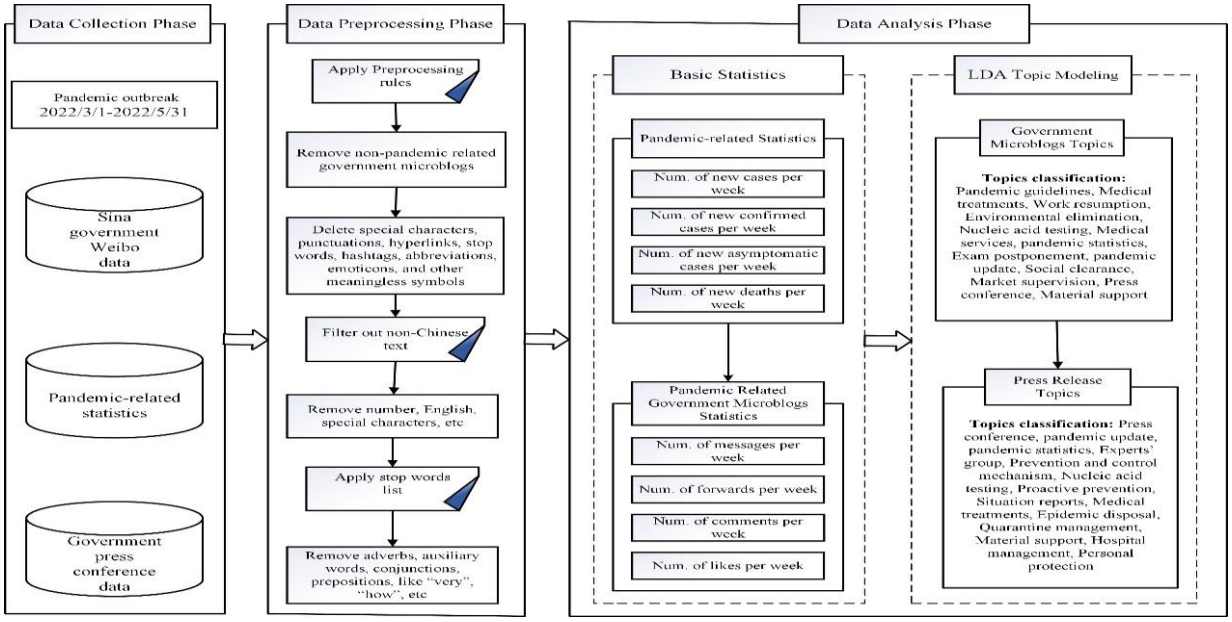


Fig. 1. Research framework.

3. Results

3.1 The evolution of government microblog activities and association with the pandemic

The time series of government microblog activities (number of messages, likes, forwards, and comments) and weekly epidemiological updates on pandemic (number of deaths, confirmed cases, asymptomatic cases, and new cases) from March 1 to May 31, 2022, are plotted in Figs. 2 and 3. It is evident that the variations in government microblog activities were similar to the evolution of the pandemic, except for the number of pandemic-related

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

messages. The pandemic began on March 1 and lasted until May 31, causing severe socioeconomic, physical, and mental health impacts. During the incubation period (before March 1, 2022), few cases were reported in government website "Shanghai Municipal Health Commission" and government microblog "Released in Shanghai." During the outbreak period (March 1 to April 13, 2022), the number of new cases increased every week, but government microblog activities showed some fluctuations, especially for the number of pandemic-related messages; the number of likes, forwards, and comments display the same variation trend. During the recession period (April 14 to May 17, 2022), the number of new cases gradually decreased each week, but government microblog activities gradually stabilized at a lower level of participation. During the recovery period (May 17 to May 31, 2022), the number of new cases gradually stabilized after a precipitous decline, and the government microblog activities were maintained at a lower level of participation except for May 31, when the Shanghai government announced a full resumption of normal production and life order in the city, which resulted in strong government microblog activities, except for the number of messages.

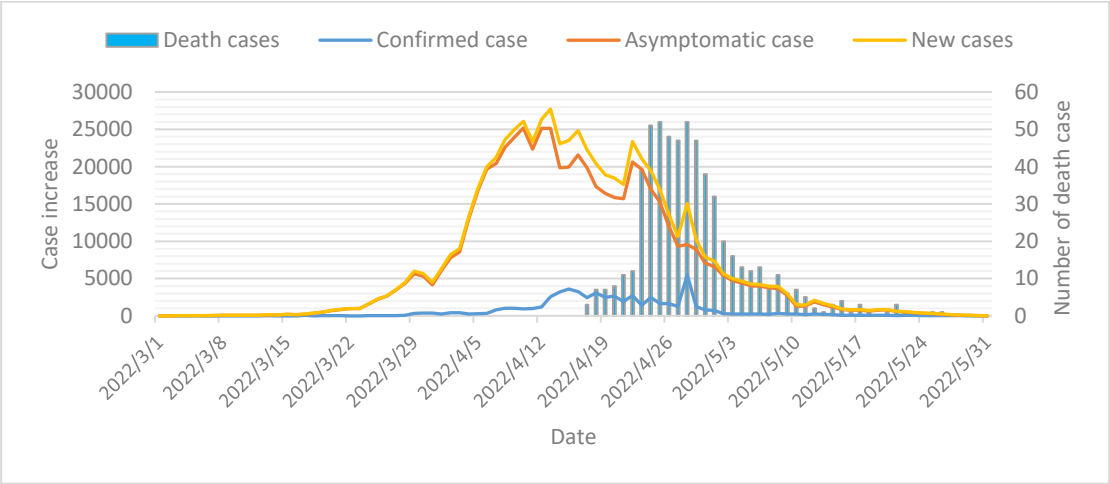


Fig. 2. The pandemic-related case information.

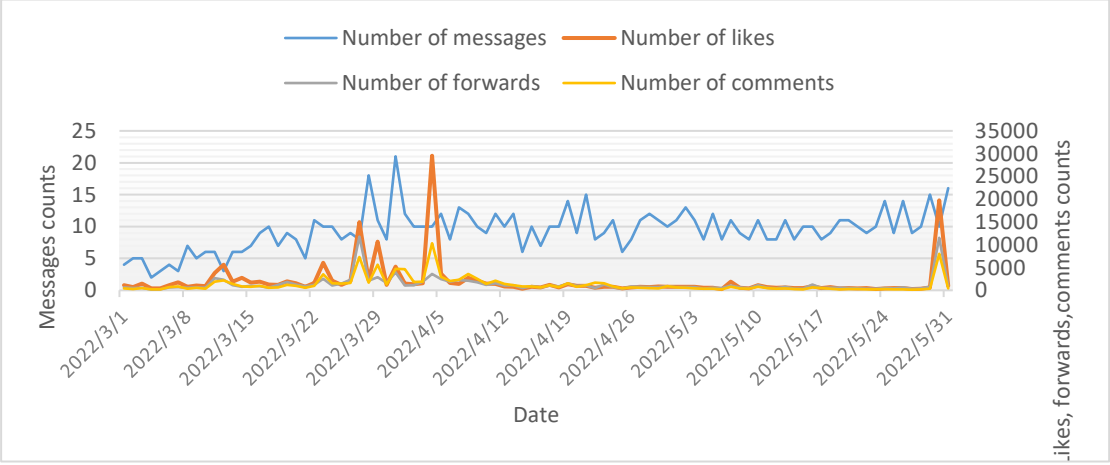


Fig. 3. Temporal variations of government microblog activities (number of messages, likes, forwards, comments) during the pandemic.

3.2 The evolution of pandemic-related government microblog topics

Government microblogs were assigned topics using the LDA algorithm. For the LDA, the number of keywords per topic was set to 10. We calculated the perplexity scores for different numbers of topics (e.g., 20, 30, and 50). For government microblog message data, we found that the perplexity score is a minimum for 13 topics, which means that the maximum accuracy of the LDA model is achieved when the number of topics is 13. We then employed LDA with 2,000 Gibbs sampling iterations to train the dataset. Gibbs sampling is a Markov chain Monte Carlo algorithm that is used to acquire a sequence of samples from an approximate multivariate probability distribution when direct sampling is difficult. The 13 topics were identified from government microblog message data. The 13 topic categories of the government microblog message data, followed by the corresponding keywords from the LDA output, are summarized in Table 1, where each topic is characterized by 10 words and manually interpreted and labeled based on the characterized words.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Tab. 1 LDA topic modeling results of government microblog message data.

No	Category	Keywords
1	Pandemic guidelines	home, quarantine, tips, buying, convenience, details, anti-epidemic, masks, standards, wear
2	Medical treatments	hospital, inoculate, vaccination, service, COVID-19, patients, flight, treatment, achieve, seniors
3	Work resumption	work, resumption, production, enterprise, epidemic, prevention, control, recover, details, Shanghai
4	Environmental elimination	sterilize, disinfection, hint, environment, courier, clean, convenience, preventive, items, citizens
5	Nucleic acid testing	nucleic, acid, testing, registration, citizens, inquire, health, code, epidemic, personnel
6	Medical services	medical, institutions, citizens, service, suspend, treatments, main, district, daily, health
7	Pandemic statistics	cases, locally, infected, COVID-19, governance, screening, district, epidemic, diagnosed, asymptomatic
8	Exam postponement	epidemic, prevention, control, exam, work, host, examinee, Shanghai, latest, postpone
9	Pandemic update	testing, infector, quarantine, asymptomatic, governance, COVID-19, cases, diagnosed, newly, added
10	Social clearance	action, reset, social, office, district, crucial, special, launch, implement, essential
11	Market supervision	price, market, supervision, case, lawfully, illegal, acts, regulators, epidemic, infringe
12	Press conference	conference, prevention, control, epidemic, latest, news, director, health, reply, introduce
13	Material support	enterprise, testing, personnel, antigen, guarantee, supply, distribution, materials, platform, support

3.3 The evolution of pandemic-related government press release conferences topics

To detect hidden topics in our government press release dataset, we leveraged the LDA algorithm for topic modeling analysis. For the municipal government's official press release data, we found that the perplexity score was the minimum for 14 topics. Table 2 reports the 14 topic categories of the press release data, and each topic is characterized by 10 words and with manual interpretation and labeling based on the characterized words.

Tab. 2 LDA topic modeling results of government press release conference data.

No	Category	Keywords
1	Press conference	Epidemic, prevention, control, conferences, news, introduce, reporter, timely, inquiry, Shanghai
2	pandemic update	cases, diagnosed, personnel, risk, quarantine, investigation, proceed, registration, arrange, Omicron
3	pandemic statistics	cases, infector, positive, asymptomatic, male, female, children, parents, COVID-19, pneumonia
4	Experts' group	Wu Jinglei, epidemic, prevention, control, director, Wu Fan, Shanghai, group, members, experts
5	Prevention and control mechanism	risk, district, work, mechanism, prevention, control, defense, epidemic, council, requirements
6	Nucleic acid testing	testing, nucleic, acid, governance, negative, close-knit, investigation, sampling, personnel, measures
7	Proactive prevention	proceed, screening, ventilate, district, initiative, distribution, amid, windowing, rounds, items
8	Situation reports	number, street, road, alley, Xuhui, Putuo, reporter, center, require, quarantine
9	Medical treatments	treatment, medical, hospitals, designated, therapy, diagnosis, admitted, cases, work, scheme
10	Epidemic disposal	citizens, epidemic, problem, reinforce, capacity, live, friend, very, dispose, effect
11	Quarantine management	site, quarantine, management, spot, personnel, residence, identical, code, Japan, Putuo
12	Material support	guarantee, service, resident, work, volunteer, live, demand, materials, achieve, platform
13	Hospital management	request, service, personnel, management, reinforce, prevention, control, demand, hospital, patients

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

14	Personal protection	personal, protection, mask, achieve, wear, distance, keep, citizens, health, reinforce

4. Discussion

Compared with the LDA topic modeling analysis results of government microblog message data, there were certain consistent pandemic-related themes (medical treatments, nucleic acid testing, pandemic statistics, pandemic updates, press conferences, and material support), revealing that government emergency management agencies attach great importance to medical treatments, nucleic acid testing, pandemic statistics, pandemic updates, press conferences, and material support. Additionally, those some consistent pandemic-related themes are in line with the public concern about issues related to the pandemic, and in line with Shanghai's epidemic prevention and control measures. However, they also have some unique pandemic-related themes; for example, government microblogs focused on the topics of pandemic guidelines, work resumption, environmental elimination, medical services, exam postponement, social clearance, and market supervision, while government press release conferences concentrated on the themes of expert groups, prevention and control mechanisms, proactive prevention, situation reports, epidemic disposal, quarantine management, hospital management, and personal protection. This difference in pandemic-related topics may be due to the functional positioning of government microblogs and press releases. Government microblogs are more functional carriers for the timely release of authoritative pandemic-related information, whereas government press release conferences mainly introduce the pandemic situation and answer reporters' questions.

5. Conclusion

In this study, we selected government microblogs, government websites, and government press release conferences to investigate the linear relationship between government microblog activities (number of messages, likes, forwards, and comments) and weekly epidemiological updates on pandemic (number of deaths, confirmed cases, asymptomatic cases, and new cases) in fine-grained detail, and utilized LDA topic modeling methods to identify various pandemic-related themes from the government microblog dataset and government press release conference dataset during the pandemic. Our r results revealed that the variations in government microblog activities were similar to the evolution of the pandemic. Furthermore, we found that government microblog messages and press releases had consistent pandemic-related themes (medical treatments, nucleic acid testing, pandemic statistics, pandemic updates, press conferences, and material support). However, government microblogs mainly focused on the topics of pandemic guidelines, work resumption, environmental elimination, medical services, exam postponement, social clearance, and market supervision, while government press release conferences mainly focused on the themes of expert groups, prevention and control mechanisms, proactive prevention, situation reports, epidemic disposal, quarantine management, hospital management, and personal protection.

Acknowledgement

We would like to mention our greatest appreciation to the anonymous reviewers for their insightful suggestions and constructive comments.

Funding or Grant

We acknowledge supported by the Shanghai Philosophy and Social Sciences Planning Project under Grant Number 2024EGL007 and the China Scholarship Council (CSC) under Grant number 202406890077.

Data/Software Access Statement

Data will be made available on request.

Contributor Statement

Houcai Wang: Conceptualization, Data Curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Supervision, Resources, Validation, Visualization, Writing – Original Draft, Writing - Review & Editing.

Conflict Of Interest (COI)

There is no conflict of interest.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

References

Dong, X. F., & Lian, Y. (2022). The moderating effects of entertainers on public engagement through government activities in social media during the COVID-19. *Telematics and Informatics*, *66*, 101746.

Fang, J., Hu, J. M., Shi, X. W., & Zhao, L. (2019). Assessing disaster impacts and response using social media data in China: A case study of 2016 Wuhan rainstorm. *International Journal of Disaster Risk Reduction*, *34*, 275-282.

Tang, Z. Y., Miller, A. S., Zhou, Z. Y., & Warkentin, M. (2021). Does government social media promote users? information security behavior towards COVID-19 scams? Cultivation effects and protective motivations. *Government Information Quarterly*, *38*(2), 101572.

Wang, H. C., & Xiong, L. (2022). Understanding the antecedents of mobile social media acceptance during the public health crisis maintenance stage. *International Journal of Disaster Risk Reduction*, *74*, 102925.

Wang, H. C., Xiong, L., Guo, J. L., Lu, M. Y., & Meng, Q. S. (2023). Predicting the antecedents of discontinuous usage intention of mobile government social media during public health emergencies. *International Journal of Disaster Risk Reduction*, *87*, 103582.

Wong, C. M. L., & Jensen, O. (2020). The paradox of trust: Perceived risk and public compliance during the COVID-19 pandemic in Singapore. *Journal of Risk Research*, *23*(7-8), 1021-1030.

Zeemering, E. S. (2021). Functional fragmentation in city hall and Twitter communication during the COVID-19 Pandemic: Evidence from Atlanta, San Francisco, and Washington, DC. *Government Information Quarterly*, *38*(1), 101539.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Measuring the Social Impact of Digital Services: A Case of St. Petersburg, Russia

Radomir Bolgov [a,b*], *Olga* Filatova [b], *Daniil* Volkovskii [c]

[a] Saint Petersburg State University, Russia, rbolgov@yandex.ru

[b] ITMO University, Russia.

[c] Université Paris 1 Panthéon-Sorbonne, Paris, France.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract. The paper presents the results of using automated tools to study the dissemination of information in media, social networks and instant messengers, as well as the comments to mobile applications, allowing to search for information by keywords. The cases analysed are the Unified Ecosystem of Urban Services "Digital Petersburg" and its flagship application "I Live Here", as well as the mobile application "Unified Card of St. Petersburg Resident" as part of a study on the social impact of digital services. The data obtained indicate on low awareness of citizens about digital public services. At the same time, we can talk about the high demand among citizens for the "Unified Card of St. Petersburg Resident" service, where, unlike the first case, there is active feedback from the authorities and work to eliminate the shortcomings of the service.

Keywords. Digital Services, Social Networks, Messengers, Mobile Applications, Social Impact, User Satisfaction.
Poster, DOI: https://doi.org/10.59490/dgo.2025.932

1. Introduction

Currently, many governments are actively developing portals, public accounts in social networks and instant messengers, as well as digital services for interaction with citizens. But how to evaluate the impact of such interaction? We made an attempt to contribute answering this question. We reveal the fragments of a research project which aims to contribute to the measuring the social impact of digital urban services based on the case of St. Petersburg, Russia. For this purpose, a corresponding empirical base is collected using different research methods. In addition, digital services and their social impact are studied in conjunction with a specific local context, which differs, as expected, depending on the administrative level. We use the capabilities of a new automated tool that allows, based on user comments, to identify the demand for digital services by city residents using the cases of the digital services ecosystem “Digital Petersburg” (and its flagship project “I Live Here”), as well as the mobile application “Unified Card of St. Petersburg Resident”. The study allows us to understand the reasons and motivation on the part of both city authorities and users.

Since urban digital services are provided to citizens by government, the process of using services can be considered as network interactions ranked according to the principle of satisfying citizens' needs for a specific service. Several studies (Alawneh et al., 2013; Kitsios et al., 2019; Horan & Abhichandani, 2006) developed the frameworks for evaluating citizen satisfaction with digital services. The studies a focus on specific fields (for instance, health) and countries (for instance, Jordan and Greece). Kitsios et al. (2019) applied the MUSA (MUlticriteria Satisfaction Analysis) method to assess the users’ satisfaction with an e-appointment system in Greece. Alawneh et al. (2013) conducted a survey of 400 employees in four universities of Jordan and identified five factors (security and privacy, trust, accessibility, awareness of public services, and quality of public services) that may affect the Jordanians' satisfaction with e-government. Novak, Hoffman & Yung (2003), Tang & Wang (2004) and Reynolds (2011) used usability/ease of use to measure electronic customer satisfaction. To summarize, it can be noted once again that the social impact of digital services (electronic interaction between citizens and authorities) is an indicator of

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

satisfaction with the services provided, in the form of a social resource of citizens (time, efforts, new communication opportunities, etc.) and a social resource of authorities (trust).

2. Research Case 1: Ecosystem of Urban Services "Digital Petersburg"

The unified ecosystem of city services "Digital Petersburg" (ECS) was launched on the initiative of the Government of St. Petersburg in December 2021. ECS is a model for providing digital services or services aggregated on a unified Internet platform (https://petersburg.ru/mainPortal/services). The mini-application "I Live Here", implemented on the VKontakte (VK, Russian online social media based in Saint Petersburg) platform, is the flagship project of "Digital Petersburg", launched in December 2022. The developers position the mini-application as the most useful project for users, so the conducted study is focused more on the analysis of the mini-application "I Live Here". In essence, the mini-application is an adapted catalogue of the portal's services for VKontakte users. In general, the ecosystem of urban services seems to be an innovative solution for creating and maintaining a sustainable urban environment, which can be scaled to other regions (Minaev et al., 2023).

However, as our previous research has shown (Filatova et al., 2024), not all services created by the authorities are in demand by citizens and only a small part of St. Petersburg residents access the ecosystem, although almost three years have passed since the launch of the ecosystem.

A series of focus groups conducted as part of the project showed that the use of digital services depends on two main factors: perceived quality of the service and awareness of it. Perceived quality is influenced by several external variables: how people perceive the security and privacy of a service; the discrepancy between supply and demand in terms of what is offered and what people are looking for; and the quality of the content, which includes web design and the quality of the information provided. However, as a very important reason, citizens named the poor awareness about the application "I live here" and the created ecosystem as an obstacle to the growth of the ecosystem. Therefore, as part of the research, we tested a tool for studying the dissemination of information in the media, social networks, instant messengers and mobile apps, which in the future can help in developing strategies for promoting new services.

3. Pilot Testing of an Automated Tool for Studying the Dissemination of Information in Social Networks and Instant Messengers

For the pilot testing of the new tool, the task was to collect all publications in the media and posts in social networks and instant messengers for six months that contain the phrases "ecosystem of urban services" and the separate service "I live here". Next, it was analysed how users discuss these topics in social networks and instant messengers and how information is disseminated.

The stages of the study included several key steps. At the initial stage, the analytical service "Medialogy" was used to collect data, which allowed collecting all messages and publications that contained the phrases "I live here" and "Ecosystem of city services" from various sources, such as media, social networks and instant messengers. These data were accumulated and stored in a database for subsequent analysis. Based on the collected data, topic modelling was carried out using machine learning algorithms such as LDA (Latent Dirichlet Allocation) to identify the main topics and sentiments in the discussions. The topic modelling stage allowed identifying key topics related to the use of the "I live here" service, determining positive, negative and neutral user sentiments, and detecting the trends in the discussions. The final stage of the study was a comparative analysis of data collected from social networks and messengers.

The messages were collected for the period from February 1, 2024 to May 1, 2024. The database for the query "I live here" consisted of 17,691 posts and 9,935 comments. However, this is too common a phrase, so the words "service", "application" and others were added to identify comments on the topic of the application. As a result, 3,820 thematic posts and 115 comments on the topic were identified. For the query "ecosystem of urban services", 928 posts and only 5 comments were found.

Table 1 presents the results of topic modelling performed using the LDA (Latent Dirichlet Allocation) algorithm to analyse the corpus of comments containing mentions of the “I Live Here” service. LDA is a machine learning method for topic modelling that allows to automatically detect hidden topics in texts. The main principle of the method is that each document is considered as a mixture of several topics, and each topic is represented by a set of words associated with certain probabilities.

The algorithm identified four key topics in the analysed dataset (Table 1). The topic 2 contains mostly general words that do not carry a specific information load. Topics 1, 3, and 4 include more subject groups of words related to various aspects of the service. The first topic concerns issues related to energy resource management and news about power outages, the third topic concerns issues related to kindergartens and the provision of services through

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

the public services portal, and the fourth topic concerns the availability of preschool institutions for children in different age groups and areas.

Overall, the analysis showed that, with some exceptions, no residents discuss the topic of urban digital services provided by the city government. Thus, only five key news items were identified over the six months, which were initially released by the government of St. Petersburg, and then these same news items were verbatim posted a large number of times in various government public pages, mainly in the accounts of schools, kindergartens, and housing agencies. Comments on them are extremely rare and almost always with zero engagement.

Table 1. Results of topic modelling

No.	Topics
1	water, follow, energy resources, news, development, group, service, being developed, notifications, shutdowns
2	I live, application, service, residents, month, meaning, unfortunately, pick up
3	kindergarten, portal, translation, online, carried out, course, reception, submit, public services
4	children, available, level, places, areas, age, availability, preschool, age, present

4. Research Case 2: Mobile Application "Unified Card of St. Petersburg Resident"

To conduct the study, a parser program was created that allowed to automatically collect all reviews for the period 2019-2024 from the Google Play Market platform related to the mobile application "Unified Card of St. Petersburg Resident" (Russian abbreviation: EKP). As a result, more than 600 reviews were collected, which contained both text data and user ratings (grades). The analysis included several stages: collecting data from the platform, preprocessing the text array, classifying reviews and topic modelling using the LDA (Latent Dirichlet Allocation) method.

To prepare the data before applying LDA, they were pre-processed to improve the quality of the analysis. At this stage, the texts were “cleaned”, including the removal of punctuation, numbers and extra spaces, as well as conversion to a single lower case. Stop words that do not have a semantic value were excluded, and lemmatization was carried out, allowing words to be converted to basic grammatical forms.

The next step was to implement the topic modelling procedure using LDA. The algorithm, trained on the prepared text data, identified a specified number of topics. The key topics related to the functionality of the application, the quality of its implementation, the convenience of the interface, and the desired expansion of functionality by users were identified (Table 2).

Table 2. Results of user comments topic modelling

No.	Topics
1	card, travel, code, enter, ekp, in general, get, metro, excellent, application
2	cards, balance, top up, application, metro, application, world, extremely, idea, developers
3	applications, balance, ekp, application, metro, money, top up, application, cards, activate
4	application, stop, works, sheet, card, convenient, support, map, entrance, transport
5	application, fit, metro, ekp, googl, pay, opens, password, updates, upd
6	works, application, record, updates, application, applications, enter, balance, confirmed, travel card
7	in general, application, cards, opportunity, pin, enter, travel card, stopped, constantly, top up
8	useless, card, password, impossible, map, application, works, internet, get, bank
9	card, application, cards, fingerprint, data, writes, transport, metro, podorozhnik, balance
10	works, application, writes, application, cards, impossible, top up, activation, useless, card

The overall analysis shows that the main concerns of users are related to technical problems, balance management, and functionality in the context of transport. User comments contain a lot of useful information for improving the application. Figure 1 shows that this mobile application was evaluated in more than half of cases as “1” (369 out of 638), the lowest grade on a 5-point scale.

Authorities’ responses (Table 3) to user feedback focus on several key aspects: Technical troubleshooting; Feedback and

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

support; New features and expanded capabilities; Security and Access.

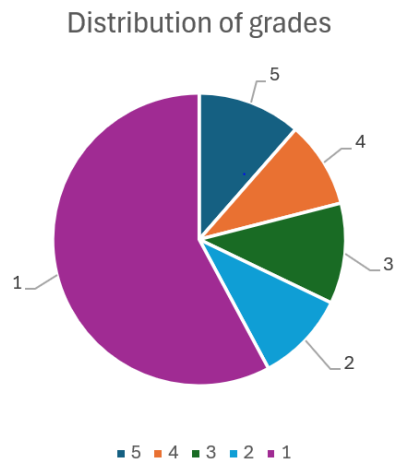


Fig. 1. Distribution of grades

Table 3. Results of authorities' responses topic modelling

No.	Topics
1	moment, application, ekp, evaluate, additional, inclusion, we plan, is, informational, in nature
2	technical, absent, independent, reasons, electronic, unfortunately, wallet, replenishment, possibility, application
3	apologies, we bring, inconvenience, eliminated, temporary, technical, pay, real, moment, will appear
4	should, application, clarify, errors, could, incident, payment, ekp, I ask, be sure
5	version, form, feedback, understand, model, indicating, we ask, review, error
6	authorization, service, support, ekp, application, mobile, contact, site, go through, public services
7	find out, store, incentives, application, project, surveys, news, service, you can, participate
8	pin, login, code, code, configure, cards, qr, you can, system, come up with
9	application, continue, work, useful, increase, number, functions, soon, problem, googl
10	pay, payment, add, vtb, ekp, rustor, available, first, samsung, mir

The general trend shows that authorities are actively working to improve the technical component of the application, its functionality and interaction with users, especially in terms of security and stability. There are also changes in feedback from the EKP: in 2019 about 10-15% of comments remained unanswered, but after 2022 all comments began to be answered. This indicates increased attention to user opinions and the readiness to improve the service.

5. Conclusion

The St. Petersburg government is campaigning to promote the city services ecosystem, and in particular the mini-application "I Live Here", but users still rarely use it. Citizens say that there is a lack of necessary information about the digital ecosystem, and also point out the lack of interactive functions for providing feedback. There are noticeable problems with the web design, navigation and search in the mini-application. The citizens are concerned about security and privacy issues. In fact, citizens are practically unaware of the "I Live Here" services and the product has no value for users yet. At the same time, we can talk about the high demand among citizens for the "Unified Card of St. Petersburg Resident", where, unlike the first case, there is active feedback from the authorities and work to eliminate the shortcomings of the service.

The further research will be related to identifying the reasons for the widespread use of non-governmental digital channels by citizens and the low use of government digital services, as well as a comparative analysis of data characterizing the behaviour of citizens with indicators of offline user activity.

Acknowledgement

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- **Funding or Grant** (if applicable)**:** The research was supported by the Russian Science Foundation and St. Petersburg Science Foundation Grant No. 23-18-20079 "The Social Efficacy of Electronic Interaction between Citizens and the Government: The Case of Urban Digital Services in St. Petersburg" (https://rscf.ru/en/project/23-18-20079/).
- **Contributor Statement***: Radomir Bolgov: Methodology, Investigation, Writing – Original Draft. Olga Filatova: Conceptualization, Methodology, Investigation. Daniil Volkovskii: Methodology, Writing - Review & Editing
- **Use of AI***: There is no use of AI
- **Conflict Of Interest (COI)***: There is no conflict of interest

References

Alawneh, A., Al-Refai, H., Batiha, K. (2013), Measuring user satisfaction from e-Government services: Lessons from Jordan. *Government Information Quarterly*, 30(3), 277-288.

Filatova O., Meteleva A., Slav Y. (2024). Assessing the Impact of Digital Services on Value-based City Management. *Proceedings of the 2024 Communication Strategies in Digital Society Seminar (2024 ComSDS)*. P.33-37.

Horan, T. A., & Abhichandani, T. (2006). Evaluating user satisfaction in an e-government initiative: results of structural equation modeling and focus group discussions. *Journal of information technology management*, 17(4), 187-198.

Kitsios, F., Stefanakakis, S., Kamariotou, M., Dermentzoglou, L. (2019). E-service Evaluation: User satisfaction measurement and implications in health sector. *Computer Standards & Interface*s, 63, 16-26. https://doi.org/10.1016/j.csi.2018.11.002.

Minaev, N.N., Lung, D.V., Korablyov, M.A., Tyueva-Zryakhova, A.A., Filatova, O.G. (2023). Digital Urban Services in the Regional Management System (using the St. Petersburg Urban Services Ecosystem as an Example). *Regional Economy: Theory and Practice*, 21(12), 2327–2341. (In Russian).

Novak, T.P., Hoffman, D.L., Yung, Y.-F. (2003). Measuring the customer experience in online environments: a structural modeling approach. *Marketing Science*, 19(1), 22-42.

Reynolds, R.A. (2011). Measurement of end-user computing satisfaction. In *End-User Computing* (pp. 894-896). Management Information Systems Research Center, University of Minnesota, 12.

Tang, J., Wang, W. (2004). Sources of aggregate labour productivity growth in Canada and the United States. *Canadian Journal of Economics*, 37(2), 421-444.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Performance Indicators Development for Public Services using an AI-based clustering approach.

Victor de Almeida Xavier[a*], *Felipe* Maia Galvão França[b], *Priscila* Machado Vieira Lima[c,d], *Nelson* Maculan[e],

[a]PESC, COPPE, UFRJ, Brazil, victorx@cos.ufrj.br, 0000-0002-2281-6356.

[b]IT, University of Porto, Portugal, felipe@ieee.org, 0000-0002-8980-6208.

[c]PESC, COPPE, UFRJ, Brazil, priscilamvl@cos.ufrj.br, 0000-0002-8515-9904.

[d]AEP, NCE, UFRJ, Brazil, priscilamvl@cos.ufrj.br, 0000-0002-8515-9904.

[e]PESC, COPPE, UFRJ, Brazil, macualn@cos.ufrj.br, 0000-0002-3897-3356.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. Despite the hype for AI-based generative applications, the original pitfalls in implementing AI-based technologies remain: data quality, readiness, and availability. AI results are tied to the quality of the data provided to the underlying algorithms. Inevitably, bad data produces bad results. The same happens for data readiness and availability: without correct preparation and access, even high-quality data cannot be used in AI-based solutions. To help decision-makers in the public sector, performance indicators applied to processes and, therefore, to public services can be used as tools to guide public project selection, allocation of resources, monitoring of results, etc. In this way, performance indicators can be used to standardize the evaluation of public policies, helping citizens and city administrators make more informed decisions regarding the environment they live in. In the present work, we propose a performance indicator development process (PIDP) based on AI clustering techniques, which can be used to gather key performance indicators (KPI) among available data from open data sources and consumed and/or produced by the core processes that implement a public service.

Keywords. Performance Indicators, KPI, AI, Clustering, ClusWiSARD, K-Means, DBSCAN, Hierarquical, DDDM
Poster, DOI: https://doi.org/10.59490/dgo.2025.1055

1. Introduction

Data-driven decision-making (sometimes abbreviated as DDDM) is the process of using data to inform your decision-making process and validate a course of action before committing to it (Stobierski, 2019). Despite its extensive use as a business management tool in the private sector, DDDM can and should be used to help decision makers in the public sector. The main goal of DDDM is to provide mechanisms for stakeholders in the public sector to make more informed decisions. For this reason, the ”data” part in DDDM is crucial in the decision-making process. Low-quality data should certainly lead to poor information provided to those stakeholders. Data quality is not easily verifiable during the decision-making process.

Performance indicators (PIs) are one of the most commonly used tools to evaluate processes in terms of effectiveness (Fisher, 2019) and their use is ubiquitous in the public sector (Smith, 1999). Key Performance Indicators (KPIs) are the result of performance indicators development and is tightly correlated to data processing based on artificial intelligence methods and technologies, as pointed by Bilal and Oyedele, 2020. The capacity of a KPI correctly identify in which level a public policy or service stands is closely dependent on the capacity of each PI that composes it. And each identified PI relays on the data that was used to gauge it.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2. Performance Indicators Development Process (PIDP)

The Performance Indicators Development Process (PIDP), as defined in our previous work brought by Xavier et al., 2024, explores and analyzes processes-related data to look for candidates for performance indicators. The PIDP uses clustering techniques to group related data together. First, the data is downloaded from available public data sources. The samples with the standardized data are analyzed to search for performance indicators among the features, present as the name of the columns of the data set. The PIDP also deals with difficulties regarding the quality of the data being processed. The same process is presented by other techniques like data envelopment analysis (DEA), as pointed by Ferreira et al., 2023. The PIDP depicts the basic concepts of PIs implementation. For this aspect, it can be seen as a framework to achieve the PIs implementation's goals, as a stakeholder-centred process developed by Dransfield et al., 1999

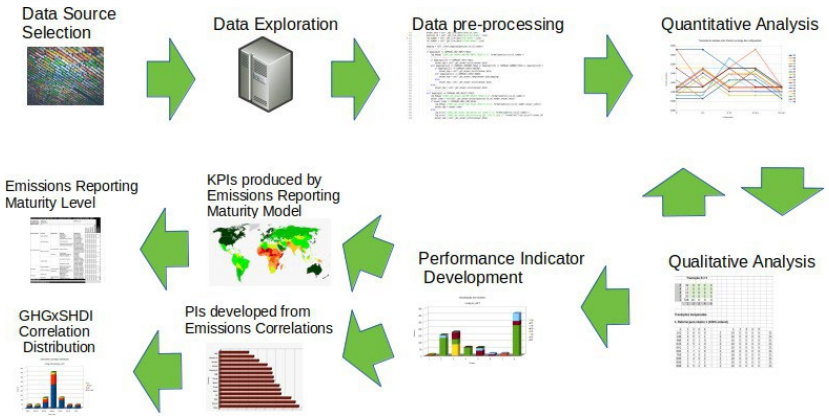


Fig. 1 – Performance indicators development process (PIDP) general view

The PIDP workflow overview is synthesized in Figure 1.

2.1. Data sources selection

The first step in the performance indicators development process (PIDP) is to obtain reliable data used in the decision-making process. For example, if the city administrators are interested in green-house gas' (GHG) emissions impacts, the PIDP will download data from databases that contain emissions-related data. Thus, cities represent a minimal viable comparison unit in this work.

In this work, we will use a public database provided by CDP (Carbon Disclosure Project) that contains emissions-related data from 814 cities gathered in 2019.

2.2. Data exploration

The next step in the PIDP is to narrow the emissions-related data into data units. A data unit is an abstraction extracted from the data structure (answers field in the CDP database, for example) that can provide insights on candidates to performance indicators.

The data to be explored should be initially reduced to represent a context (period of time, origin of the data, focus of the study - cities). Thus, the main goal of this scope filtering is to filter the valuable data among the data available from the databases. The process initiates attempts to correct errors such as inconsistencies found in the available data: e.g. wrong data type, empty value in "selection" or "multi-selection" answer type, empty value in "not null" answer. If the error cannot be recovered using other data from the same record, the record is discarded.

2.3. Data pre-processing

The data preprocessing step is responsible for preparing the available data to be correctly used by the cluster- ing algorithms and it requires the data to be cleaned from consistency errors. After an initial inspection of the data in the CDP database forms, inconsistencies and errors were found that could jeopardise the clustering process.

According to Shepperd et al., 2013, the best preprocessing strategy is that in which the problematic data should be treated first. Some cases of either conflicting feature values or implausible values should be discarded

before data can be used. Therefore, it was necessary to build a support system to deal with these issues and leverage the quantitative and qualitative analysis steps.

In this work, we use **functional data filtering**, in which filtering parameters are passed to preprocessing execution module to segregate only the information needed in the context of a preprocessing configuration and optimise the drill down during quantitative and qualitative analyses, and **errors mitigation** techniques, which can try to mitigate the effects of typos and other simple errors in the next steps of PIDP.

2.4. Quantitative analysis

The quantitative analysis of the results obtained from the clustering methods can be used to indicate features with better chances to be used as performance indicators. Thus, the clustering results are treated and viewed as an alternative to purely statistical ones. However, the main goal is to search for similarities and answers that indicate different approaches implemented by the cities that are grouped in the same cluster. The nuances of the clustering process, the comparative data generated, and the validation techniques are shown in the following sections.

2.5. Qualitative analysis

The main objective of the qualitative analysis phase is to compare the responses of different cities present in the same cluster, indicating a convergent approach over the data. Another strategy is to compare different responses from cities in different clusters, indicating a divergent approach in this case. The following sections detail the techniques involved in the step of the process.

To achieve this goal, the PIDP uses two techniques: and adaptation of **Grounded Data Theory**, in which the samples are checked for inconsistencies, and **Case Study**, in which a sample can be used to downgrade a PI's candidate.

3. Results

3.1. PIs developed from Emissions Reporting Correlations

Analysing the emissions reporting data correlations are another way to look for performance indicators. After some experiments with broadly used indicators like GDP, HDI and their variants, and others like OECD, C40, GCoM and SCI memberships, some results indicate correlations between then and emissions reported by cities. The cities total emissions clusters distribution is shown in Figure 2.

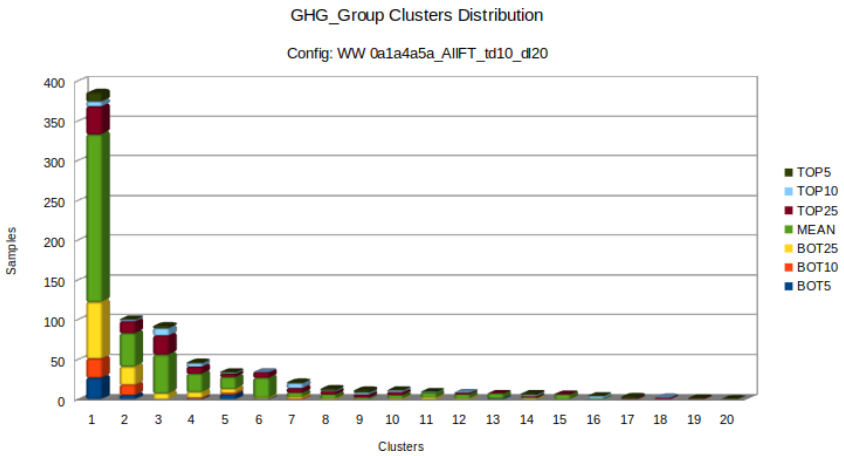


Fig. 2 – Cities total emissions in 2019 clusters distribution using configuration WW_0a1a4a5a_AllFT.

3.1.1. PI: SHDI x Cities Emissions

The correlations between emissions and human development index (HDI) can be seen in studies at the country level. Nevertheless, this work aims to use available sub-national human development index (SHDI) information to investigate the correlation between this index and cities total emissions.

3.1.2. PI: OECD x Cities Emissions

The organisation for Economic Co-operation and Development (OECD)OECDorganisation for Economic Co-operation and Development is a membership of developed countries that cooperate in economic matters. The cities in these countries follow the policies and directives negotiated in forums promoted by OECD. To some extent, part of these policies is applied as is by the cities.

3.1.3. PI: GCoM Membership

The Global Covenant of Mayors for Climate & Energy (GCoM) has more than ten thousand participant cities. It aims to monitor hazardous events related to climate and energy that occur inside cities' boundaries through mitigation plans and other additional information.

During the analysis, the prevalence between GCoM and CDP database was 73%, indicating that 219 cities reached by CDP partnership are still not part of GCoM by 2019. Considering the clusters with a prevalence ratio over 90%, clusters 5, 12, 16, 17, 18, 19, and 20 had 59 samples reprocessed.

However, the data obtained during the implementation of the plans are not uniform. A reason is that even though these cities were selected by representing overall performance, their methodology varies based on many aspects not covered by the questions set. An example of it is the question "4.3:Please give the name of the primary protocol; standard; or methodology ... city-wide GHG emissions".

3.1.4. PI: Smart Cities Index Membership

A consortium of international organisations maintains the Smart Cities Index (SCI) to rank cities in terms of developing connectivity to services provided by the cities. The list of cities in SCI in 2019 is available in the appendix. The cluster distribution of SCI members is shown in Figure 3. The SCI 2019 had 111 cities, and

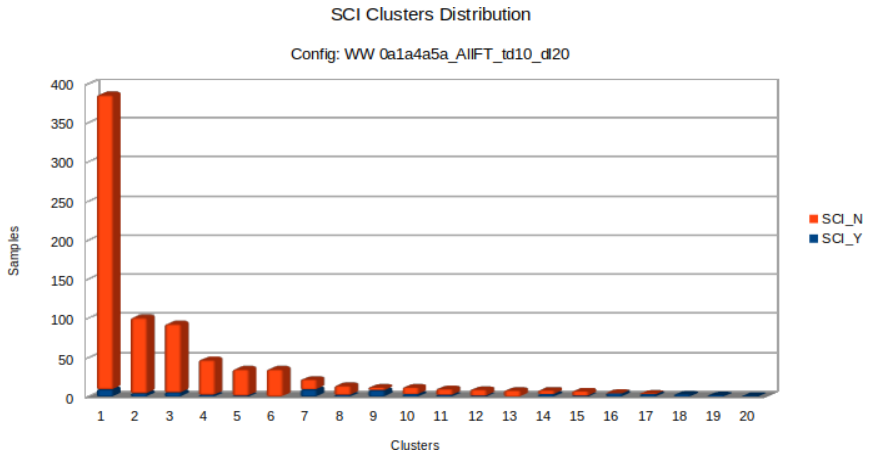


Fig. 3 – SCI clusters distribution using configuration WW_0a1a4a5a_AllFT.

63 of them are part of the CDP initiative. Even though it is not expected that all SCI cities have any direct goal related to emissions reduction, selecting the ones that are part of the CDP initiative introduces a bias that needs to be considered during the analysis. The clusters with SCI minimal prevalence were 1, 7, 9, 16, 18, 19, and 20, and the frequency of positive answers is similar to those of C40, although the execution of the actions is better. The distribution is shown in table 1 for comparison.

The distribution of the answers is a little more stable in this case. Still, 10% of the selected cities does not have a GHG emissions reduction target in place. In clusters 1 and 2, we have situations that represent errors during data processing or cities entered; the value "0" indicates that no information was provided. However, in clusters 4 and 7, there are some indications of "planning and not executing", confirming some cities have problems running the last mile and, for this, not getting the full benefits from emissions reduction initiatives.

The average of SHDI for cities in SCI is very high (879) and it is inclined to some uniformity in answers for at least 90% of them. It can be seen in distributions by clusters and by regions.

Tab. 1 – Selected samples clusters 1, 7, 9, 16, 18, 19 and 20 which are also in SCI database. The answers frequencies to the questions 1.0, 4.0 and 5.0 are shown.

Question	Positive Answers	Negative Answers
1.0: Does your city incorporate sustainability goals and targets (e.g. GHG reductions) into the master planning for the city?	93.65%	6.35%
4.0: Does your city have a city-wide emissions inventory to report	96.83%	3.17%
5.0: Do you have a GHG emissions reduction target in place at the city-wide level?	90.84%	9.52%

4. Conclusion and future works

According to the results of the experiments using PIDP and CDP, GCoM and SHDI databases, we can support the conclusion that it is possible to address the key performance indicators discovery through the development of performance indicators based on the analysis of the data present in those databases and the inter relations expressed in correlations found in them. Despite the correlations are weak in the first view, the qualitative analysis of the data showed problems regarding the quality of the data, mainly in the CDP database, in which data set were found both type of errors: typos and leniency, expressed in the form of the selection of the "first option" of the list box in some answers in which they are not suppose to exist.

To address this finding, one alternative is to develop an evaluation model of the quality of the data capable of predict idiosyncrasies in the fulfilment of the forms that are in the origin of the problematic data. In future works, we are aiming to develop these model, aggregating other AI-based technologies and a time series evaluation mechanisms.

Acknowledgement

- **Contributor Statement** based on Policies (tudelft.nl):
  Victor: Conceptualization, Data Curation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing – Original Draft, Writing - Review & Editing
  Priscila: Supervision, Validation
  Felipe: Validation
  Maculan: Supervision
- **Conflict Of Interest (COI)***: "There is no conflict of interest"

References

Bilal, M., & Oyedele, L. O. (2020). Big data with deep learning for benchmarking profitability performance in project tendering. *Journal of Expert Systems with Applications, vol 147, pp. 113194*.

Dransfield, S. B., Fisher, N. I., & Vogel, N. J. (1999). Using statistics and statistical thinking to improve organisational performance (with discussion). *Int. Statist. Rev., 67, 99–150*.

Ferreira, D. C., Figueira, J. R., Greco, S., & Marques, R. C. (2023). Data envelopment analysis models with imperfect knowledge of input and output values: An application to portuguese public hospitals. *Journal of Expert Systems with Applications, vol 231, pp. 120543*.

Fisher, N. (2019). A comprehensive approach to problems of performance measurement. *J. R. Stat. Soc. A, 182: 755-803. https://doi.org/10.1111/rssa.12424*.

Shepperd, M., Song, Q., Sun, Z., & Mair, C. (2013). Data quality: Some comments on the nasa software defect datasets. *IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, vol. 39, n. 9, pp. 1208-1215*.

Smith, P. (1999). The use of performance indicators in the public sector. *Journal of the Royal Statistical Society Series A, Royal Statistical Society, vol. 153(1), pages 53-72*.

Stobierski, T. (2019). *The advantages of data-driven decision-making* (tech. rep.). Harvard Business School.

Xavier, V., França, F. M., & Lima, P. M. (2024). Emissions reporting maturity model: Supporting cities to leverage emissions-related processes through performance indicators and artificial intelligence. *RAIRO-Operations Research, v.58 ed.2 pp.1401-1428*.

PIX, Open Finance, and DREX: Cases of digital public infrastructure in Brazil

Vanessa da R. S. Almeida [a*], *Marie* Anne Macadar [b]

[a] COPPEAD Graduate School of Business, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, vanessa.almeida@coppead.ufrj.br, 0009-0002-2693-7355.

[b] COPPEAD Graduate School of Business, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, marie.macadar@coppead.ufrj.br, 0000-0003-2744-5352.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 3 June 2025

Abstract. Digital Public Infrastructure (DPI) is a new concept that garnered significant attention during the 2023 G20 discussions. DPIs can help advance all United Nations Sustainable Development Goals, making research in this area critically important. Despite its significance, academic literature on DPI is still scarce. To help cover this gap, this poster proposes a DPI evaluation framework based on the United Nations' definition of DPI. The evaluation framework was applied to three potential DPI cases that emerged from the Brazilian finance sector. The selected cases include PIX, an instant payment solution; Open Finance Brazil, a consent-based data exchange solution; and DREX, the Brazilian central bank digital currency. Using the proposed evaluation framework, it was demonstrated that the first two cases can be considered DPIs, and the last one has the potential to become a DPI.

Keywords. Digital Public Infrastructure (DPI), PIX, Open Finance, DREX, Central Bank Digital Currency (CBDC).
Poster, DOI: https://doi.org/10.59490/dgo.2025.931

1. Introduction

During G20 India's presidency in 2023, the concept of Digital Public Infrastructure (DPI) got much attention (G20 Global Partnership for Financial Inclusion, 2023). In partnership with G20 India's presidency, the United Nations published a report connecting DPI's examples with the challenges of the Sustainable Development Goals (SDGs). The United Nations considers that the DPI approach has the potential to accelerate all the SDGs (United Nations, 2023).

Academic literature on this concept remains scarce. Researchers are trying to cover this gap. A DPI Map (Eaves et al., 2024) was recently published, identifying more than 250 cases of DPIs. However, these cases were not analyzed in depth. This poster addresses the following research question: what are the cases of DPI emerging in the Brazilian finance sector?

United Nations defines DPIs as: "a set of shared digital systems that should be secure and interoperable and can be built on open standards and specifications to deliver and provide equitable access to public and/or private services at societal scale and are governed by applicable legal frameworks and enabling rules to drive development, inclusion, innovation, trust, and competition and respect human rights and fundamental freedoms" (United Nations, 2023). Considering this concept of DPI, we identified three possible DPI cases in the Brazilian finance sector: PIX, Open Finance Brazil (OFB), and DREX. We proposed a framework to evaluate whether a case is a DPI and applied it to the three identified cases. After that, we discussed the implications of our findings for the DPI

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

scenario.

The remainder of this poster is organized into seven sections. Section 1 introduces the subject and the research. Section 2 presents the research method. Section 3 presents the DPI evaluation framework. Section 4 presents the three cases identified and evaluates them using the proposed framework. Section 5 discusses the implications of the findings and proposes future research. Section 6 presents the references.

2. Method

After conducting an exploratory review of the bibliography, the authors found that the concept of DPI is not well-established in the academic literature. Unsurprisingly, finding an evaluation framework for potential DPI cases was impossible. The authors focused on the United Nations definition of DPI and developed a DPI Evaluation Framework. This framework aims to support evaluating a case to determine whether it is a DPI, has the potential to scale as a DPI, or is not a DPI.

Some case studies of potential DPIs were performed, and the framework was applied. A case study is a research strategy that focuses on understanding particular situations. The research can involve single or multiple cases and collect different data types, like documents, interviews, questionnaires, and observations. Case studies are suitable for emergent study fields (Eisenhardt, 1989). Although the triangulation of multiple data collection methods is recommended (Eisenhardt, 1989), it is not mandatory. Case studies can be applied and used in many ways. Multiple cases may not yield the same rich descriptions as single cases, but they enable cross-data analysis (Cavaye, 1996).

The authors conducted a multiple-case study, selecting three cases from the Brazilian finance sector. It is essential to note that the finance sector was selected for scrutiny due to its direct connection to financial inclusion. Financial inclusion has been reported as an expected benefit of the DPI approach (G20 Global Partnership for Financial Inclusion, 2023). The cases identified were analyzed using secondary source data from official websites and online press. Then, the proposed DPI Evaluation Framework was applied to the cases. The retrieved data was sufficient to perform the evaluation using the evaluation framework. The cases and the evaluation results were compared and discussed.

3. DPI Evaluation Framework: a proposal

Based on the United Nations definition (United Nations, 2023), we proposed an evaluation framework for potential DPIs that can be in use, under implementation, or in conception. To develop the framework, the concept of DPI was broken into twelve characteristics that a potential DPI can have. These characteristics are respect for human rights, respect for fundamental rights, security, interoperability, open standards and specifications, access to public or private services, societal scale, legal frameworks, inclusion, innovation, trust, and competition.

Then, the characteristics were grouped into five topics, considering their similarities- and these topics were added to the framework. The five topics are (a) the qualifying conditions, (b) the technical aspects, (c) the value proposition, (d) the legal support, and (e) the enablers.

The qualifying conditions are the first to be analyzed, as cases without them cannot be considered potential DPIs. Technical aspects relate to a DPI's intrinsic characteristics, while the value proposition is related to how the DPI will be used. Legal support is closely tied to the enforcement of DPI and is essential to its legitimacy. The enabler aspect addresses what the DPI does not deliver but can enable through its use and dissemination.

Each characteristic of the evaluation framework can be evaluated in one of the proposed classifications: confirmed, planned, not considered, or missing information. The status “confirmed” will be used for potential DPIs that are in use and have the characteristic. The status “planned” will be used for potential DPIs under implementation/concept that plan to release the characteristic. The status “not considered” will be used for potential DPIs that do not (or will not) deliver the characteristic. The status “missing information” will be used when the researcher does not have sufficient information to analyze a characteristic.

4. Results

The case studies were based on secondary source data, including documents, websites, press media, videos, and norms. The authors collected four documents about PIX, five documents about OFB, and five documents about DREX. Table 1 summarizes the PIX, OFB, and DREX evaluations using the proposed framework. Sections 4.1, 4.2, and 4.3 describe the main characteristics and benefits of each infrastructure.

Table 1: Summary of PIX, OFB, and DREX evaluation using proposed framework

	PIX	OFB	DREX

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Qualifying conditions	Respects human rights	Confirmed	Confirmed	Planned
	Respects fundamental freedoms	Confirmed	Confirmed	Planned
Technical aspects	Secure	Confirmed	Confirmed	Planned
	Interoperable	Confirmed	Confirmed	Planned
	Open standards and specifications	Confirmed	Confirmed	Planned
Value proposition	Access to public or private services	Confirmed	Confirmed	Planned
	Societal scale	Confirmed	Confirmed	Planned
Legal	Governed by legal frameworks	Confirmed	Confirmed	Planned
Enabler	Of inclusion	Confirmed	Confirmed	Missing information
	Of innovation	Confirmed	Confirmed	Planned
	Of trust	Confirmed	Confirmed	Planned
	Of competition	Confirmed	Confirmed	Planned

5.1 Case 1: PIX

PIX is an instant payment solution created by the Brazilian Central Bank (BCB) and launched in 2020. The significant benefits of PIX are its availability, cost, and ease of use. A person or business can make a payment 24 hours a day and 7 days a week, including holidays. People who use PIX do not incur transaction fees. Businesses that use PIX may incur lower fees compared to other payment methods. To make a transfer with PIX, it is not necessary to know the bank account of the recipient because the transfer uses a key that can be an email address, telephone number, Brazilian identifier (CPF or CNPJ), a random number, or a QR code.

PIX brought democratization and financial inclusion. It is a versatile solution that can handle various use cases. It is secure because banks have invested in ensuring robustness and security. Additionally, it is open and integrated, allowing for seamless engagement with both the traditional financial ecosystem and new entrants. The financial ecosystem has benefited from the launch of PIX. It helped increase digital payment, reducing the cost of using cash. It also stimulates competition between payment methods and the entry of fintech and big tech companies into this market.

5.2 Case 2: Open Finance Brazil

Open Finance Brazil (OFB) is a solution that enables the sharing of clients' data between authorized agents, as specified by the BCB, with the client's consent. OFB supports the sharing of data about each participant institution's products and services, the sharing of transactional client data, the starting of instant payments from interfaces that are not owned by the institution that has custody of funds and plans to connect with the insurance market.

The significant benefits for clients are easier control of their financial lives and ownership of their financial data. With OFB, clients can visualize multiple accounts using a single interface, making it easier to manage savings and debts. Data ownership enables clients to leverage their history to establish a relationship with other financial institutions, secure better rates, and gain access to credit. OFB can benefit the financial services ecosystem by enabling competition among financial institutions and fostering a more dynamic market.

5.3 Case 3: DREX

DREX is digital Real (Brazilian currency), a central bank digital currency (CBDC) for Brazil. A central bank digital currency (CBDC) is a digital liability of a central bank or other competent authority representing a jurisdiction’s sovereign currency available to the private sector (Dionysopoulos et al., 2023). More than a solution, DREX intends to be a platform for tokenization.

DREX aims to address the issue of delivery versus payment, where individuals must trust intermediaries to facilitate secure exchanges of expensive goods, such as cars or apartments. DREX may also address the challenges of international remittances and trade. Additionally, DREX can bring innovation to the financial market, generating benefits that cannot be accurately measured in advance.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

5. Discussions and Future Research

The evaluation showed that considering the United Nations' definition of DPI (United Nations, 2023) and the evaluation framework proposed in this poster, PIX and OFB can be considered a DPI. On the other hand, DREX should be considered a potential DPI. The project is under implementation, but from the outset, it considers important characteristics of DPI as foundations for the platform it intends to deliver. The characteristic enabler of inclusion was identified as missing information, as it was not possible to find consistent references to inclusion in the retrieved documents. Hence, it is desirable to gather more information to determine whether or not it is a planned characteristic that was not well communicated.

DPIs in use must be continually evaluated, particularly in how they enable development, inclusion, innovation, trust, and competition. Although it is important to be an enabler of such actions to be considered a DPI, it is not guaranteed that these actions will happen. The creation of key indicators to measure the impact of DPIs on the entire ecosystem can help inform decisions about investments in the evolution and growth of DPIs.

This evaluation must be accompanied by a governance established for each project (implementation phase) or product (usage phase). Technical governance can evaluate the technical aspects and supervise the implementation and evolutions to guarantee that security, interoperability, open standards, and specifications are delivered and continually updated. Institutional governance can evaluate the value proposition, legal support, and enablers, make decisions about how to implement them, how to expand the usage of the infrastructure, and which partnerships need to be developed. All the cases analyzed use collaborative governance strategies (Olvik, 2024). These strategies are crucial to managing wicked problems that traditional methods cannot easily solve. Collaborative strategies try to create value for all parties involved, transforming the problem-solving process into a win-win game.

Unsurprisingly, the BCB led all the cases analyzed. BCB is a regulator of the Brazilian finance sector, aiming to make the market more efficient and promote financial inclusion. In a public report, BCB recognizes the difficulty of articulation of the private sector to create PIX infrastructure and the essential role of a public sector institution in coordinating the project (Banco Central do Brasil, 2022). It is important to study and theorize the role of public and private institutions in creating and promoting DPIs. Mazzucato and Ryan-Collins (2022) propose that the public sector needs to set a direction and public purpose for private and public actors to collaborate and innovate in solving societal problems, which they refer to as a "market-shaping" perspective. BCB may act in a "market-shaping" perspective, considering their coordination role in the three cases studied.

Considering that DREX is currently under implementation, further research is needed to investigate DREX in more detail. Future work can explore the relationship between CBDCs and DPIs. Another aspect that could be investigated in future studies is the issues related to the collaboration governance established for the project and how they connect to governance literature.

Contributor Statement

Vanessa da R. S. Almeida was responsible for conceptualization, data curation, methodology, and writing – original draft. Marie Moron Macadar was responsible for supervision, methodology and writing – review and editing.

Use of AI

During the preparation of this work, the author(s) used Grammarly in order to correct grammatical errors. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Banco Central do Brasil. (2022). *Relatório de Gestão do Pix Concepção e primeiros anos de funcionamento*. Available:https://www.bcb.gov.br/content/estabilidadefinanceira/pix/relatorio_de_gestao_pix/relatorio_gestao_pix_2023.pdf Accessed: 03/29/2025

Cavaye, A. L. M. (1996). Case study research: A multi-faceted research approach for IS. *Information Systems Journal*, *6*(3), 227–242. https://doi.org/10.1111/j.1365-2575.1996.tb00015.x

Dionysopoulos, L., Marra, M., & Urquhart, A. (2023). Central bank digital currencies: A critical review. *International Review of Financial Analysis*, 103031. https://doi.org/10.1016/j.irfa.2023.103031

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Eaves, D., Rao, K., Pagliarini, G., & Vera, K. (2024). Global State of DPI. In *DPI Map*. Available:https://dpimap.org/global-state-of-dpi Accessed: 03/29/2025
Eisenhardt, K. M. (1989). Building Theories from Case Study Research. In *Source: The Academy of Management Review* (Vol. 14, Issue 4). https://www.jstor.org/stable/258557
G20 Global Partnership for Financial Inclusion. (2023). *G20 Policy recommendations for advancing financial inclusion and productivity gains through digital public infrastructure*. Available:https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099092023121016458/p178703046f82d07c0bbc60b5e474ea7841 Accessed: 03/29/2025
Mazzucato, M., & Ryan-Collins, J. (2022). Putting value creation back into "public value": from market-fixing to market-shaping. *Journal of Economic Policy Reform*, *25*(4), 345–360. https://doi.org/10.1080/17487870.2022.2053537
Olvik, J. (2024). Navigating Complexity: Potentials and Paradoxes Within Governance Strategies for Public and Third Sector Collaboration. *Voluntas*. https://doi.org/10.1007/s11266-024-00682-3
United Nations. (2023). *Accelerating the SDGs through digital public infrastructure.* Available:https://www.undp.org/publications/accelerating-sdgs-through-digital-public-infrastructure-compendium-potential-digital-public-infrastructure Accessed: 03/29/2025

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The evolving AI regulation space: A preliminary analysis of US state legislations addressing AI, 2024

Nic DePaula [a*], *Lu* Gao [b], *Sehl* Mellouli [c], *Luis* F. Luna-Reyes [d], *Teresa* M. Harrison [e]

[a] College of Health Sciences, SUNY Polytechnic Institute, Utica, NY, USA, depauln@sunypoly.edu

[b] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, Albany, NY, USA

[c] Department of Management Information Systems, Université Laval, Québec, Canada

[d] Rockefeller College of Public Affairs and Policy, University at Albany, Albany, NY, USA

[e] Department of Communication, University at Albany, Albany, NY, USA

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19May 2025

Abstract. As artificial intelligence (AI) technologies proliferate, the US federal government has oscillated on related executive orders, and no federal laws have addressed AI comprehensively. However, many states have passed legislations related to AI in the previous 5 years, and these laws are evolving and becoming more targeted, creating challenges and opportunities for government agencies. For this study, we compiled all passed and enacted legislations across the 50 US states in 2024 and examined them in terms of: *domains; regulation of AI use in the public sector and industry; and novel topics and issues being addressed.* In this preliminary analysis, we find that recent AI legislations are multiplying across US states, but unevenly. AI regulation across states continue to address various domains, including healthcare, education, and now also generative AI and AI-generated content. Legislations are expanding the role of the public sector in AI governance and AI policies, but issues of AI ethics, such as bias, are unevenly addressed across states, and few states have comprehensive AI governance frameworks.

Keywords. AI regulation, AI legislation, AI in government, AI policy, AI governance
Poster, DOI: https://doi.org/10.59490/dgo.2025.937

1. Introduction

Artificial intelligence (AI) technologies continue to proliferate in public and private organizations (Medaglia et al., 2023; Zuiderwijk et al., 2021). Although the use of AI technologies is attractive through the promise of increased efficiencies, productivity and augmented cognitive capabilities, it has also proven to be a risky endeavour with potential negative consequences (Sousa et al., 2019; Wirtz et al., 2020). To address these negative consequences, ethical frameworks and regulations have been proposed (Barfield & Pagallo, 2022; Harrison & Luna-Reyes, 2022). Globally, the European Union is leading in terms of AI regulation (Artificial Intelligence Act, 2024) where the EU AI act mandates governance mechanisms and risk management practices for different types of AI technologies. In the United States (US), there is no broad legal framework to address AI, but executive orders and references to AI activities have been made in some legislations. On January 23, 2025, President Trump rescinded President Biden's prior Executive Order on AI (Federal Register, 2023) but promised that his administration would create an AI action plan to "sustain and enhance America's global AI dominance in order to promote human flourishing, economic competitiveness, and national security" (White House, 2025, Jan. 23).

In the meantime, many US states are actively promoting and/or regulating various aspects of AI (DePaula et al., 2024). While previous research has examined some aspects of these US state legislations, in this study we report on US state legislations passed or enacted in 2024 and discuss them in relation to previous trends in AI state legislations. We find a considerable increase in the amount of legislation addressing AI, an expansion into distinct issues not previously addressed, and a notable increase in the legislations providing comprehensive frameworks to address AI. In the following sections we explain our methods, report on preliminary results and discuss findings in terms of the implications for governments and digital government scholars.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

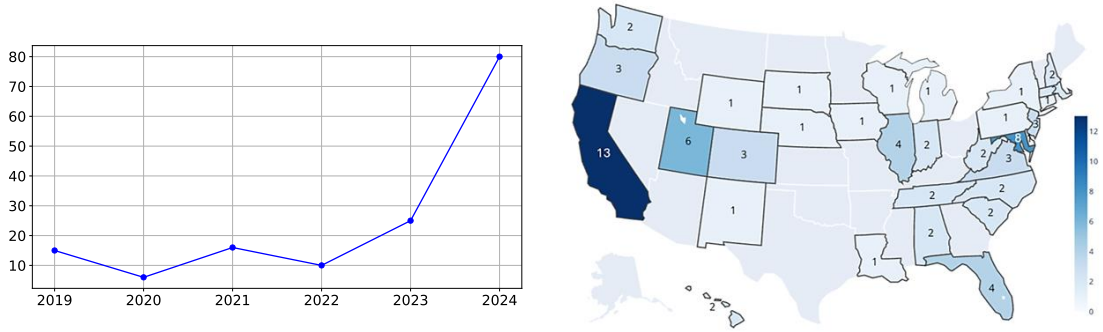
2. Methodology

For this study, we compiled all passed and enacted legislation addressing AI in 2024 across the 50 US states from the National Conference of State Legislatures (NCSL, 2024) which yielded N=79 legislations. For this preliminary report, we examined these legislations in terms of several aspects, namely: *domains; regulation of AI use in the public sector and industry; and novel topics and issues being addressed.* The authors discussed and examined the categories of analysis in multiple coding iterations, and then divided the legislations among the authors so that each legislation was independently examined by at least two authors (detailed protocol available upon request). Further, we discussed commonalities and discrepancies across authors, and reached agreement on the most reasonable interpretation of the legislation for our categories given the text of the legislature and our coding rules.

3. Results

We present preliminary results of our analysis of US state legislations related to AI passed or enacted in year 2024. First, Figure 1 shows the growth in legislations over the years, and the total number of legislations passed/enacted across states in 2024.

Fig 1. Total passed and enacted legislations addressing AI: 2019-2024 time-series, and 2024 map.



Our results show that AI-related state legislation in the US have largely increased, but not all states are enacting AI legislations. The 79 pieces of legislation passed/enacted in 2024 amounts to more legislations than the previous 4 years combined. Legislative acts seem to be getting more comprehensive and further reaching, covering various domains, including healthcare, education, and now AI-generated content. However, some legislations simply appropriate funding for a particular activity (e.g. an AI-related organization) without any regulatory development. Legislations are expanding the role of the public sector in AI governance, but several issues, such as AI bias and workforce development, are not widely addressed across the states. California continues to be the state with the most passed/enacted AI-related legislations (N=13 in 2024), many of which are addressing ethical issues.

In our comparison of the 2024 legislations with the previous 4-year period (DePaula et al., 2024), we found roughly similar development of legislative acts in domains addressing health and education. In bills passed from 2019-2023, 36% focused on using AI for health purposes (e.g., cancer detection or drug development) or education programs featuring AI and other advanced technologies at the secondary and college levels. In 2024, the distribution of legislations addressing health-related or educational programs with AI is at a similar range. Legislation in the earlier period focused on the creation of advisory groups to inventory and/or make recommendations about existing uses of AI in state government (n=14/68), and we continued to see this emphasis in the 2024 legislations. Thirty percent of the earlier 2019-2023 legislations addressed private industry's use of AI through grants to encourage technology intensive manufacturing or certain regulations of business. However, in contrast, at this stage of analysis only about 11% legislative acts in 2024 focused on regulation of business and industry.

In a marked and dramatic departure from earlier legislation, the 2024 collection featured several acts that sought to enable individuals to clearly identify AI-generated content in contexts such as political and election advertisements and in child pornography, as well as providing individuals with a cause of action for litigating such uses. Legislations in 2024 began to address "generative AI" directly. Moreover, several legislations in this year, for example Maryland S818 and Utah S149, have developed comprehensive governance frameworks for AI regulation in their respective states.

4. Discussion

Based on this investigation, we made three main observations. First, several states, such as California, Florida, Maryland and Utah, have passed multiple legislative acts in 2024 suggesting that they are attempting to fill the federal void, but in so doing they are creating a patchwork of distinct governance systems across the country.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Second, given the various bills requiring advisory groups and task forces on AI, it would be prudent for states and local governments to exchange knowledge and findings from these working groups, and to capitalize on the different work being conducted. Finally, states provide different definitions of AI, and sometimes none at all. Disparities and lack of definitions can make it difficult for businesses to develop their plans or benefit from government incentives. Making sure that AI is clearly defined should benefit the AI policy process.

The future of federal guidance on AI remains uncertain. In the meantime, the challenges for digital government scholars are to track the volume and modalities of AI usage within state governments and assess the consequences. AI can potentially help with innovation in government service delivery, job creation and workforce development. However, there are many challenges associated with discrimination, disinformation, deep fakes, and other infringements on citizen rights that are not being addressed by AI legislation across US states.

Acknowledgements

- **Funding:** This work has been supported by the State of New York/United University Professions, SUNY Polytechnic Joint Labor Management Committee, and the Individual Development Award Program.
- **Data/Software Access Statement**: Data for this work has been obtained from the National Conference of State Legislatures at: https://www.ncsl.org/technology-and-communication/artificial-intelligence-2024-legislation
- **Contributor Statement**: All authors contributed to analysis of the data, and to the writing and editing of the manuscript.
- **Use of AI**: During the preparation of this work, the author(s) did not use AI or AI-related services for the analysis, writing or editing of the manuscript.
- **Conflict Of Interest (COI)**: Authors declare no conflict of interest.

References

Artificial Intelligence Act (2024). *Regulation (EU) 2024/1689*. European Parliament. https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng

Barfield, W., & Pagallo, U. (Eds.). (2022). *Research handbook on the law of artificial intelligence*. Edward Elgar Publishing.

DePaula, N., Gao, L., Mellouli, S., Luna-Reyes, L. F., & Harrison, T. M. (2024). Regulating the machine: An exploratory study of US state legislations addressing artificial intelligence, 2019-2023. *Proceedings of the 25th Annual International Conference on Digital Government Research*, 815–826. https://doi.org/10.1145/3657054.3657148

Federal Register (2023). *Safe, secure, and trustworthy development and use of artificial intelligence: A presidential document by the executive office of the president*. Federal Register. https://www.federalregister.gov/documents/2023/11/01/2023-24283/safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence

Harrison, T. M., & Luna-Reyes, L. F. (2022). Cultivating trustworthy artificial intelligence in digital government. *Social Science Computer Review*, *40*(2), 494–511. https://doi.org/10.1177/0894439320980122

Medaglia, R., Gil-Garcia, J. R., & Pardo, T. (2023). Artificial intelligence in government: Taking stock and moving forward. *Social Science Computer Review*, *41*(1), 123–140. https://doi.org/10.1177/08944393211034087

NCSL. (2024). *Artificial Intelligence 2024 Legislation*. National Conference of State Legislatures. Retrieved March 31, 2025, from https://www.ncsl.org/technology-and-communication/artificial-intelligence-2024-legislation

Sousa, W. G. D., Melo, E. R. P. D., Bermejo, P. H. D. S., Farias, R. A. S., & Gomes, A. O. (2019). How and where is artificial intelligence in the public sector going? A literature review and research agenda. *Government Information Quarterly*, *36*(4), 101392. https://doi.org/10.1016/j.giq.2019.07.004

White House. (2025, January 23). *Removing barriers to American leadership in artificial intelligence*. White House. https://www.whitehouse.gov/presidential-actions/2025/01/removing-barriers-to-american-leadership-in-artificial-intelligence/

Wirtz, B. W., Weyerer, J. C., & Sturm, B. J. (2020). The dark sides of artificial intelligence: An integrated AI governance framework for public administration. *International Journal of Public Administration*, *43*(9), 818–829. https://doi.org/10.1080/01900692.2020.1749851

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Zuiderwijk, A., Chen, Y.-C., & Salem, F. (2021). Implications of the use of artificial intelligence in public governance: A systematic literature review and a research agenda. *Government Information Quarterly*, *38*(3), 101577. https://doi.org/10.1016/j.giq.2021.101577

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The Impact of Government Emotion-based Response Strategies on Citizens' Satisfaction.

Ruoyun Wang[a], Corey Kewei Xu[b*], Liang Ma[c]

[a]Thrust of Innovation, Policy and Entrepreneurship, The Hong Kong University of Science and Technology(Guangzhou), Guangzhou, China, rwang585@connect.hkust-gz.edu.cn, 0009-0002-6553-7864

[b]Thrust of Innovation, Policy and Entrepreneurship, The Hong Kong University of Science and Technology(Guangzhou), Guangzhou, China, coreyxu@hkust-gz.edu.cn, 0000-0002-3244-9297

[c]School of Government, Peking University, Beijing, China, liangma@pku.edu.cn, 0000-0002-8779-5891.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 19 May 2025

Abstract: Government responsiveness is a critical component in citizen-government interac-tions, shaping public trust and the effectiveness of e-governance initiatives. However, resource constraints often lead to strategic responses aimed at managing citizens' emotions and avoiding conflicts, rather than resolving all issues. Despite this, few studies have examined government response strategies and their impact on citizen satisfaction. This study examines the impact of emotion-based responses on citizen satisfaction within the context of China's e-governance ini-tiatives. Utilizing data from the Chinese People's Daily "Message Board for Leaders" platform, we introduce the Emotion-based Responsiveness Framework in Government Communication, which quantifies government responses along four dimensions: positivity, empathy, reassurance, and personalization. We first use text analysis to identify linguistic patterns and emotional cues in gov-ernment replies. Then, we apply few-shot learning via the ChatGPT API to infer dimension scores across the dataset. Lastly, we test whether government's emotion-based responses will affect cit-izen's overall satisfaction. The result shows that the emotion-based response will positively affect citizens' satisfaction. The study contributes to e-governance literature by providing empirical ev-idence on the effectiveness of emotional communication strategies in digital government-citizen interactions. These insights have important implications for theory development in public admin-istration and offer practical guidance for improving government communication strategies in the digital age, especially in situations where complete problem resolution may not be feasible.

Keywords: Government responsiveness, Emotion-based response, Citizen satisfaction
Poster, DOI: https://doi.org/10.59490/dgo.2025.933

1. Introduction

Government-citizen interactions have undergone a digital transformation, enabling more frequent and scalable engagement through online platforms (Wong & Welch, 2004). However, responsiveness in the digital era requires more than timely replies; it demands empathetic, emotionally intelligent communication (Bons'on et al., 2012; Mergel, 2013b). This is especially essential when governments face limited capacity to fully resolve complex issues raised by citizens (Mergel, 2013a).In such contexts, emotional strategies in communication may serve as substitutes to manage expectations and build trust.

Scholars and practitioners alike recognize that digital governance is no longer solely concerned with service efficiency or technical transparency. Instead, it involves managing complex expectations, demonstrating empathy, and conveying respect and care through online responses on digital platforms. As governments face

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

mounting service requests and constrained administrative capacity, emotional strategies emerge as a cost-effective and symbolically powerful means to enhance public perception and manage dissatisfaction—especially when full resolution is not feasible. Recent studies have highlighted the emotional and relational dimensions of public service delivery, showing that tone, empathy, and perceived sincerity significantly affect citizen attitudes (Guy & Lee, 2015; Mergel, 2013b). However, this line of inquiry remains underdeveloped in the digital context. In particular, there is limited empirical research that systematically measures emotional responsiveness and evaluates its impact on citizen satisfaction. Therefore, this study addresses a key research question: to what extent do emotion-based government responses influence citizen satisfaction?

This study addresses existing gaps by developing a multi-dimensional framework to quantify emotion-based responsiveness and examining its effects on citizen satisfaction in a non-Western context. It moves beyond binary resolution metrics to assess how governments use emotional language as a communicative strategy in digital service delivery.

2. Theoretical Framework and Research Hypothesis

To better understand government responsiveness in government-citizen online interaction, this study proposes the Emotion-based Responsiveness Framework in Government Communication (as shown in Fig. 1) to analyze the emotional and personalized aspects of government responses in digital communication platforms. In this model, it examines government's emotion-based response by evaluating the extent to which it demonstrates positivity, empathy, reassurance and personalization, and subsequently analyzes how these dimensions influence citizens' overall satisfaction.

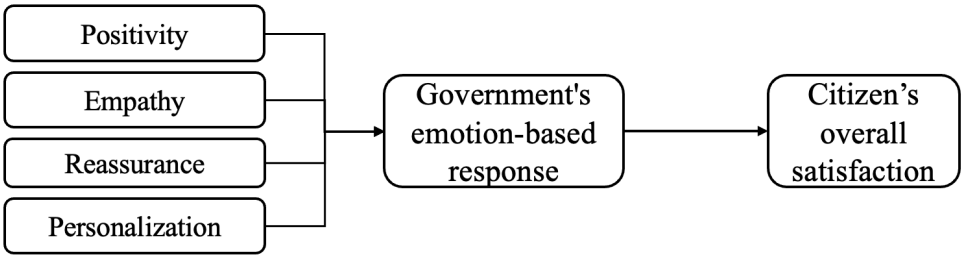


Fig. 1 – The Emotion-based Responsiveness Framework in Government Communication

Drawing from theories of emotional intelligence (Vigoda-Gadot & Meisler, 2010), we argue that emotion-based responsive communication can enhance perceived procedural fairness and reduce dissatisfaction. These emotional dimensions serve as signals of respect, engagement, and concern, all of which are associated with higher citizen trust and satisfaction in public administration literature. Based on the theoretical discussion, we propose the following hypotheses:

- **H1:** The degree of emotion-based responsiveness in government responses is positively associated with citizens' satisfaction.

3. Methodology

The data comes from the Chinese People's Daily *Message Board for Leaders*, a national platform for digital citizen-government interaction. Our dataset includes over 900,000 entries from 2019 to 2022, of which 333,892 include both government responses and citizen satisfaction ratings. For preliminary testing, we randomly select 3,000 pieces for investigation.

For data analysis, we begin by manually coding a stratified sample of several thousand responses to establish ground truth labels across the four emotional dimensions: positivity, empathy, reassurance, and personalization. Each dimension is coded as binary variable. This annotated dataset serves as the foundation for training few-shot learning prompts using the ChatGPT API. Carefully crafted examples guide the large language model (LLM) in predicting emotion scores for the remaining unlabeled responses. The performance of the ChatGPT model is assessed using standard classification metrics (as shown in Tab. 1). These metrics indicate a high

level of performance, with the precision score highlighting the model's ability to correctly identify positive instances, and the recall score reflecting its effectiveness in capturing all relevant instances. The F1 score, a harmonic mean of precision and recall, further confirms the model's balanced performance.

Tab. 1 – Performance metrics for classification models

	Accuracy	Precision	Recall	F1 Score
Reassurance	0.910	0.923	0.910	0.916
Positivity	0.888	0.906	0.888	0.890
Empathy	0.829	0.829	0.829	0.828
Personalization	0.854	0.954	0.854	0.886

Besides, we incorporate contextual and structural controls, including city-level socioeconomic indicators, message type, length of response and response time. Tab. 2 shows the details of the measurements and summary statistics of the variables.

Tab. 2 – Measurement of variables and descriptive statistics

Variable	Measurement	N	Mean	SD	Min	Max
Dependent Variable						
Satisfaction with government' response	Citizens' evaluation of response (Range: 0–5)	3,000	3.887	1.591	0.700	5.000
Independent Variable						
Emotion-based response	Total score of 'positivity', 'empathy', 'reassurance' and 'personalization'.	3,000	3.664	1.216	0.000	5.000
Positivity	Neutral or negative = 0, Positive = 1	3,000	0.762	0.426	0.000	1.000
Empathy	No empathy = 0, Empathy = 1	3,000	0.328	0.469	0.000	1.000
Reassurance	No reassurance = 0, Reassurance = 1	3,000	0.908	0.289	0.000	1.000
Personalization	No personalization = 0, Personalization = 1	3,000	0.833	0.373	0.000	1.000
Control Variable						
GDP per capita	GDP per capita (Logged)	3,000	4.251	0.389	3.612	5.255
Population	Total population (Logged)	3,000	3.856	0.667	1.539	4.851
Urbanization	Urban population / total population	3,000	0.642	0.109	0.357	0.893
Length of response	Total number of response words (Logged)	3,000	5.372	0.757	3.045	7.766
Response time	Response time – message time (Logged)	3,000	2.881	0.910	0.000	5.927
Message type	Consultation = 1, Suggestion = 2, Appreciation = 3, Complaint = 4, Assistance-seeking = 5	3,000	3.569	1.498	1.000	5.000

To estimate the effect of emotion-based responses on satisfaction, this study employs fixed-effects linear regression models accounting for temporal and regional heterogeneity.

4. Results and Key Findings

Tab. 3 shows that emotion-based responses have a statistically significant and positive effect on citizen satisfaction across both models. In Model (1), without control variables, the coefficient for emotion-based response is 0.055 ($p < 0.05$). When control variables are added in Model (2), the coefficient increases to 0.080 ($p < 0.01$), indicating a stronger and more robust association. This result suggests that citizens are more satisfied when government replies convey emotional qualities such as positivity, empathy, reassurance, and personalization.

These findings provide empirical support for the hypothesis that emotion-based responsiveness contributes meaningfully to citizen satisfaction. The positive and robust effect across models highlights the relevance of emotional cues in shaping perceptions of government responsiveness. This reinforces the theoretical claim that emotional strategies can serve as important tools in maintaining citizen trust and managing expectations in digital governance.

Tab. 3 – Effect of Emotion-based Response on Citizen Satisfaction

VARIABLES	(1) Without controls	(2) With controls
Emotion-based response	0.055**	0.080***
	(0.025)	(0.025)
GDP per capita		0.899
		(1.563)
Population		-14.597
		(11.809)
Urbanization		-8.283
		(11.176)
Length of response		-0.027
		(0.041)
Response time		-0.081**
		(0.031)
Message type		-0.116***
		(0.019)
Constant	3.678***	62.174
	(0.091)	(46.040)
Observations	2,938	2,938
R-squared	0.346	0.360
City FE	YES	YES
Year FE	YES	YES

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5. Implications

This study makes several important theoretical contributions. First, it introduces emotional responsiveness as a multi-dimensional construct in digital government communication and situates it within the broader literature on citizen satisfaction and public service delivery. While traditional e-governance research emphasizes transparency, efficiency, and responsiveness in terms of timeliness or completeness of resolution, our work expands the theoretical boundaries by incorporating emotional quality as an essential explanatory factor. Second, by proposing and validating the Emotion-based Responsiveness Framework in Government Communication, the study offers a systematic and replicable approach to measure emotional cues in government-citizen digital interactions. This enriches existing public administration theory by linking emotional intelligence to e-governance and showing that emotions are not ancillary but integral to citizen evaluations of public services.

From a practical perspective, the findings offer actionable strategies for governments seeking to enhance service quality and citizen satisfaction in the digital age. Public administrators can be trained in emotionally intelligent communication practices, including empathetic language, personalized content, and tone management. These elements can be embedded in standard operating procedures for frontline digital communication. Second, the application of LLM demonstrates the feasibility of scaling emotional analysis across large datasets. Governments can leverage such tools not only for monitoring response quality but also for real-time feedback loops and automated training systems. Moreover, emotion-based responsiveness metrics could be integrated into government performance evaluation frameworks to complement traditional measures like resolution rates and timeliness. Finally, for digital platform designers, the results suggest the value of embedding emotional logic into AI-powered response systems. Emotionally adaptive bots and response templates can significantly improve user experience and perception of fairness, especially in contexts where human capacity is limited and not all issues can be fully resolved.

6. Next Steps

Building on the preliminary findings, the next stage of the study will involve several key extensions. First, we will further improve the predictive accuracy of ChatGPT by refining prompt design, optimizing few-shot examples, and exploring advanced scoring mechanisms to better capture subtle emotional cues. Second, we will expand the analysis to cover the entire dataset of government responses to ensure greater generalizability and statistical power. Third, we will incorporate resolution degree as a moderating variable to assess whether emotion-based responses remain effective in the absence of full problem resolution. This will allow us to test

whether emotion-based communication can compensate for limited administrative action. Finally, we will replicate the emotion-based classification using Deepseek's API to validate the consistency of the results as a robustness check. These next steps aim to strengthen the empirical foundation of the study and provide more nuanced insights into the dynamics of strategic responsiveness in digital governance.

Funding

This research is supported by the Guangdong Planning Office of Philosophy and Social Science, 2024 Guangdong Regular Program of 14th Five-Year Plan on Philosophy and Social Sciences (No.GD24YGL37); Guangzhou Municipal Science and Technology Bureau (GZ-STB), 2024 Guangzhou Basic and Applied Basic Research Scheme (No. 2024A04J01836); Guangzhou Higher Education Teaching Quality and Teaching Reform Engineering Project (2024YBJG093); and Guangdong Higher Education Society Sino-Foreign Cooperative Education Research Branch "14th Five-Year Plan" 2023 Annual Youth Research Project (GAHE23CRS011).

Contributor Statement

Ruoyun Wang: Methodology; Formal analysis; Methodology; Software; Visualization; Writing – original draft. Corey Kewei Xu: Conceptualization; Data Curation; Software; Funding acquisition; Writing - Review & Editing. Liang Ma: Conceptualization; Writing - Review & Editing.

Use of AI

During the preparation of this work, the authors used ChatGPT to improve the writing. After using this tool, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Bons'on, E., Torres, L., Royo, S., & Flores, F. (2012). Local e-government 2.0: Social media and corporate transparency in municipalities. *Government Information Quarterly*, *29*(2), 123–132. DOI: https://doi.org/10.1016/j.giq.2011.10.001.

Guy, M. E., & Lee, M. A. (2015). How emotional intelligence mediates emotional labor in public service jobs. *Review of Public Personnel Administration*, *35*(3), 261–277. DOI: https : / / doi . org / 10 . 1177 / 0734371X13514095.

Mergel, I. (2013a). A framework for interpreting social media interactions in the public sector. *Government Information Quarterly*, *30*(4), 327–334. DOI: https://doi.org/10.1016/j.giq.2013.05.015.

Mergel, I. (2013b). Social media adoption and resulting tactics in the u.s. federal government. *Government Information Quarterly*, *30*(2), 123–130. DOI: https://doi.org/10.1016/j.giq.2012.12.004.

Vigoda-Gadot, E., & Meisler, G. (2010). Emotions in management and the management of emotions: The impact of emotional intelligence and organizational politics on public sector employees. *Public Administration Review*, *70*(1), 72–86. DOI: https://doi.org/10.1111/j.1540-6210.2009.02112.x.

Wong, W., & Welch, E. (2004). Does e-government promote accountability? a comparative analysis of website openness and government accountability. *Governance*, *17*(2), 275–297. DOI: https : / / doi . org / 10 . 1111/j.1468-0491.2004.00246.x.

Urban Resilience and Virtual Communities: Leveraging Networking Platforms for Immigration Challenges

Dulce M. Villegas N. [a], *Larissa Galdino* [b], *Jan Westermann* [c]

[a] Faculty of Mathematics and Computer Science, University of Bremen, Bremen, dulcemar@uni-bremen.de ORCID number 0009-0003-0359-7615

[b] Faculty of Mathematics and Computer Science, University of Bremen, Bremen, ORCID number 0000-0002-9116-892X

[c] Faculty of Mathematics and Computer Science, University of Bremen, Bremen, ORCID number 0009-0009-3004-1982

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Urban resilience is perceived as the response of governments towards unforeseen events. However, communities also develop their own mechanisms to transform and adapt more efficiently. With the integration of ICT in cities, rapid response and predictive capabilities are expected to improve urban management. Currently, cities face a critical, unprepared challenge: immigration. If inadequately addressed, immigration can strain national cohesion, identity, and economic stability. This paper examines urban resilience within virtual communities, focusing on how networking platforms foster integration and social cohesion enhancing urban and economic resilience. The networking platform *Meetup,* being used in 230 cities aiming to enhance trust among members and a faster integration through online and face-to-face interaction. With a qualitative approach including surveys, it is possible to measure how these communities' foster resilience and self-directed development.

Keywords. virtual communities, urban resilience, migration, networking platforms, integration.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1016

1. Introduction

Resilience refers to the ability to adapt in the face of adversity (Wu et al., 2013), and in urban contexts, it addresses a city's capacity to recover from physical, economic, institutional, and social challenges. Cities are increasingly vulnerable to political, economic, and social crises, not just natural disasters (Büyüközkan et al., 2022). Achieving urban resilience requires collaboration between communities and governments, addressing threats through the four pillars: resisting, recovering, adapting, and transforming (Gomes Ribeiro and Pena Jardim Gonçalves, 2019). Smart Cities aim to enhance resilience through technology, but technology alone isn't sufficient. High-quality companies, skilled labor, and the enhancement of adaptability are equally vital for urban systems to thrive (Zhou et al., 2021). Additionally, cities face challenges like immigration, which can strain economic, social, and cultural structures, highlighting the need for proactive policies to avoid urban failure (Castles, 2011).

Community resilience in informal settings involves self-reliant communities that adapt to challenges, with key components such as communication, cooperation, cohesion, coping, credibility, and a vision for the future (Matarrita-Cascante et al., 2017; Olcese et al., 2024; Ganor and Ben-Lavy, 2003). The role of Information and Communication Technologies (ICTs) in urban change is significant, as they enhance governance and civic engagement, turning citizens into agents of transformation (Miklian and Hoelscher, 2017). As digital transformation unfolds, citizens are creating platforms to promote integration and inclusion, which directly impact urban resilience (Panori et al., 2021). This highlights the gap in research on the direct effects of digital platforms and virtual communities on urban resilience.

Research question: **How is the creation of digital platforms and virtual communities fostering integration and inclusion, enhancing urban resilience?**

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The paper explores citizen-driven efforts to integrate post-migration, contributing to existing strategies related to migration and integration. The structure includes an introduction to urban resilience, social cohesion, and the research question, followed by a theoretical background on urban resilience, smart cities, socio-cultural artifacts, social innovation, cultural importance, human capital, social capital, bridging the digital divide, and privacy concerns in smart communities. The methodology section discusses qualitative approaches and planned data collection, with a concluding outlook.

2. Theory background

2.1 Urban resilience responding to migration and integration

The migration crisis, driven by conflict and economic hardship, has intensified political tensions in the European Union, with concerns about cultural change and the erosion of shared values. However, migration also offers opportunities: with effective integration policies, it can benefit both migrants and host societies by strengthening socio-ecological systems and urban resilience (Sansus et al., 2020; Zapata-Barrero, 2023). As migration accelerates and urban populations grow—especially in smaller cities (UNDESA, 2014)—successful integration must address both physical needs (education, housing, healthcare) and social inclusion (Meijers et al., 2017). Highly skilled migrants, when well-integrated, can significantly contribute to shaping resilient, innovative urban economies (Tadesse and White, 2010). Human capital is central to Urban Economic Resilience, enhancing technological transformation and digital growth through shock resistance, recovery, and risk adaptation, making investment in human capital a policy priority (Zhou and Qi, 2023).

2.2 Cultural Sphere in Smart Cities

While smart cities primarily aim to enhance sustainability through technology, performance indicators often emphasize economic efficiency and the deployment of smart solutions. A more comprehensive concept is the "Smart Sustainable City," which integrates environmental and social sustainability alongside economic goals (Ahvenniemi et al., 2017). Key dimensions for ranking cities under this model—such as those outlined by the University of Navarra and the UN's SDGs—include human capital, social cohesion, governance, and environmental responsibility. Human capital involves cultural engagement and access to education (Berrone, 2024; UN, 2023), while social cohesion emphasizes inclusion and diversity. Economic vitality is gauged by factors like investment returns and startup activity, with cities generating the majority of global GDP. Governance highlights citizen-centered solutions, and environmental efforts focus on sustainable development and pollution reduction. Efficient mobility systems and inclusive urban planning are essential for shaping equitable urban spaces. A strong international profile boosts investment and tourism, while technology reflects societal prosperity and sets the foundation for future urban innovation. These interconnected dimensions reinforce the idea that truly smart cities must also be sustainable and inclusive.

2.3 Social Cohesion and Social Capital

Social cohesion refers to the shared values, sense of belonging, and solidarity among individuals in a society, especially across diverse backgrounds. While it promotes unity, it is often contrasted with social capital, which emphasizes functional networks and relationships. A key challenge is the perceived tension between ethnic diversity and social cohesion, with multiculturalism sometimes viewed as a threat to societal harmony (Goodhart, 2004; Cheong et al., 2007). The term itself is complex and can be measured at both national and community levels, though community-based assessments face limitations due to the subjective nature of social constructs and administrative boundaries. Social cohesion is commonly evaluated across three dimensions: political (e.g., voting and volunteering), economic (e.g., employment, income, labor force participation), and social (e.g., civic engagement, diversity, and informal interactions).

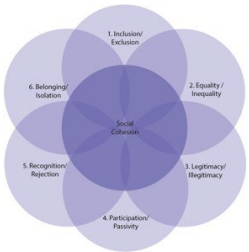


Fig. 1 - Dimensions of social cohesion (Rajulton et al., 2006).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Social capital, which reflects the quality of relationships within and beyond communities, is a key indicator of well-being and a powerful tool for local policy implementation (Nakano and Washizu, 2021). It is typically categorized into bonding and bridging capital, assessed through trust, networks, and norms. In urban settings, leveraging social capital requires addressing challenges like population heterogeneity and the preservation of cultural heritage. This demands a shift in policy approaches, as changes can significantly influence urban planning, economic development, transportation, social initiatives, and tourism (Carrá, 2007).

2.4 Socio-technical ecosystems in the smart City and the Digital Divide

Smart cities are evolving as socio-technical ecosystems where digital socio-cultural artifacts empower citizens, foster social innovation, and enhance cultural value. However, unequal access to technology—the digital divide—threatens inclusivity (Baltac, 2019). This divide spans access, digital skills, and the benefits of ICT, often reflecting deeper social inequalities. Effective social innovation requires not just technology, but human-centered strategies and intermediaries to connect citizens, governments, and businesses. While ICT can enhance social capital, its impact is limited without support for marginalized groups. Thus, bridging the digital divide is essential to ensure smart cities truly serve as inclusive platforms for innovation and equitable urban transformation.

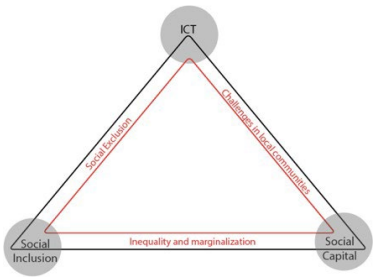


Fig. 2 - The triangle of Social Capital, ICT, Social Inclusion (Zinnbauer, 2007).

3. Methodology

3.1 Method and use case

This research uses a mixed-methods approach, combining Social Network Analysis (SNA), Actor-Network Theory (ANT), and Quantitative Data Analysis to explore the intersection of technology and migration. While online group interactions have existed since the 1970s, virtual communities are specifically defined as social aggregations that aim to build long-term personal relationships in cyberspace, driven by human emotions and shared intentions to engage in ongoing discussions. The term "community" in the digital context highlights how online networks can foster meaningful social connections. Social media, beyond facilitating superficial interactions, enhances access to information and aids in the development of social capital (Ellis et al., 2004). To validate the research framework (Figure 4), various indicators—such as integration, social inclusion, innovation, participation, and social cohesion—are assessed through digital platforms and virtual communities to measure urban resilience following migration. The specific case study for this analysis is the Meetup platform, which was designed to create local communities and enable connections across more than 230 cities, based on shared interests.

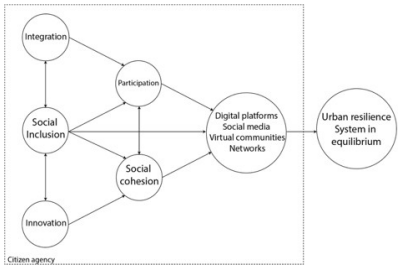


Fig. 3 - Research framework

3.2 Data Sampling and measurements

The methodology implemented to verify the proposed framework and assess the performance of sustainable smart cities focuses on key criteria such as urban resilience, sustainability and social cohesion. A questionnaire, adapted from relevant literature and adjusted to the framework of this paper. The indicators and constructs are listed in *Table 3.* Preliminary results emphasize the importance of well-being, citizen agency, technology usage, virtual communities and social cohesion as critical factors for the successful implementation of Sustainable Smart Cities

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

implementations and their impact in urban resilience. The survey will be administered to users of the platform to demonstrate the framework's applicability.

Indicators social cohesion	***Indicators efficiency in Smart Cities***	***Urban resilience***	***Construct***	***Smart cities***
Inclusion / exclusion	Innovation Concept	Redundancy	Innovation concept	Life quality
Equality / Inequity	Personal Innovativeness	Diversity	Personal innovativeness	Technology
Legitimacy / Illegitimacy	City Engagement	Efficiency	City engagement	People
Participation / Passivity	Service Quality	Robustness	Service quality	Government and administration
Recognition / rejection	Acceptance/Usage	Connectivity	Acceptance / usage	Systems
Belonging / Isolation	Trust	Adaption	Perceived privacy	Economy
Bridging	Quality of life	Resources	trust	Sustainability
		Independence		ICT
		Innovation		Resources
		Inclusion		Health, safety and protection.
		Integration		

Table 3. Measurement indicators (Rajulton et al., 2006; S. Nakano and A. Washizu 2021; Markus 2014; H. Yeh 2017)

References

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities*, *60*, 234–245. https://doi.org/10.1016/j.cities.2016.09.009

Baltac, V. (2019). Smart Cities—A View of Societal Aspects. *Smart Cities*, *2*(4), 538–548. https://doi.org/10.3390/smartcities2040033

Berrone, P., & Ricart, J. E. (2024). *IESE Cities in Motion Index*.

Büyüközkan, G., Ilıcak, Ö., & Feyzioğlu, O. (2022). A review of urban resilience literature. *Sustainable Cities and Society*, *77*, 103579. https://doi.org/10.1016/j.scs.2021.103579

Carrà, N. (2016). Heritage / Culture and Social Cohesion in the Project of Metropolitan City. *Procedia - Social and Behavioral Sciences*, *223*, 583–589. https://doi.org/10.1016/j.sbspro.2016.05.353

Castles, S. (2011). Migration, Crisis, and the Global Labour Market. *Globalizations*, *8*(3), 311–324. https://doi.org/10.1080/14747731.2011.576847

Cheong, P. H., Edwards, R., Goulbourne, H., & Solomos, J. (2007). Immigration, social cohesion and social capital: A critical review. *Critical Social Policy*, *27*(1), 24–49. https://doi.org/10.1177/0261018307072206

Ellis, D., Oldridge, R., & Vasconcelos, A. (2004). Community and virtual community . *Annual Review of*

Ganor, M., & Ben-Lavy, Y. (2003). Community Resilience: Lessons Derived from Gilo Under Fire. *Jewish Communal Service Association of North America*, *79*.

Goodhart, D. (2004). Too diverse? *Prospect Magazine*, 7.

Markus, A. (2014). *Mapping Social Cohesion*.

Matarrita-Cascante, D., Trejos, B., Qin, H., Joo, D., & Debner, S. (2017). Conceptualizing community resilience: Revisiting conceptual distinctions. *Community Development*, *48*(1), 105–123. https://doi.org/10.1080/15575330.2016.1248458

Meijers, E., Hoogerbrugge, M., & Cardoso, R. (2018). Beyond Polycentricity: Does Stronger Integration Between Cities in Polycentric Urban Regions Improve Performance? *Tijdschrift Voor Economische En Sociale Geografie*, *109*(1), 1–21. https://doi.org/10.1111/tesg.12292

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Miklian, J., & Hoelscher, K. (2017). Smart Cities, Mobile Technologies and Social Cohesion in India. *Indian Journal of Human Development*, *11*(1), 1–16. https://doi.org/10.1177/0973703017712871

Nakano, S., & Washizu, A. (2021). Will smart cities enhance the social capital of residents? The importance of smart neighborhood management. *Cities*, *115*, 103244. https://doi.org/10.1016/j.cities.2021.103244

Olcese, M., Cardinali, P., Madera, F., Camilleri, A. P., & Migliorini, L. (2024). Migration and community resilience: A scoping review. *International Journal of Intercultural Relations*, *98*, 101924. https://doi.org/10.1016/j.ijintrel.2023.101924

Panori, A., Kakderi, C., Komninos, N., Fellnhofer, K., Reid, A., & Mora, L. (2021). Smart systems of innovation for smart places: Challenges in deploying digital platforms for co-creation and data-intelligence. *Land Use Policy*, *111*, 104631. https://doi.org/10.1016/j.landusepol.2020.104631

Rajulton, F., Ravanera, Z. R., & Beaujot, R. (2007). Measuring Social Cohesion: An Experiment using the Canadian National Survey of Giving, Volunteering, and Participating. *Social Indicators Research*, *80*(3), 461–492. https://doi.org/10.1007/s11205-006-0011-1

Ribeiro, P. J. G., & Pena Jardim Gonçalves, L. A. (2019). Urban resilience: A conceptual framework. *Sustainable Cities and Society*, *50*, 101625. https://doi.org/10.1016/j.scs.2019.101625

Sansus, L., Ramiro Troitiño, D., & Kerikmäe, T. (2020). Migration to Europe: A Threat or an Opportunity? In *The EU in the 21st Century* (pp. 59–84). Springer International Publishing. https://doi.org/10.1007/978-3-030-38399-2_5

Tadesse, B., & White, R. (2010). Cultural distance as a determinant of bilateral trade flows: do immigrants counter the effect of cultural differences? *Applied Economics Letters*, *17*(2), 147–152. https://doi.org/10.1080/13504850701719983

United Nations Economic Commission for Europe. (2023). *Social Cohesion: Concept and Measurement*.

United Nations. (2023). Social Cohesion: Concept and Measurement.

United Nations (2023). TIMES OF CRISIS, TIMES OF CHANGE.

Wu, G., Feder, A., Cohen, H., Kim, J. J., Calderon, S., Charney, D. S., & Mathé, A. A. (2013). Understanding resilience. *Frontiers in Behavioral Neuroscience*, *7*. https://doi.org/10.3389/fnbeh.2013.00010

Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. *Government Information Quarterly*, *34*(3), 556–565. https://doi.org/10.1016/j.giq.2017.05.001

Zapata-Barrero, R. (2023). Urban migration governance under the resilience lens: conceptual and empirical insights. *Ethnic and Racial Studies*, *46*(13), 2833–2862. https://doi.org/10.1080/01419870.2023.2166793

Zhou, Q., & Qi, Z. (2023). Urban economic resilience and human capital: An exploration of heterogeneity and mechanism in the context of spatial population mobility. *Sustainable Cities and Society*, *99*, 104983. https://doi.org/10.1016/j.scs.2023.104983

Zhou, Q., Zhu, M., Qiao, Y., Zhang, X., & Chen, J. (2021). Achieving resilience through smart cities? Evidence from China. *Habitat International*, *111*, 102348. https://doi.org/10.1016/j.habitatint.2021.102348

Zinnbauer, D. (2007). *What can Social Capital and ICT do for Inclusion?*

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

XML as a Basis for Interoperability in Technical Education Documents.

Giovana Nunes Inocêncio[1*], Jean Everson Martina[1]

[a]Department of Informatics and Statistics, Federal University of Santa Catarina (UFSC), Florianópolis, Santa Catarina, Brazil. Emails: gioinocencio017@gmail.com, jean.martina@ufsc.br. ORCID: https://orcid.org/0009-0000-5995-7470 (Giovana Nunes Inocêncio), https://orcid.org/0000-0003-4104-1741 (Jean Everson Martina).

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Technical Education in Brazil faces challenges in standardizing digital certificate issuance and exchange across diverse platforms, affecting compliance, efficiency, and workforce integration. Unlike higher education, technical education has unique structural and regulatory demands that require a tailored interoperability solution. This study proposes an XML Schema Definition (XSD) designed specifically for technical education, extending beyond existing mod- els used in higher education. Leveraging XML's flexibility, the schema creates machine-readable digital certificates that improve security, transparency, and fraud prevention by providing a struc- tured framework. The research aims to facilitate regulatory compliance and streamline data ex- change between technical institutions and the Ministry of Education. A systematic literature re- view and comparative analysis highlight gaps in current digital document practices and support the schema's development. The findings demonstrate XML's potential as a transformative stan- dard for managing educational records in technical education, optimizing accessibility and en- abling seamless platform integration. Unlike prior efforts focused on higher education, this model addresses the specific operational and regulatory complexities of technical education. Implement- ing this schema tackles critical interoperability challenges and lays the foundation for advancing digital certification. By fostering innovation and collaboration, this work supports a unified, se- cure, and accessible digital certification system, promoting modernization and trust in Brazil's educational environment.

Keywords. Interoperability, Interoperability Standards, XML, Technical Education.
Poster, DOI: https://doi.org/10.59490/dgo.2025.1022

1. Background

Technical education improves employability, with rising employment rates highlighting the need for modernized document management. However, fragmented systems in Brazil hinder data exchange and increase fraud risks (Costa et al., 2020; de Barros & Ferraz, 2023; dos Anjos, 2019; Lepiane et al., 2019). Digitally signed documents reduce costs and enhance security (Martina et al., 2019; Pereira, 2015), while interoperability enables standardized, regulation-compliant exchanges (Costa et al., 2020; Diallo et al., 2011). This study proposes an XSD-based framework for technical diplomas, supporting integration with the Ministry of Education and offering scalability to other education levels.

2. Research Methods

- Objective:
  - Develop an XML-based interoperability model tailored for technical education.
- Methodology:

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

- Qualitative research and comparative analysis of XML models.
- Literature review of XML for digital certification in higher education.
- Analysis of interoperability models to ensure data integrity, authenticity, and compliance.

• Proposed Solution:
- A customized XML schema for seamless data exchange between technical education institutions and the Ministry of Education.
- Incorporation of essential metadata, standardized structures, and security mechanisms.
- XSD aligned with regulatory guidelines, including fields to support diverse technical curricula.

3. Proposal for a Standardized Interoperability Model

Brazil faces challenges in student retention and completion, particularly in technical education, due to the lack of standardized diploma recognition (OECD, 2024). The absence of uniformity in technical diplomas complicates the validation of skills and competencies, hindering student mobility and reducing employment and educational opportunities, contributing to higher dropout rates.

Figure 1 shows the drop in out-of-school rates from 16% (2013) to 8% (2022), underscoring how digital diplomas support transparency, efficiency, and secure, standardized verification (Martina et al., 2019; OECD, 2024). In Brazil, technical diplomas are still paper-based (Pereira, 2015), unlike in higher education. This work reviews legislation (Brasil, 2019; Ministério da Educação, 2019) and suggests adapting higher education XML/XSD interoperability models to technical education (Murray, 2002), where XML remains underused.

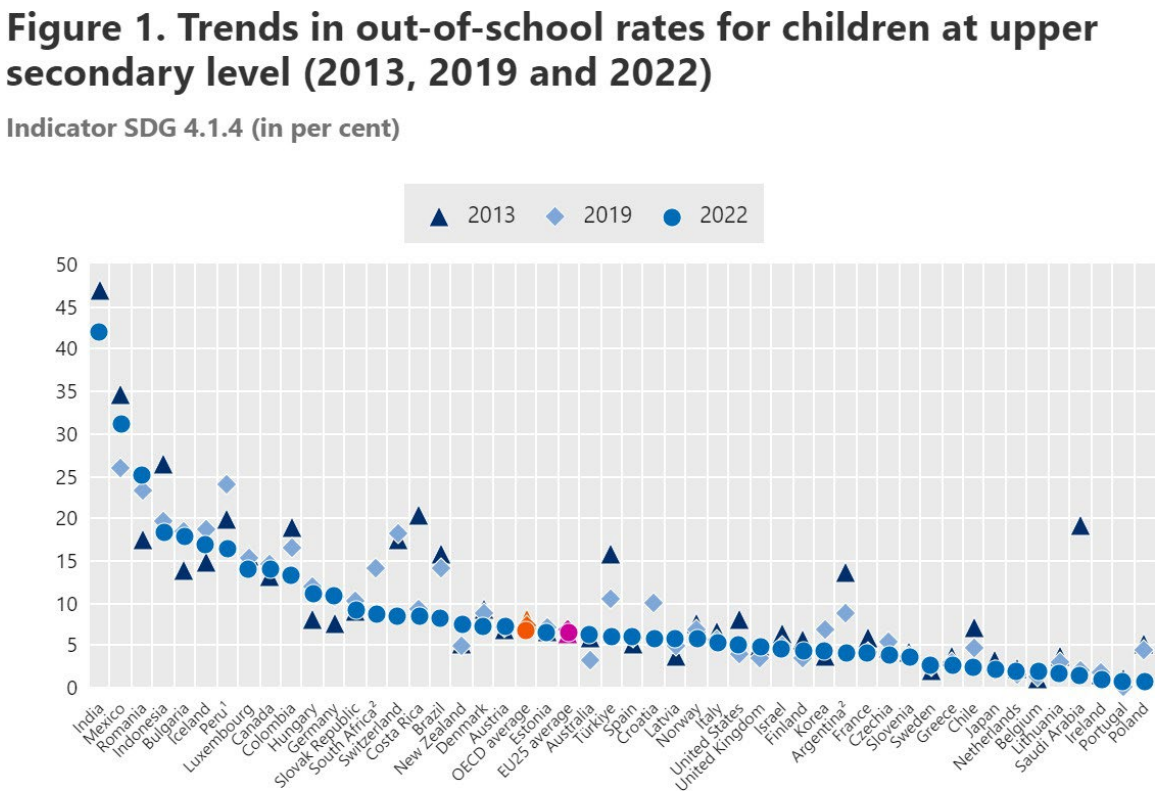


Fig. 1 – OCDE Trends in out-of-school rates for children at the upper secondary level (2013, 2019, and 2022)

Figure 2 demonstrates how XML enables secure, validated, and standardized academic record exchange between institutions. By replacing manual input with structured file exchanges, the interoperability standard ensures consistent communication. XML's flexible, hierarchical structure—combined with XSD—guarantees data consistency and enhances interoperability in technical education (Hedgebeth, 2008).

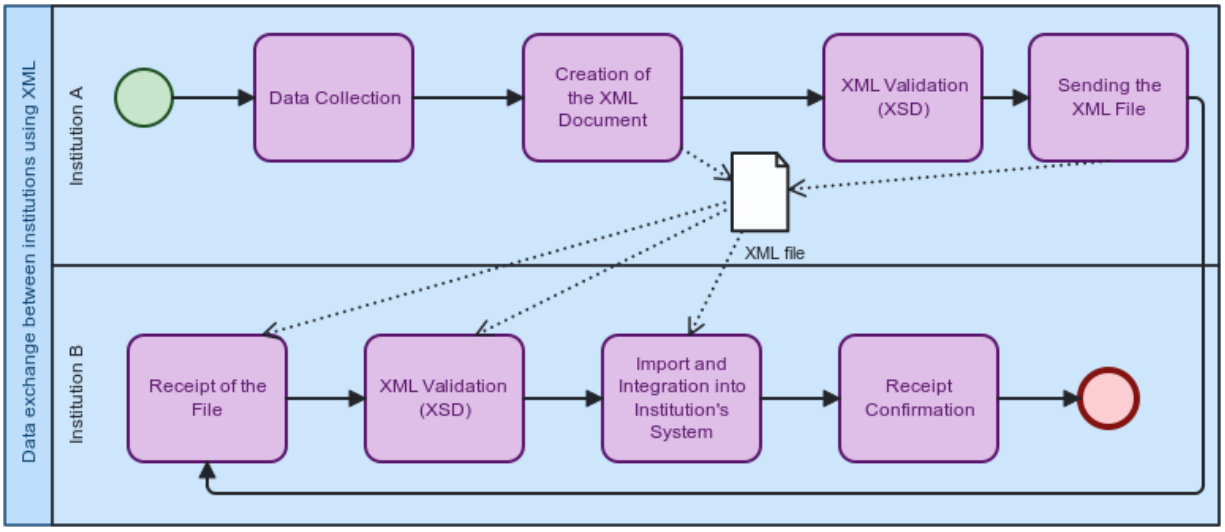


Fig. 2 – BPMN of data exchange between institutions using XML

4. Results

4.1. Academic Registration and Diploma Issuance Process

Figure 3 illustrates the graduation process at Technical Education Institutions (IEPT), where XML-based diplomas are generated, validated via SISTEC, digitally signed, and delivered to students. This automated workflow ensures secure, standardized, and interoperable credential exchange across educational systems.

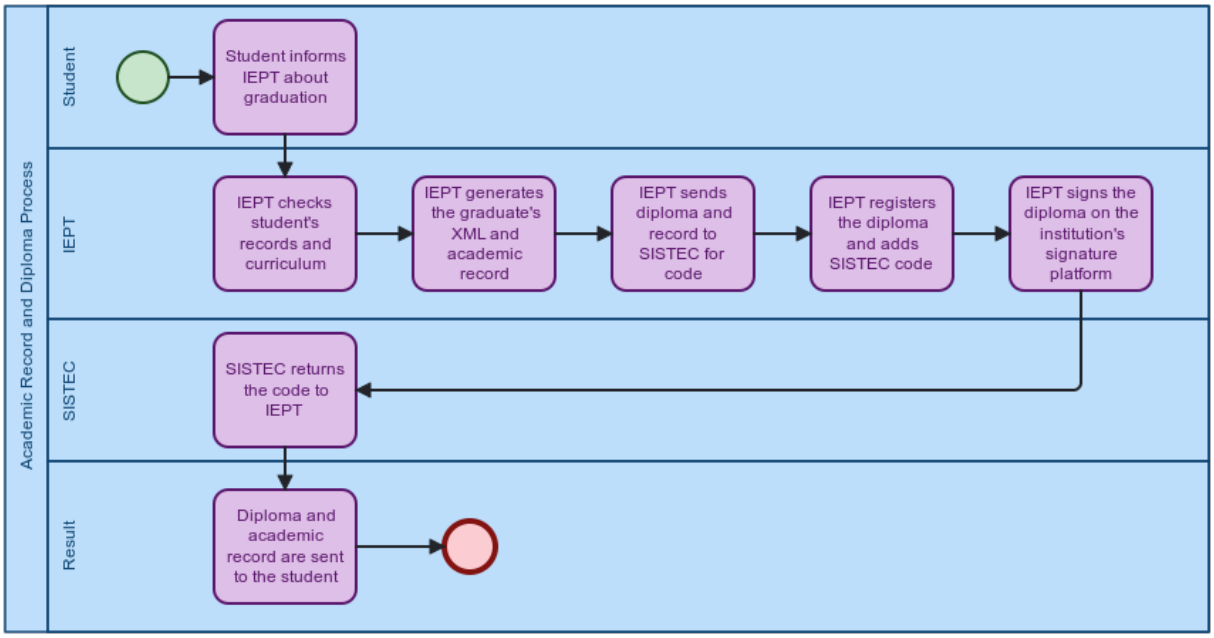


Fig. 3 – Academic Record and Diploma Process BPMN diagram

4.2. Classification of Digital Diploma Elements

We recommend directly adopting the same standard used in higher education to obtain the same advantages but with adjustments and specificities necessary for implementation in this teaching modality. Based on the higher education model, tags were classified according to their XSD structure:

- **General Diploma Information**
  - **Diploma tag:** Contains the diploma structure and signature.
  - **Diploma Information tag:** Includes diploma data, registration, and court decision information.
  - **Diploma Data tag:** Defines data about the graduate, completion date, course, issuing institution, and signatories.
  - **NSF tag:** Similar to Diploma Data but for institutions outside the federal system.
- **Registration**
  - **Registration Data tag:** Defines diploma registration data, such as educational system, record book, academic documentation, security, and additional info.
  - **NSF tag:** Similar to Registration Data but for institutions outside the federal system.
  - **Court Decision tag:** Defines registration information for diplomas affected by court decisions.
- **Graduate**
  - **Graduate Data tag:** Includes personal data such as nationality, birthplace, and personal IDs (e.g., CPF, ID).
  - **Data Diploma by Court Decision tag:** Similar to Graduate Data, but not all information will be inserted for court-affected diplomas.
- **Course**
  - **Course Data tag:** Defines course details, such as name, code, address, and authorization.
  - **NSF tag:** Similar to Course Data but for institutions outside the federal system.
  - **Course Data By Court Decision tag:** Defines course information for diplomas affected by court decisions.
- **Record Book**
  - **Record Book tag:** Defines documentation and control information for diplomas, including unique code, registration number, and diploma page.
  - **NSF tag:** Similar to Record Book but for institutions outside the federal system.
- **Judicial Process**
  - **Legal Process Information tag:** Contains details of legal processes related to the diploma, such as case number, judge, and decision.
  - **Statements About Process tag:** Defines statements about the diploma process.
- **Regulatory Act**
  - **Regulatory Act tag:** Defines information about regulatory acts to ensure educational service quality, such as type, number, date, and publication source.
  - **With or without systems tag:** Similar to the Regulatory Act, but with or without an information system.
- **Processing in systems**
  - Tag that contains information about degree processing in information systems.

The XSD schema is used to validate XML documents for digital diplomas by defining their required structure, including diploma details, course information, digital signatures, and academic records. The structure centers the diploma as the main element, with related data as subordinate elements. This flexible model supports special cases like judicial decisions or non-federal courses. At the end of the schema, a digital security layer ensures authentication and data integrity.

4.3. Data Control in Technical Education

SISTEC is the centralized system for managing technical education records in Brazil. Unlike higher education, where registration is decentralized, SISTEC unifies data, allowing seamless interoperability between institutions and the Ministry of Education. The system uses a unique locator code for diploma validation, replacing traditional registration books.

4.4. Digital Diploma Components

The digital diploma follows a structured XML schema, defining key elements such as diploma data, registration records, and legal decisions. Attributes like version, unique ID, and environment settings ensure standardization and interoperability across institutions.

4.5. Regulatory Framework Adaptations

Unlike higher education, which operates under a National Higher Education Assessment System and formal regulatory acts, technical education follows decentralized validation by State Education Councils. The XML model adjusts by excluding the higher education regulatory tag and focusing on course accreditation and authorization.

4.6. Tag Nomenclature Adjustments

Higher education terms like "IesEmissora" were adapted to "IeptEmissora" to reflect technical education institutions. Additionally, distinctions were made between federal and non-federal institutions, introducing "NSFT" (Non-Federal Technical System) tags.

4.7. Structural Modifications for Technical Education

The XML schema was adjusted to incorporate state and federal guidelines, accommodate course diversity, and enhance interoperability. Advanced security features, such as XML Advanced Electronic Signatures (XAdES), were integrated to ensure document integrity and authentication.

4.8. Enhancing Security with Digital Signatures

Digital signatures, regulated by ICP-Brasil, provide authenticity and integrity to digital diplomas. Already used in higher education, this security measure is proposed for technical education to ensure reliable, tamper-proof certification.

4.9. Validation and Feasibility Analysis in the Literature



Fig. 4 – Signed digital technical diploma, using the XML format for interoperability.

We validated the technical digital diploma's XSD using the ITI official validator (de Tecnologia da Informação (ITI), 2023), which ensures authenticity and compliance with digital signature standards in Brazil. Our validation process provided additional detailed information beyond the standard ITI output. The digitally signed diploma file diplomaTecnico_assinado.xml was successfully verified, as shown in Figure 4, containing three compliant signatures aligned with W3C XML Schema and ICP-Brasil standards. All cryptographic checks passed, and the certificates, issued by the Brazilian Federal Revenue and valid until 2025, showed no revocation issues, confirming the diploma's security and compliance.

4.10. Feasibility Analysis

This feasibility analysis assesses technical and operational challenges of adopting the XML standard in technical education. It examines system compatibility, security, stakeholder acceptance, and adaptability. Using a sociotechnical framework (Inocêncio et al., 2024), the study compares literature findings with key criteria relevant to Technical Education:

- **Compatibility:** XML is compatible with systems used by Technical Education institutions, supporting integration and interoperability (Inocêncio et al., 2024).
- **Acceptance:** XML is already accepted and implemented in Higher Education, which facilitates its adoption in Technical Education (Inocêncio et al., 2024).
- **Ease of Implementation:** XML is simple to implement and does not require major changes to existing processes and systems (Inocêncio et al., 2024).
- **Efficiency:** XML supports effective data exchange between students, institutions, and the Ministry of Education, improving operational performance (Inocêncio et al., 2024).
- **Security:** XML ensures the confidentiality and integrity of student data, complying with privacy and information security standards (Inocêncio et al., 2024).
- **Flexibility:** XML can adapt to various institutional contexts and needs within Technical Education. The use of NSFT tags, for example, allows for multiple scenarios without requiring structural changes (Inocêncio et al., 2024).
- **Regulatory Compliance:** XML complies with existing Brazilian standards and regulations. It is already used in Higher Education under various ordinances and decrees issued by the Ministry of Education (Inocêncio et al., 2024).

Based on the presented criteria, the feasibility of implementing the interoperability standard in Technical Education is assessed positively. Additionally, the authors specify that Technical Education must be addressed to establish a viable interoperability standard, including the diversity of institutions providing these programs (Inocêncio et al., 2024).

5. Conclusions

This study explores how XML enhances interoperability in technical education diplomas in Brazil, building on its proven use in higher education. An XSD-based structure enables secure document exchange with the Ministry of Education, addressing risks like fragmentation and fraud. The proposed model offers a scalable foundation for global digital credentialing.

In addition to interoperability, XML supports transparency, policy development, and efficient education management. This work contributes to standardization efforts and proposes an XML-based framework for technical diplomas. Future research should assess its scalability across education levels. Aligned with dg.o's focus, this study addresses digital governance, secure data exchange, and open standards. It offers a model that improves trust, transparency, and efficiency in credential verification—relevant for attendees working in education policy, digital identity, and public administration.

References

Brasil. (2019). Portaria mec nº 554, de 11 de março de 2019.

Costa, S. C., Sousa, M., Silva, M., Oliveira, E., & Guimarães, J. (2020). Dbacademic: Conectando os dados abertos das instituições de ensino do brasil. *Ciência da Informação*, *49*(3), 1–10. DOI: https://doi.org/10.18225/ci.inf.v49i3.5500.

de Barros, D. M., & Ferraz, R. (2023, October). *Mercado ilegal de escolas põe à venda diplomas de ensino técnico* [Accessed: 2025-04-21]. https://veja.abril.com.br/educacao/mercado-paralelo-e-ilegal-poe-a-venda-certificados-de-ensino-tecnico

de Tecnologia da Informação (ITI), I. N. (2023). Verificador de conformidade [Accessed: 2025-04-21]. https://pbad.labsec.ufsc.br/verifier-hom/

Diallo, S. Y., Herencia-Zapana, H., Padilla, J. J., & Tolk, A. (2011). Understanding interoperability. *Proceedings of the 2011 Emerging MS Applications in Industry and Academia Symposium*, 84–91.

dos Anjos, E. (2019, July). *Falsos diplomas de cursos técnicos em administração são identificados* [Accessed: 2025-04-21]. https://cra-rj.adm.br/falsos-diplomas-de-cursos-tecnicos-em-administracao-sao-identificados/

Hedgebeth, D. (2008). Managing structured data with the extensible markup language (xml). *VINE*, *38*(3), 348–356. DOI: https://doi.org/10.1108/03055720810904853.

Inocêncio, G. N., Pereira, F. L., & Martina, J. E. (2024). Gestão documental com aplicação do padrão de interoperabilidade na validação de disciplinas do ensino técnico no ensino superior: Uma análise sociotécnica [Accessed: 2025-04-21]. *Revista de Gestão e Secretariado*, *15*(4). DOI: https://doi.org/10.7769/gesec.v15i4.3672.

Lepiane, C. D., Pereira, F. L., Pieri, G., Martins, D., Martina, J. E., & Rabelo, M. L. (2019). Digital degree certificates for higher education in brazil: A technical policy specification [Accessed: 2025-04-21]. *Proceedings of the ACM Symposium on Document Engineering 2019*. DOI: https://doi.org/10.1145/3342558.3345398.

Martina, J., Pereira, F., Pieri, G., Bezerra, R., Cordeiro, L., Meurer, L., Gerônimo, G., Custodio, R., Martins, D., & Macelai, V. (2019). Certificado digital acadêmico na nuvem [Accessed: 2025-04-21]. *Anais do IX Workshop de Gestão de Identidades Digitais*, 19–20. DOI: https://doi.org/10.5753/wgid.2019.14023.

Ministério da Educação, S. d. E. S. (2019). Nota técnica no. 13 [Accessed: 2025-04-21]. http://www.abmes.org.br/arquivos/legislacoes/Nota-tecnica-13-2019-12-01.pdf

Murray, M. (2002). Using the extensible markup language (xml) as a medium for data exchange. *Communications of the Association for Information Systems*, *9*.

OECD. (2024). *Education at a glance 2024: Oecd indicators*. DOI: https://doi.org/10.1787/c00cad36-en.

Pereira, F. L. (2015). *Perspectivas para o desenvolvimento e implantação de um sistema de emissão de diplomas baseado em certificação digital na universidade federal de santa catarina - ufsc* [Dissertação (Mestrado profissional)]. Universidade Federal de Santa Catarina [Accessed: 2025-04-21]. https://repositorio.ufsc.br/xmlui/handle/123456789/158763

Track 25: Workshops

Contents

Building Capacity for Smart Cities and Urban Resilience through Digital Transformation 1691
G. V. Pereira, L. Temple, M. Wild, T. Janowski, G. Musiatowicz-Podbial, E. Estevez, E. M. Luciano, and M. P. R. Bolivar

Data, Algorithms, and Automation in Social Protection: A Data Justice Perspective on the Single Registry 1695
D. Carvalho, M. Valente, C. Tavares, and I. Bassani

Indigenous worldviews and Digital Humanism: Implications for inclusive e-Governance.....1699
B. Ngoqo, E. Skjærseth, A.-S. Engelschiøn, and S. Bosire

The Potential of Blockchain Technology for Collaboration among Countries 1704
J. B. Charczuk, K. Silva, and M. T. da S. Lima

Workshop "Digital Government Measurement for Research and Public Policies" 1709
M. M. Ribeiro

Building Capacity for Smart Cities and Urban Resilience through Digital Transformation

Gabriela Viale Pereira [a], *Lucy* Temple [a], *Moritz* Wild [a], *Tomasz* Janowski [b], *Grazyna* Musiatowicz-Podbial [b], *Elsa* Estevez [c], *Edimara* Mezzomo Luciano [d], *Manuel Pedro* Rodríguez Bolivar [e]

[a] Department for E-Governance and Administration, University for Continuing Education Krems (Danube University Krems), Austria, gabriela.viale-pereira@donau-uni.ac.at, 0000-0002-7602-3052; lucy.temple@donau-uni.ac.at, 0000-0003-4131-7648; Moritz.wild@donau-uni.ac.at, 0009-0005-8251-8392.

[b] Department of Informatics in Management, Faculty of Management and Economics, Gdańsk University of Technology, Gdańsk, Poland, tomasz.janowski@pg.edu.pl, 0000-0001-8950-5782; grazyna.podbial@pg.edu.pl, 0000-0002-9343-1883

[c] Department of Computer Science and Engineering, Universidad Nacional del Sur, Bahía Blanca, Argentina, ece@cs.uns.edu.ar, 0000-0002-2596-4397

[d] Graduate Program in Management, Management School, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil, eluciano@pucrs.br, 0000-0002-2847-8845

[e] Department of Accounting and Finance, Faculty of Business Studies, University of Granada, Granada, Spain, manuelp@ugr.es, 0000-0001-8959-7664

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. This workshop explores capacity-building needs for public sector digital transformation in the context of smart cities and systemic resilience. Framed within the Erasmus+ CAP4CITY_DM project, it brings together academics, practitioners, and students to identify emerging skills and competencies across governance levels and sectors. The program includes a brief introduction to the REALITIES Joint Master's Curriculum, lightning talks from invited experts on digital governance, AI, smart communities, and innovation, followed by a collaborative session to map skill gaps in the field. Expected outcomes include shared insights on cross-sectoral capacity needs, contributions to curriculum development, and stronger connections between education, practice, and policy. The workshop supports a broader understanding of smart cities as part of interconnected systems to address complex societal challenges.

Keywords. Public sector transformation, smart city governance, resilient cities.
Workshop, DOI: https://doi.org/10.59490/dgo.2025.1012

1. Introduction

Smart sustainable cities represent a progression of how local governments – and increasingly, broader governance systems – apply digital technology to serve their populations, pursue sustainable development, and transform themselves to cope with societal challenges. With the goal of creating inclusive, safe, and climate-resilient urban development, collective efforts are needed including policymakers, academics, practitioners and citizens (Almulhim et al., 2024).

With the goal of tackling complex urban challenges, the success of smart cities requires more than just technology. A well-formulated data governance strategy, along with intelligent tools to use government data, is imperative for evidence-based policymaking. However, a governance strategy alone is not sufficient to ensure the improvement

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

of the overall well-being of inhabitants and, according to Mora et al. (2025), urgent reforms are needed to better incorporate scientific insights into smart city governance practices. Creating a citizen-centric approach is essential, ensuring participation and communication during the development, execution, and evaluation of policies to create equitable urban transformations.

The concept of Smart Sustainable Cities (SSC) has emerged from the increasing and urgent emphasis on providing social and environmental sustainability solutions for urban planning. It has become a significant term within policy and politics (Bibri and Krogstie, 2017), aligning with the Sustainable Development Goals (SDGs) (Beck et al., 2023). SSC is a field in continuous transformation, enabled by digital technologies and innovation, and empowered by stakeholder engagement and collaboration. An SSC constructs human, institutional and technical capacities to solve problems and create new development opportunities to raise and maintain the quality of life in communities and pursue sustainable development. As urban challenges become increasingly intersect with regional, national, and global dynamics, addressing sustainability and resilience requires a comprehensive, systemic perspective that extends beyond the local level (UN-Habitat, 2022).

Building on this conceptual foundation, research has demonstrated the relevance of digitalization in urban areas for a variety of purposes. Several studies have indicated that digitalization can enhance economic growth by attracting new business, driving higher innovation (Albino et al., 2015; Ismagilova et al., 2019; Hu & Zheng, 2021), and improving the efficiency of processes and resource utilization (Silva et al., 2018; Khan & Salah, 2018; Attaran et al., 2022). Other studies underscore the pivotal role of technologies in fostering interoperability among disparate systems, thereby creating a more cohesive and interconnected infrastructure to confront societal challenges (Gharaibeh et al., 2017; Bellini et al., 2022) and promote sustainability (Lim et al., 2018; Ismagilova et al., 2019; Xie et al., 2019). In summary, previous research underscores the pivotal role of digitalization in generating public value (Pereira et al., 2017) and its substantial impact on enhancing the quality of life of residents (Rodríguez Bolívar, 2019, 2021).

However, as highlighted before, the effectiveness of digital solutions increasingly depends on the collaborative ecosystems that support their implementation. There is an increasing understanding that collaboration among local governments might be as important for the success of smart cities as technology advances (UN-Habitat, 2022). The literature shows the importance of stakeholder collaboration as a vital element for effective development of smart cities (Komninos et. al., 2019), its performance (Appio, Lima and Paroutis, 2019; Komninos et al., 2019) and sustainability of its results (Correia et al., 2022). Additionally, a study shows that there are certain configurational approaches to increase collaboration in smart cities, which are context dependent, and that for large ecosystems there is a need for a smart city manager or a dedicated department (Clement, Manjon and Crutzen, 2022).

Given the complexity of smart city ecosystems, it is crucial to implement initiatives that not only provide technical training for current and future practitioners engaged in smart cities but also facilitate the exchange of experiences, perspectives, and expertise starting from a transdisciplinary approach. Academic programs should enable participants to develop a comprehensive understanding of the political, technical, and social landscape. This, in turn, will empower them to assess scenarios and cultivate successful collaborations for the effective development of smart cities that align with their objectives. This workshop is aimed at better understanding how academic programs – such as a master's in *Resilient Innovation Systems* – can help bridge the skills gap in public sector digital transformation. As the emerging concept of resilient smart cities evolves beyond a local governance tool, it is increasingly viewed as part of a wider network of interconnected systems –, including technical, institutional, and social – that span regions and sectors. Therefore, to effectively address today's most pressing societal challenges, future professionals must be prepared to think systemically, act collaboratively and innovate in multiple levels of governance.

2. Workshop Objectives and Program

This workshop welcomes academics, practitioners, and students interested in the topic of capacity building for smart cities and urban resilience through digital transformation. The objective is to advance understanding of the competencies and structures needed to support public sector innovation and to explore the growing demand for interdisciplinary capacity building in the context of digital governance, smart communities, and systemic resilience.

The workshop is organized into three main segments:

Welcome and Project Introduction: The session will begin with a brief round of introductions, followed by a short presentation of the Erasmus+ CAP4CITY_DM Project and the curriculum of the REALITIES Joint Master's Program, which focuses on resilient innovation systems and digital transformation in public governance.

Lightning Talks: A series of short expert talks will cover key themes related to smart governance, technological innovation, resilience, and stakeholder engagement. The talks will be followed by a moderated panel discussion

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

and an open Q&A session to foster dialogue and knowledge exchange.

The planned lightning talks include:

- Digital Governance for Societal Transformation *by Gabriela Viale Pereira*
- AI for Supporting Governance of Smart Sustainable Cities in Latin America *by Elsa Estevez*
- The role of Smart Communities in Emergency Situations *by Edimara Luciano*
- Smart City Governance and Multi-Level Collaboration *by Manuel Pedro Bolivar*
- Technology and Innovation for Digital Transformation and Resilience *by Tomasz Janowski*

These lightning talks illustrate the evolution of smart cities from local initiatives to complex, resilient systems that require coordinated governance, innovation, and stakeholder collaboration across scales.

Group Discussion and Collaborative Activity: Participants will take part in a structured collaborative session aimed at identifying current and emerging skills gaps in public sector digital transformation—particularly within the context of smart cities, urban innovation, and resilience. The session will explore what capacities are needed across governance levels and sectors to address complex societal challenges.

3. Expected Results and Conclusions

The workshop aims to generate insights into the key competencies and systemic capacities required for advancing public sector digital transformation and resilience. Through the collaborative group activity and expert talks, participants will contribute to a shared understanding of emerging skill gaps and cross-sectoral demands in the governance of resilient smart cities.

Key expected outcomes include:

- A preliminary map of relevant skills and knowledge areas to be addressed in transdisciplinary education for smart cities and digital governance
- Reflections on the challenges and opportunities of multi-level collaboration and stakeholder engagement
- Inputs that will inform the further development and refinement of the REALITIES Joint Master's Program curriculum
- Strengthened dialogue between academia, practitioners, and policy actors on advancing resilient digital innovation at scale

Acknowledgement

- **Funding or Grant:** The CAP4CITY_DM project was funded by the Erasmus Mundus Design Measures (EMDM) program of the European Union under Grant Agreement No. 101180294.
- **Contributor Statement***: All authors contributed equally.
- **Use of AI***: N/A.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology, 22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

Almulhim, A. I., Sharifi, A., Aina, Y. A., Ahmad, S., Mora, L., Filho, W. L., & Abubakar, I. R. (2024). Charting sustainable urban development through a systematic review of SDG11 research. *Nature Cities, 1*(10), 677–685. https://doi.org/10.1038/s44284-023-00076-0

Appio, F. P., Lima, M., & Paroutis, S. (2019). Understanding Smart Cities: Innovation ecosystems, technological advancements, and societal challenges. *Technological Forecasting and Social Change, 142*, 1–14. https://doi.org/10.1016/j.techfore.2018.12.018

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Attaran, H., Kheibari, N., & Bahrepour, D. (2022). Toward integrated smart city: A new model for implementation and design challenges. *GeoJournal, 87*(Suppl 4), 511–526. https://doi.org/10.1007/s10708-020-10358-7

Beck, D., Ferasso, M., Storopoli, J., & Vigoda-Gadot, E. (2023). Achieving the sustainable development goals through stakeholder value creation: Building up smart sustainable cities and communities. *Journal of Cleaner Production, 399*, 136501. https://doi.org/10.1016/j.jclepro.2023.136501

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society, 31*, 183–212. https://doi.org/10.1016/j.scs.2017.02.016

Clement, J., Manjon, M., & Crutzen, N. (2022). Factors for collaboration amongst smart city stakeholders: A local government perspective. *Government Information Quarterly, 39*(4), 101746. https://doi.org/10.1016/j.giq.2022.101746

Correia, D., Marques, J. L., & Teixeira, L. (2022). The state-of-the-art of smart cities in the European Union. *Smart Cities, 5*(4), 1776–1810. https://doi.org/10.3390/smartcities5040092

Hu, Q., & Zheng, Y. (2021). Smart city initiatives: A comparative study of American and Chinese cities. *Journal of Urban Affairs, 43*(4), 504–525. https://doi.org/10.1080/07352166.2020.1741676

Ismagilova, E., Hughes, L., Dwivedi, Y. K., & Raman, K. R. (2019). Smart cities: Advances in research—An information systems perspective. *International Journal of Information Management, 47*, 88–100. https://doi.org/10.1016/j.ijinfomgt.2019.01.004

Khan, M. A., & Salah, K. (2018). IoT security: Review, blockchain solutions, and open challenges. *Future Generation Computer Systems, 82*, 395–411. https://doi.org/10.1016/j.future.2017.11.022

Komninos, N., Kakderi, C., Panori, A., & Tsarchopoulos, P. (2019). Smart city planning from an evolutionary perspective. *Journal of Urban Technology, 26*(2), 3–20. https://doi.org/10.1080/10630732.2018.1485363

Lim, C., Kim, K. J., & Maglio, P. P. (2018). Smart cities with big data: Reference models, challenges, and considerations. *Cities, 82*, 86–99. https://doi.org/10.1016/j.cities.2018.04.011

Mora, L., Gerli, P., Batty, M., Binet Royall, E., Carfi, N., Coenegrachts, K. F., ...& Ziemer, G. (2025). Confronting the smart city governance challenge. *Nature Cities*, 1–4. https://doi.org/10.1038/s44284-024-00080-0

Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017). Delivering public value through open government data initiatives in a Smart City context. *Information Systems Frontiers, 19*, 213–229. https://doi.org/10.1007/s10796-016-9673-7

Rodríguez Bolívar, M. P. (2019). In the search for the 'Smart' source of the perception of quality of life in European Smart Cities. In *Proceedings of the 52nd Hawaii International Conference on System Sciences* (pp. 3325–3334). Maui, HI, USA. https://hdl.handle.net/10125/59757

Rodríguez Bolívar, M. P. (2021). Influence of smart cities sustainability on citizen's quality of life. In *Handbook of Smart Cities* (pp. 1–27). Springer. https://doi.org/10.1007/978-3-030-60777-5_88-1

Silva, B. N., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. *Sustainable Cities and Society, 38*, 697–713. https://doi.org/10.1016/j.scs.2018.01.053

Townsend, A. M. (2013). *Smart cities: Big data, civic hackers, and the quest for a new utopia*. W. W. Norton & Company.

UN-Habitat. (2022). *World Cities Report 2022: Envisaging the future of cities* (HS/004/22E). United Nations Human Settlements Programme. https://unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf

Xie, J., Tang, H., Huang, T., Yu, F. R., Xie, R., Liu, J., & Liu, Y. (2019). A survey of blockchain technology applied to smart cities: Research issues and challenges. *IEEE Communications Surveys & Tutorials, 21*(3), 2794–2830. https://doi.org/10.1109/COMST.2019.2899613

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Data, Algorithms, and Automation in Social Protection. A Data Justice Perspective on the Single Registry.

Danyelle Carvalho [a*], *Mariana Valente* [b], *Clarice Tavares* [c], *Isabella Bassani* [d] .

[a] Researcher at InternetLab; Master of Laws (LL.M.), University of São Paulo Law School (FDUSP), São Paulo, Brazil, danyelle.reis@internetlab.org.br, ORCID: https://orcid.org/0000-0002-9104-1152

[b] Assistant Professor of International Economic Law, University of St. Gallen, St. Gallen, Switzerland, mariana.valente@unisg.ch, ORCID: https://orcid.org/0000-0002-4714-3426

[c] Research Director, InternetLab; MA student, Postgraduate Program in Social Anthropology, University of São Paulo (PPGAS-USP), São Paulo, Brazil, clarice.tavares@internetlab.org.br, https://orcid.org/0009-0006-4103-7258

[d] PhD Candidate, IDHEAP | Institut de hautes études en administration publique, University of Lausanne, Lausanne, Switzerland, isabellafbassani@gmail.com, https://orcid.org/0000-0001-9266-4469

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. In recent years—particularly following the COVID-19 pandemic—governments have expanded the use of digital technologies and automated systems in social protection policies. One of the most prominent developments in this field is the spread of Single Registries: unified databases of individuals and families in vulnerable situations, often integrated with artificial intelligence (AI) and automated decision-making tools. In Brazil, the Unified Registry for Social Programs ("Cadastro Único") has become the main infrastructure for identifying and selecting beneficiaries of a wide range of social programs, including Bolsa Família. As of late 2024, it holds data on over 95 million people. In July 2024, the Brazilian government launched its national Artificial Intelligence Plan, allocating R$ 1.76 billion to the use of AI in public services—part of which is earmarked for modernizing Cadastro Único. While automation can improve the management and coordination of social policies, it also introduces new risks. If not carefully implemented, automated systems can produce errors, limit access to rights, and reinforce existing inequalities. In 2019, the UN Special Rapporteur on extreme poverty warned of the emergence of a "digital welfare dystopia" marked by opacity, exclusion, and lack of accountability. This workshop proposes a critical dialogue on the expansion of AI and automation in social protection, using the Brazilian experience as a starting point. We aim to discuss how data-driven tools are reshaping eligibility, targeting, and control in welfare systems, and to reflect on how a data justice approach can help ensure that digital governance in this field promotes — not undermines — equity and inclusion.

Keywords. Data Justice, automated decisions. Artificial Intelligence, Social Protection
Workshop, DOI: https://doi.org/10.59490/dgo.2025.1011

1. Introduction

Created in 2001, the Unified Registry for Social Programs (*Cadastro Único para Programas Sociais – CadÚnico*) is a

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

tool of the Brazilian Federal Government designed to identify, register and select low-income families for access to social programs such as *Bolsa Família* and the Social Electricity Tariff, among others. Comprising software and forms that collect, process, and cross-check personal data of Brazilians living in poverty and extreme poverty [1], CadÚnico serves as an infrastructure for the implementation of social assistance programs [2]. It does so by applying income criteria and specific conditionalities for each government program, allowing cross-referencing information with other government agencies.

As of December 2024, more than 95 million Brazilians (or 41 million families) were registered in CadÚnico. In total, 45 Federal Government social programs currently rely on CadÚnico. States and municipalities also run programs that use the registry. Given the high number of programs and beneficiaries, datafication and automation are structural components of CadÚnico. It operates as a vast database which is automatically and periodically cross-checked with other government databases to verify the income data of registered families [3].

The increasing use of technology and automation in social protection programs is not a phenomenon exclusive to Brazil. The so-called Single Registries—unified databases of vulnerable citizens that incorporate artificial intelligence and automation—have been multiplying worldwide, with notable examples in South Africa (e.g., SOCPEN) and the Netherlands (e.g., BRP). In recent years, many of these Single Registry systems have introduced various technologies to automate registration, data cross-referencing, and beneficiary selection processes.

As Dencik et al. [4] point out, "smart" technologies, machine learning, and artificial intelligence are integral to how societies are organized and how decisions are made across different spheres. The types of services that can be accessed, how they are accessed, and the various governance models for public policies potentially involve data processing practices and automated decision-making.

The widespread use of technology can optimize the management of social protection programs, but it can also pose challenges for individuals who rely on these tools to exercise their rights. In 2019, in an analysis of the impact of data-driven and automated systems on income redistribution and service administration, the UN Special Rapporteur highlighted the potential risk of creating a dystopian state of digital welfare characterized by a passive and automated existence.

Studies in the field of Data Justice [5] [6] [7] seek to analyze this new era of digital governance in public policy from a perspective that, on the one hand, addresses power asymmetries in the use of personal data and, on the other, examines how data-driven technologies can promote distributive justice by increasing the visibility of marginalized groups [8].

In this context of intensified scrutiny of social assistance programs through a datafication-driven approach, artificial intelligence and automation have increasingly been incorporated into monitoring strategies. In 2024, the Federal Government announced the use of AI to "strengthen the fight against fraud in Bolsa Família and CadÚnico." [9] In other words, beyond the challenges related to the disproportionate exposure of beneficiaries' data in social protection programs, the growing use of invasive technologies for monitoring raise concerns about potential errors and injustices caused by automation.

REFERENCES

[1] Nazareno, B. R. de, & Tortato, C. de S. B. (2019). A tecnologia do cadastro único no âmbito da política pública de assistência social – Reflexões correlatas ao campo de estudos em ciência, tecnologia e sociedade em face às políticas sociais adotadas no Brasil. Revista Tecnologias e Sociedade, 15(37), 371–388

[2] Farias, L. de, & Dias, R. de B. (2018). O Cadastro Único: A consolidação de uma infraestrutura para programas sociais. Revista Teoria & Pesquisa, 27(1), 22–47. https://doi.org/10.31068/tp.27102

[3] Sposati, A., Monteiro, M., & Anazawa, T. (Eds.). (2024). IMPDS: Um outro olhar do CadÚnico. SMADS/Paulus Social.

[4] Dencik, L., & Sanchez-Mondero, J. (2022). Data justice. Internet Policy Review, 11(1). https://doi.org/10.14763/2022.1.1615

[5] Van der Ploeg, L., & de Lange, T. (2021). Digital welfare fraud detection and the Dutch SyRI judgment. Journal of European Social Policy, 31(4), 487-499. https://doi.org/10.1177/13882627211031257

[6] Barreneche, C., Bermúdez, A., & Martín, J. (2021). Datafication in corruption contexts: Sociotechnical imaginaries and resistance practices vis-a-vis anti-poverty systems in Colombia. Palabra Clave, 24(3). https://palabraclave.unisabana.edu.co/index.php/palabraclave/article/view/15107/6563

[7] Redden, J., et al. (2022). Automating public services: Learning from cancelled systems. Carnegie UK Trust. https://carnegieuktrust.org.uk/publications/automating-public-services-learning-from-cancelled-systems/

[8] Taylor, L. (2017). What is data justice? The case for connecting digital rights and freedoms globally. Big Data &

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Society, 4(2), 2053951717736335.

[9] Agência Brasil. (2024, março). IA vai auxiliar no combate a fraudes no Bolsa Família. Agência Brasil. https://agenciabrasil.ebc.com.br/radioagencia-nacional/geral/audio/2024-03/ia-vai-auxiliar-no-combate-fraudes-no-bolsa-familia#:~:text=A%20intelig%C3%AAncia%20artificial%20vai%20refor%C3%A7ar,cheguem%20a%20quem%20realmente%20precisa

2. Objectives

Based on the Brazilian case of CadÚnico, this workshop aims to discuss the challenges of expanding automated decision-making and AI in social protection policies. We seek insights into:

(1) **how automation has been incorporated into social protection programs worldwide**, focusing on the different technological tools and models being used, the role of AI in these systems, and the outcomes and challenges faced in various countries;
(2) **the benefits and risks of these automated systems,** examining both the positive impacts (such as increased efficiency) and the potential drawbacks, such as increased surveillance and potential biases. We also intend to discuss how automation can either improve or worsen access to services for marginalized groups;
(3) **how technologies can effectively address inequalities**; and
(4) **whether these technologies may inadvertently perpetuate inequalities**.

Through this dialogue, we aspire to collectively tackle challenges and explore more effective pathways for developing social protection policies grounded in data justice.

3. Methodology and Format

This workshop will adopt a participatory format that combines the World Café and Chatham House methods to foster an open and reflective environment (*The World Café is a structured conversational process aimed at encouraging collaborative dialogue and knowledge sharing through rotating small-group discussions. The Chatham House Rule offers the possibility of workshops in an atmosphere of trust: participants are free to use the information received, but the identity and affiliation of other speakers cannot be revealed; the event is not recorded or transcribed; and participants are allowed to post about it on social media, as long as no attributions are made to the statements*).

The structure is designed to balance theoretical framing with collaborative discussion, while respecting the time allocation of two 90-minute sessions. It will combine a conceptual presentation on Data Justice and the Brazilian Single Registry case, based on the research conducted by InternetLab and the Privacy International in partnership with University of St, Gallen. After the initial presentation, the workshop participants will be divided into four groups, each tasked with collectively discussing one targeted question. The activity will have the following structure:

1) Introduction and contextualization (15 minutes):
This opening segment will present the workshop's objectives, structure, and participatory rules. It aims to frame the discussion and foster a space for collective inquiry into the role of data and automation in social protection policies.

Presentation on Data Justice and CadÚnico (35 minutes):
To ensure a common foundation of knowledge among all participants, the workshop moderators will conduct a theoretical presentation on the concept of data justice. They will also present the results of the research *Data Justice and Social Protection: Technologies, Algorithms, and Automated Decisions in CadÚnico*, conducted by InternetLab, which will support the group discussions.

Group discussion (1 hour 30 minutes):
The workshop room will be organized into four discussion tables, each focused on one of the workshop's four key questions (as outlined in the previous section). Participants will be divided into groups and will rotate through two different tables in 45-minute rounds. Each table will have post-its on which participants will write key points from the discussion. This format ensures that everyone engages with at least two of the key questions, allowing for both focused and diverse contributions across topics.

Collective discussion (40 minutes):
Participants will reconvene in a plenary session to share key takeaways and reflect on cross-cutting themes.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Moderators will synthesize insights from the discussion tables, identifying tensions, convergences, and directions for future research and advocacy. The workshop will close with a collaborative exercise to draft a preliminary agenda for data justice in the field of social protection.

4. Target Audience

The workshop is designed for researchers, policymakers, and civil society organizations that work at the intersection of technology, social protection, digital governance, artificial intelligence and data justice.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Indigenous worldviews and Digital Humanism: implications for inclusive e-Governance.

Bukelwa Ngoqo [a*], *Eirik* Skjærseth [b], *Anne-Sofie* Engelschiøn [c] and *Samuel* Bosire [d].

[a] Faculty of Engineering, Built Environment and Technology, Nelson Mandela University, Gqeberha, South Africa. bukelwa.ngoqo@gmail.com, ORCID number [0000-0002-5441-5477].

[b] Bolder, Stavanger, Norway, ORCID number [0009-0000-7541-9541].

[c] Faculty of Social Sciences, Universitetet i Stavanger, Stavanger, Norway, ORCID number [0009-0008-3596-0200].

[d] Information and Communication Technology department, Nelson Mandela University, Gqeberha, South Africa, ORCID number [0000-0002-9851-5939].

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 30 June 2025

Abstract. As the world grapples with the challenge of integrating Artificial Intelligence (AI) into existing systems or processes, there is a resultant tension associated with the inherent nuances between determining where the role of the human-stops and that of the machine-begins. As new 4IR driven technologies are integrated into main-stream society, dialogue on the important topics of inclusive e-Governance and Digital Humanism from a global south perspective must be encouraged. This paper acknowledges the limitations of technologies developed from a western viewpoint that prioritises individualism over community which is an inherent trait of the indigenous worldviews. In the universal viewpoint of Digital Humanism, indigenous perspectives must be included. Digital humanism transposes the social concept of humanism into the digital realm. Digital humanism seeks to ensure that human values such as dignity, freedom, ethics, democracy, social justice and self-determination are not overlooked as technological capabilities become more sophisticated. Historically, developing countries have been identified as late adopters of technological advancements. This paper seeks to unpack the concept of Digital Humanism, explore its relevance to e-Governance and investigate its alignment to existing (global south) e-inclusion discourse.

Keywords. Digital Humanism, e-Governance, e-inclusion, inclusive e-Government, Digital democracy.
Workshop, DOI: https://doi.org/10.59490/dgo.2025.1067

1. Introduction

The global discussion around technology development and constraints cannot overlook the persistent threat of digital segregation of the global south. Foley *et al.* (2022) posit that the separation between 'the haves' and 'have nots' has transcended the socio-economic lines and now finds form in the online or digital world. This online isolation of population groups based on their socio-economic standing has potential to distort the potential benefits of using technology for the benefit of society. Kwet (2019) accuses Big Tech corporations of controlling the digital ecosystem by monopolising computer-mediated experiences, giving them direct power over political, economic and cultural domains of life. Kwet considers the United States responsible for reinventing colonialism in the Global South through the domination of digital technology. Bon *et al.* (2022) expresses the concern addressed in this paper of the omission of people from the global south from the debates about the future of the digital society, despite the large impact of digital technology on the lives and future of all people on the planet. With the introduction of digital humanism in the discourse of the future global south digital landscape, creates an opportunity including these 'overlooked' voices from the global south. Evolving from ideologies of authors like McLuhan (1964) who spoke of 'technological humanism', digital humanism is viewed as the cognitive shift of transposing the 'online world' into our perceived reality. According to McLuhan technology as a 'medium' affects

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

how we perceive and understand the world around us. Lollini (2011) raised concerns about the resultant side effects of an impoverished human culture and experience of the world as the quality of human experiences is neglected in favour of quantitative, neutral, impersonal, and commercial criteria.

2. Indigenous worldviews in the digital landscape

Johnson (2022) suggests that our perception of the world is biased by our experiences. It can therefore be deduced that the personal experiences of the HCI user experience (UX) designer permeate the final product. The premise of the deliberations of this paper are aligned with the proposition made by Gong et al. (2018) claiming that the user's physical, psychological and behavioural and (familiar) experience characteristics have become an integral part of human-computer inter-action design. Increasingly researchers are observing the potentially exclusionary impact of technological advancements. Lazem et al. (2021) partially attribute this to the dominance of Western methods, practices, standards, and classifications in the way new technology-related knowledge is created and globalised. To dilute the discriminatory effect of computerised systems, it is important to acknowledge that as stated by Zabel and Otto (2021) biases in human cognition and language find their way into a system and affect user perception. Further expansion from the individual to the wholistic view of the human experience Pigeon and Riley (2021) introduces the Indigenous Wholistic Framework (see Figure 1) which aims to promote access and inclusivity when conducting indigenous research.



Figure 1: Indigenous Wholistic Framework *(Pigeon and Riley, 2021)*

According to Cull et. al (2018) indigenous worldviews refer to the comprehensive (physical, emotional, spiritual and intellectual) view of an individual that is inter-connected to land and in relationship to others (family, communities, nations). This paper considers the practical implications of adopting the indigenous worldview perspective to the digital humanism context for application to the public sector digital landscape.

3. Inclusive e-governance

While e-Governance refers to the public sector efforts to digitize government services. Digital inclusion (Refat et. al, 2023) on the other hand, refers to use of information and communication technologies (ICTs) to achieve equitable access to government services for all. Neglecting digital inclusion considerations can have dire consequences for e-Governance, Lee and Porumbescu (2019) caution that "while the potential of e-government to improve the responsiveness of public service provision is well established, there is growing evidence that it can also engender new forms of inequality and social exclusion". A deeper level of reflection is required on the adequacy and relevance of constituent elements in e-governance. The South African government in their National e-Strategy Roadmap (2017) acknowledges the role of ICTs as an efficient means to provide information to poor and marginalized communities to improve their quality of life. According to Tejedo-Romero *et al.* (2022, p2), at a local government level "e-government is a fundamental tool for participation and communication, since its functionality and content are responsible for transmitting the essence of the municipality's management to citizens and convincing them to trust in its services". In considering the future of e-government Malodia et al. (2021) describe a multi-dimensional construct with three underlying dimensions, namely empowered citizenship, hyper-integrated network, and evolutionary system architecture. The redress for socio-economic inequalities can be achieved through the establishment of democratic systems of governance.

4. Digital democracy

Digital infrastructures are increasingly mediating the relationship between citizens and public institutions, moving the questions of control, authorship, and legitimacy to the core of democratic inquiry. Digital democracy also known as e-democracy considers the political implications of the use digital systems within the public sector in the

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

pursuit of and the practice of democracy. According to Akinyetun and Ebonine (2023), Digital democracy refers to initiatives to include digital instruments in the democratic process. In the deliberations on inclusive e-governance and digital democracy there is a need to consider human-centric approaches, taking into account the ethical and socio-political implications of implementing technologies. It originated in a critical and emancipatory tradition that positions human needs, purpose, skill, and creativity as central to the design and governance of technological systems (Cooley, 1989). These principles emphasize the importance of individual agency, participatory structures, and the capacity for people to act on their own terms within social and technical environments. Digital infrastructures intended to support democratic participation must be grounded in the specific social relations, knowledge practices, and lived realities of the communities they serve. This view affirmed as relevant for the African context by Dlamini et al. (2025) who deem the adoption of e-participation in local governance to be an important approach to enhance transparency, accountability, and citizen engagement in decision-making processes.

5. Digital humanism

While scholar opinions diverge on a definition of Digital Humanism, its foundation on the sociological concept 'humanism' cannot be disputed. In concluding a critical analysis of these opinions, Coeckelbergh (2024) notes that digital humanism is "an umbrella term that captures a number of key criticisms of the ways in which digital technologies are already changing our society and culture." Werthner et. al (2023) propose a definition of Digital Humanism as a term associated with the process of describing, analysing, and, predominantly, influencing the complex interplay of technology and humankind for a more humane and fair society, respecting universal human rights and dignities. The current discourse deals with the subject of digital humanism from a philosophical perspective, this paper advocates for a move towards a pragmatic application of its principles. As is often the case with the adoption of new technological ideas or breakthroughs developing countries are at risk for becoming late adopters. The underlying aspirational goals of digital humanism emphasise the importance of creating a more humane and fairer digital world, which respects universal human rights and dignities. In the expanded definition of digital humanism consideration must be given to including global views on 'humanism'. Digital Humanism shifts the discourse beyond the dichotomy of machines mimicking human behaviour and humans leveraging on the computational and processing capabilities of machines, to considering the social, ethical and legislative impact of the adoption of AI.

To structure debates on digital humanism Prem (2024) discussed five principles of digital humanism. These principles start by diagnosing the current situation and gradually progress to making demands on future digital technologies. This paper translates these principles into questions to better align digital humanism thinking to inclusive e-governance:

1. What is the current impact of technology on people and their co-evolution?
2. What is the government mandate for using technology to protect people and environment?
3. Is there political will for using technology to strengthen democracy and society?
4. How can government capitalise on the assertion that technologies are malleable?
5. Does government communication clearly confirm the differences between people and machines?

These principles serve as guidelines for understanding how digital humanism can be incorporated into e-government planning to establish a more e-inclusive society.

6. Conclusion

This paper brings to the fore fundamental viewpoints on the importance of the inclusion of indigenous worldviews not only in the formative stages of digital humanism discourse, but also more broadly in shaping the digital future of societies in the global south. The evolution of how our online realities, will inevitably start to mimic our 'real-world' realities must find the global south prepared to leverage on consciously using technology to benefit communities at local, provincial and national government levels. The public sector in the global south context remains the custodian for helping marginalised communities addresses inequalities. With the advent of AI technologies, the digital transformation goal of the public sector is the creation of an e-inclusive society. Where the values of its citizens relating to online dignity, freedom, ethics, democracy, social justice and self-determination continue to be upheld and protected. These values are not different from those enshrined in the formation of socio-economic and digital democracies. Digital humanism provides a human-centered umbrella for understanding the future implications of technological advancements on society. The five key questions raised, or digital humanism principles introduced in this paper, provide a pragmatic link between theory and the application of digital humanism thinking to the e-governance context.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Contributor Statement

A. devised the project, the main conceptual ideas and proof outline. B., C. and D. worked on the following sections respectively: 2, 4 and 5.

Use of AI

During the preparation of this work, the author(s) used no AI tools / services. The author(s) take(s) full responsibility for the content of the publication.

Conflict Of Interest (COI)

There is no conflict of interest.

References

Akinyetun, T. S., and Ebonine, C. V. (2023). Digital democracy and democratic decline: Unpacking the role of digitalization in undermining democracy in Africa. African Journal of Democracy and Election Research, 3(1), 159.

Bon, A., Dittoh, F., Baart, A., Lô, G., Pini, M., Bwana, R., Kulathuramaiyer, N. and WaiShiang, C. (2022). Decolonizing Technology and Society: A Perspective from the Global South. In: Werthner, H., Prem, E., Lee, E.A., Ghezzi, C. (eds) Perspectives on Digital Humanism. Springer, Cham. https://doi.org/10.1007/978-3-030-86144-5_9

Coeckelbergh, M. (2024). What is digital humanism? A conceptual analysis and an argument for a more critical and political digital (post)humanism. Journal of Responsible Technology, Volume 17,100073, ISSN 2666-6596, https://doi.org/10.1016/j.jrt.2023.100073.

Cooley, M. (1989). Human-centred systems. Designing human-centred technology: a cross-disciplinary project in computer-aided manufacturing, 133-143.

Cull, I., Hancock, R.L.A., McKeown, S., Pidgeon, M. and Vedan, A. (2018). Pulling Together: A Guide for Front-Line Staff, Student Services, and Advisors. Pressbooks. ISBN: 978-1-77420-045-2

Dlamini, S., Plantinga, P., Davids, Y.D., Ayodele, O., Sanchez, D. and Dlamini, N. (2025). Design and implementation strategies for e-participation in South Africa. Policy Brief: February 2025. https://hsrc.ac.za/wp-content/uploads/2025/03/Download-1.pdf Accessed, 21 April 2025.

Foley R.W., Nadjari S., Eshirow J., Adekunle R. and Codjoe. (2022). Towards Digital Segregation? Problematizing the Haves and Have Nots in the Smart City. Frontiers in Sustainable Cities Volume (4), 2022. DOI=10.3389/frsc.2022.706670

Gong, C., Qiu, Y. and Zhao, B. (2018). Establishment of Design Strategies and Design Models of Human Computer Interaction Interface Based on User Experience. In: Marcus, A., Wang, W. (eds) Design, User Experience, and Usability: Theory and Practice. DUXU 2018. Lecture Notes in Computer Science, vol 10918. Springer, Cham. https://doi.org/10.1007/978-3-319-91797-9_5

Johnson, J. (2022). Designing with the Mind in Mind: Simple guide to understanding User Interface Design Guidelines (3rd Edition). Morgan Kaufman Publishers, Cambridge, MA. ISBN: 978-0-12-818202-4.

Kwet, M. (2019). Digital colonialism: US empire and the new imperialism in the Global South. Race & Class, 60(4), 3-26. https://doi.org/10.1177/0306396818823172 (Original work published 2019)

Lazem, S., Giglitto, D., Nkwo, M.S., Mthoko, H., Upani, J. and Peters. A. (2022) Challenges and Paradoxes in Decolonising HCI: A Critical Discussion. Computer Supported Cooperative Work 31, 159–196 (2022). https://0-doi.org.wam.seals.ac.za/10.1007/s10606-021-09398-0

Lee, J.B. and Porumbescu, G.A. (2019). Engendering inclusive e-government use through citizen IT training programs, Government Information Quarterly, Volume 36, Issue 1, 2019, Pages 69-76, ISSN 0740-624X, https://doi.org/10.1016/j.giq.2018.11.007

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Lollini, M. (2011). Humanism in the Digital Age. Humanist Studies & the Digital Age, 1(1), 1-7. ISSN: 2158-3846 (online) http://journals.oregondigital.org/hsda/

Malodia, S., Dhir, A., Mishra, M. and Bhatti, Z.A. Future of e-Government: An integrated conceptual framework, Technological Forecasting and Social Change, Volume 173, 2021,121102, ISSN 0040-1625. https://doi.org/10.1016/j.techfore.2021.121102.

McLuhan M. (1964) Understanding Media: The Ex-tensions of Man, Berkeley: Gingko Press.

National e-Strategy Roadmap. Government Gazette, No 41241. 10 November 2017. https://www.gov.za/sites/default/files/gcis_document/201711/41241gen886.pdf. Accessed, 21 April 2025.

Pigeon, M. and Riley, T. (2021). Understanding the Ap-plication and Use of Indigenous Research Methodologies in the Social Sciences Indigenous and Non-Indigenous Scholars. International Journal of Edu-cation, Policy & Leadership (IJEPL), Volume 17(8).

Prem, E. (2024). Principles of digital humanism: A critical post-humanist view. Journal of Responsible Technology, Volume 17, 2024,100075. https://doi.org/10.1016/j.jrt.2024.100075.

Refat, N., Patwary, M. and Rahman, M.A. (2023). Digi-tal Inclusion Towards e-Governance: Challenges and Issues. In: Hayes, S., Jopling, M., Connor, S., John-son, M. (eds) Human Data Interaction, Disadvantage and Skills in the Community. Post digital Science and Education. Springer, Cham. https://doi.org/10.1007/978-3-031-31875-7_8.

Tejedo-Romero, F., Araujo, J., Tejada, A. and Ramírez, Y. (2022). E-government mechanisms to enhance the participation of citizens and society: Exploratory analysis through the dimension of municipalities. Technology in Society. 70. 101978. 10.1016/j.techsoc.2022.101978.

Werthner, H., Stanger, A., Schiaffonati, V., Knees, P., Hardman, L. and Ghezzi, C. (2023). "Digital Humanism: The Time Is Now," in Computer, vol. 56, no. 1, pp. 138-142, Jan. 2023, doi: 10.1109/MC.2022.3219528.

Zabel, S. and Otto, S. (2021). Bias in, Bias Out – the Similarity-Attraction Effect Between Chatbot De-signers and Users. In: Kurosu, M. (eds) Human-Computer Interaction. Design and User Experience Case Studies. HCII 2021. Lecture Notes in Computer Science, vol 12764. Springer, Cham. https://doi.org/10.1007/978-3-030-78468-3_13.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The Potential of Blockchain Technology for Collaboration among Countries

Jefferson Bicca Charczuk[a], *Kerley* Silva[a]*, *Marco Tulio* da Silva Lima[a]

[a] Federal Data Processing Service (Serpro), Brazil

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. In today's interconnected world, cooperation between countries is crucial, whether to deal with challenges or opportunities in the economic, social, technological or environmental perspective. This document proposes a workshop regarding the potential use of blockchain technology to foster international cooperation among different countries, to address opportunities and challenges. Cross-border collaboration is often hindered by inefficiencies, lack of transparency, and trust issues between nations. Blockchain technology, characterized by its decentralized, transparent, and immutable nature, has the potential to change the way countries collaborate, offering new opportunities for more efficient, secure, and trusted cooperation.

Keywords. Blockchain, Public Sector, Collaboration, Cooperation, Opportunities, Challenges.
Workshop, DOI: https://doi.org/10.59490/dgo.2025.1009

1. Introduction

In today's interconnected world, cooperation between countries is crucial, whether to deal with challenges or opportunities in the economic, social, technological or environmental perspective. This document proposes a workshop regarding the potential use of blockchain technology to foster international cooperation among different countries, to address opportunities and challenges.

Cross-border collaboration is often hindered by inefficiencies, lack of transparency, and trust issues between nations. Blockchain technology, characterized by its decentralized, transparent, and immutable nature, has the potential to change the way countries collaborate, offering new opportunities for more efficient, secure, and trusted cooperation.

There are different ways in which blockchain can be potentially used by the public sector (Alexopoulos et al., 2019; Alketbi et al., 2018; Berryhill et al., 2018; Koster and Borgman, 2020; Olnes, Ubacht and Janssen, 2017). Some of the ways that the technology can support collaboration among countries are the following:

a) Enhancing Cross-Border Trade and Economic Cooperation

One of the most promising applications of blockchain for international collaboration lies in trade and supply chain management (Rukanova et al., 2021; Vanany, 2020; Westerlund et al., 2021; Zhang et al., 2021). Traditional international trade systems are often burdened by paperwork, delays, and inefficiencies in customs clearance, payments, and documentation. Blockchain can streamline these processes by providing a secure and transparent record of every transaction, from the manufacturer to the end consumer. This model enables and open the possibility to create standards, allowing interoperation which also aligns a common language between different actors.

Through blockchain-based platforms, countries can potentially reduce intermediaries, minimizing the risks of fraud. For example, blockchain can track goods in real-time as they cross borders, providing a transparent record that ensures compliance with international trade regulations, improving customs efficiency, and enhancing trust between trading partners.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

b) Blockchain for Cross-Border Payments

Blockchain's potential to transform cross-border payments is another area with implications for international cooperation. Crypto economic models using blockchain enable payments, investments, lending and borrowing, allowing the representation of assets as tokens, that can be traded in digital exchanges (Zutshi et al., 2021). Remittances, international business payments, and the global movement of capital often suffer from high transaction costs, slow processing times, and the involvement of many intermediaries. Blockchain can reduce intermediaries, thereby reducing costs and making financial flows faster and more transparent.

Countries can collaborate on creating a stable infrastructure for international economic cooperation, allowing for the easier exchange of money across borders. Blockchain can provide the security and efficiency needed to support these digital currencies, ensuring that international transactions are both faster and more reliable.

c) Secure Data Sharing for Global Challenges and Cooperation

International cooperation often requires the exchange of data across borders, whether for education, security, environmental monitoring, or scientific research. Blockchain can provide a secure and transparent means for data sharing between countries, reducing the risks of data manipulation.

For example, blockchain could be used to track climate change data shared between nations, creating an immutable record of emissions reductions, resource usage, or conservation efforts. This would ensure that all participating countries are held accountable to their commitments under global or regional agreements. By ensuring that data cannot be altered or tampered with, blockchain increases transparency and trust among nations.

At its core, blockchain technology offers a decentralized and trustless system. Countries can collaborate through blockchain technology, leveraging open-source solutions to enhance mutual growth. By sharing knowledge and resources, they can create more efficient, transparent systems. Together, they can unlock new opportunities for innovative solutions. Even when countries don't fully trust each other, blockchain enables them to work together without relying on a central authority or intermediary. With blockchain, nations can collaborate on projects, share information, and exchange resources in a way that ensures transparency, accountability, and security.

d) Blockchain in International Governance and Accountability

International governance often involves complex negotiations between countries with differing interests, values, and political systems. Blockchain can help facilitate these discussions by providing a decentralized platform for governance where decisions are made collaboratively, transparently, and with accountability. Furthermore, blockchain can help in creating standards and protocols that can be adopted by different countries, ensuring interoperability and alignment of interests (Koller and Douglas, 2023).

One of the most innovative uses of blockchain in the context of international collaboration is its potential to transform voting systems (Jafar, Aziz and Shukur, 2021). Blockchain-based voting systems could be used to ensure that international bodies make decisions based on real-time input from all participants. Blockchain could also enhance transparency in international aid distribution, making it easier to track how funds are allocated, how they are spent, and whether they reach their intended recipients.

For example, in humanitarian aid scenarios, blockchain can help to track donations, ensuring that funds are used appropriately and reach the right beneficiaries. This would increase trust in among civil society and organizations and foster stronger collaboration between nations in solving crises such as disaster relief.

Blockchain-based voting could also be used in global referendums on pressing issues like international trade agreements and collective measures from different dimensions, such as environmental, social, technological and economical. By leveraging blockchain's security and transparency features, global and decentralized models of governance could become more inclusive and trusted by citizens around the world.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

2. Workshop Proposal

a) Goal: to identify international challenges, analyse pain points and to map the potential use of blockchain.

b) Participants: Government representatives, tech developers, policymakers, international organizations, corporations, civil society, business leaders, researchers and students. By engaging in open dialogue, stakeholders from different backgrounds can share valuable insights, which can help shape more effective and adaptable strategies for implementing blockchain in an international context. The diversity of thought also enables the identification of potential challenges that may arise in different cultural, economic, and regulatory environments, allowing for more informed decision-making.

c) Steps:

- Brief presentation: regarding the workshop goals and about the potential of blockchain in the international context.
- Identification of international challenges or needs: Identification of common challenges, needs and inefficiencies that affect multiple countries. These challenges should be suitable for blockchain's unique features (e.g., transparency, security, tokenization, decentralization and standardization). At the end, the challenges will be organized according to PESTLE framework.
- Analysis of pain points: Dive deep into some of the specific needs and pain points of the different countries. Examination of the bottlenecks and inefficiencies in the international issues selected. Assessment regarding where is trust between parties lacking, as well as where decentralization or tokenization may be suitable.
- Map the potential use of blockchain: Explore how blockchain's capabilities can address some of the pain points identified. Map each challenge or need and align it with potential blockchain use cases. Use a value vs. feasibility matrix to prioritize ideas. The matrix should plot potential blockchain applications based on their feasibility (technical, regulatory, etc.) and value to stakeholders.

3. Conclusion: Blockchain as a Catalyst for Cooperation among Nations

Blockchain's potential to enhance international collaboration is promising and multifaceted. By offering secure, transparent, and decentralized systems, blockchain can help address some inefficiencies and trust deficits that currently exist between countries in areas such as trade, education, finance, governance, and environmental protection. As nations continue to face global challenges, as climate change and economic inequality, blockchain technology provides a powerful tool to foster more effective, transparent, and equitable international cooperation.

By embracing blockchain, countries can take a significant step toward more cohesive, accountable, and trustworthy partnerships. The time to explore its potential is now, as the future of international collaboration hinges on the willingness to innovate, adopt new technologies, and build a more connected world.

Therefore, it is expected that the workshop and discussions will consider the diverse perspectives of the participants to explore the use of blockchain technology in an international context. The exchange of different visions allows participants to deepen their understanding of blockchain's potential and limitations across various regions and sectors.

Moreover, the workshop can encourage cross-border collaboration, breaking down barriers and promoting the development of solutions that benefit many parties. This collaborative environment accelerates innovation, with participants more likely to create interoperable systems that can operate seamlessly across jurisdictions. The shared goal of maximizing blockchain's positive impact on different segments brings people together, fostering stronger partnerships and networks that extend beyond the duration of the workshop.

In conclusion, we expect that the workshop with diverse perspectives on blockchain may pave the way for more strategies that address different challenges and opportunities, while unlocking the technology's potential in an international context.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Acknowledgement

- **Contributor Statement***:
  - Jefferson Bicca Charczuk: Software, Resources, Validation, Writing – Review & Editing
  - Kerley Silva: Conceptualization, Data Curation, Investigation, Methodology, Resources, Writing – Original Draft, Writing – Review & Editing
  - Marco Túlio da Silva Lima: Project administration, Supervision, Writing – Review & Editing
- **Use of AI***: During the preparation of this work, the author(s) used ChatGPT in order to explore different ideas and techniques regarding the workshop. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

References

Alexopoulos, C., Charalabidis, Y., Androutsopoulou, A., Loutsaris, M. A., Lachana, Z. (2019). Benefits and Obstacles of Blockchain Applications in e-Government. Proceedings of the 52nd Hawaii International Conference on System Sciences.

Alketbi, A., Nasir, Q., Talib, M. A. (2018). Blockchain for government services - Use cases, security benefits and challenges. IEEE Learning and Technology Confer- ence (L&T). DOI: 10.1109/LT.2018.8368494

Berryhill, J., T. Bourgery and A. Hanson (2018), "Blockchains Unchained: Blockchain Technology and its Use in the Public Sector", OECD Working Papers on Public Governance, 28, OECD Publishing, Paris. http://dx.doi.org/10.1787/3c32c429- en

Jafar, U., Aziz, M. J. A., & Shukur, Z. (2021). Blockchain for Electronic Voting System—Review and Open Research Challenges. Sensors, 21(17), 5874. https://doi.org/10.3390/s21175874

Koller, R., Douglas, M. (2023). Open Customs Blockchain: The missing piece to unlocking the broad application of distributed ledger technology for Customs? https://mag.wcoomd.org/magazine/101-issue_2_2023/open-customs-blockchain

Koster, F., Borgman, H. P. (2020). New Kid on the block! Understanding blockchain adoption in the public sector. Proceedings of the 53rd Hawaii International Conference on System Sciences. https://hdl.handle.net/10125/63958

Olnes, S., Ubacht, J., Janssen, M. (2017). Blockchain in government: Benefits and im- plications of distributed ledger technology for information sharing. Government Information Quaterly, 34, 355-364.

Rukanova, B., Ubacht J., Engelenburg, S. V., Tan, Y., Geurts, M., Sies, M., Molenhuis, M., Slegt, M. (2021). Realizing value from voluntary business-government in- formation sharing through blockchain-enabled infrastructures: The case of im- porting tires to the Netherlands using TradeLens. International Conference on Digital Government Research. https://doi.org/10.1145/3463677.3463704

Vanany, I., Rakhmawati, N. A., Sukoso, S., Soon, J. (2020). Indonesian Halal Food Integrity: Blockchain Platform. International Conference on Computer Engineering, Network, and Intelligent Multimedia.

Westerlund, M., Nene, S., Leminen, S., Rajahonka, M. (2021). An Exploration of Blockchain-based Traceability in Food Supply Chains: On the Benefits of Distributed Digital Records from Farm to Fork. Technology Innovation Management Review, 11(6).

Zhang, Y., Liu, Y., Jiong, Z., Zhang, X., Li, B., Chen, E. (2021). Development and as- sessment of blockchain-IoT-based traceability system for frozen aquatic product. Journal of Food Process Engineering, 44(5). https://doi.org/10.1111/jfpe.13669

Zutshi, A., Grilo, A., Nodehi, T. (2021). The value proposition of blockchain technolo- gies and its impact on Digital Platforms. Computers & Industrial Engineering, 155. https://doi.org/10.1016/j.cie.2021.107187

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Appendix A

The proposed steps for the workshop may be updated according to the number of participants. The workshop consists of two sessions, each lasting 1 hour and 30 minutes.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Workshop "Digital Government Measurement for Research and Public Policies"

*Manuella Maia Ribeiro a**

[a] Regional Center for Studies on the Development of the Information Society (Cetic.br), Brazilian Network Information Center (NIC.br), São Paulo, Brazil, manuella@nic.br, https://orcid.org/0000-0002-5420-1348.

Submitted: 31 January 2025, Revised: 26 March 2025, Accepted: 21 April 2025, Published: 22 May 2025

Abstract. Based on the Regional Center for Studies on the Development of the Information Society (Cetic.br) 20 years' experience on measuring information and communication technologies (ICT) in Brazil and its participation in various international indicators standards working groups, the workshop aims to familiarize the participants with digital government indicators and strategies to use them in research and public policies. To achieve this purpose, participants will be informed about the availability of secondary data related to digital transformation and digital government from both demand- and supply-side, including international databases. The organizers also intend to present showcases using datasets of national surveys in Brazil relating to the adoption of technologies by governments and individuals.

Keywords. Digital government, measurement, indicators.
Workshop, DOI: https://doi.org/10.59490/dgo.2025.1010

1. Introduction

Digital government initiatives have been considered essential to facilitate access to public information and services by the population and support the achievement of the Sustainable Development Goals (SDGs), among other national and international commitments. However, both progress between countries and the adoption of these initiatives by individuals can vary around the world. In this context, measuring digital government becomes essential to identify not only inequalities in the inclusion of technologies in the daily activities of public organizations, but also to help define government actions to advance in this area. In addition, the need to investigate the enablers and barriers to society's access to digital public services has been highlighted by academia, governments and international organizations, especially among the most vulnerable population. Therefore, it is also necessary to monitor how society is using digital government to ensure that people have access to the services and information they need.

Based on this scenario, this workshop aims to explore the use of secondary data in research and practice related to digital transformation and digital government. It seeks to provide insights into key international digital transformation indicators and discuss how researchers, practitioners and students can leverage these datasets to analyse government digital initiatives in Brazil and worldwide. The organizers intend to present databases on digital transformation and digital government, such as from International Telecommunication Union (ITU) data hub and microdata from Cetic.br surveys, highlighting potential usage for analysing and improving public policies.

The purpose of the workshop is to provide participants with practical knowledge on how to use these datasets—supported by the indicators and studies developed by the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br) and a UNESCO Category 2 Center in Brazil—to enhance research in digital government. The workshop is designed for researchers, students, and professionals interested in leveraging data for digital transformation and public sector research.

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

The key topics of the workshop include:

- Secondary Data Analysis in Digital Transformation and Digital Government: Understanding the role of existing datasets in research and practice.
- Measuring Connectivity Across Countries in the Digital Era: Assessing the impact of connectivity on data usage by researchers, from more conservative to less conservative approaches.
- International Indicators of Digital Transformation: Exploring global datasets and methodologies for measuring digital transformation.

2. About the organizers

Since 2005, the Regional Center for Studies on the Development of the Information Society (Cetic.br), a department of the Brazilian Network Information Center (NIC.br), executive branch of the the Brazilian Internet Steering Committee (CGI.br), has been dedicated to monitor access, usage, and adoption of information and communication technologies (ICT) in Brazil. It accomplishes this by producing key indicators on ICT access, usage, and appropriation across different sectors of society. These insights support policymaking, research and the evaluation of public policies aimed at fostering Internet development in the country

In 2012, Cetic.br was designated as a Category 2 Center of UNESCO, becoming the first center focused on the advancement of information and knowledge societies. Affiliated with UNESCO's Communication and Information Sector, it plays a strategic role in supporting the institution's goals, contributing to the global effort to monitor and promote the development of information and knowledge societies, especially among Latin America and Portuguese-speaking African countries. Cetic.br's initiatives include efforts to highlight the importance of ICT measurement for public policy, facilitate discussions on the intersection of society and technology, and promote the exchange of experiences among key stakeholders involved in shaping knowledge societies.

3. Objectives for the participants

The Digital Government Measurement for Research and Public Policies workshop aims to familiarize participants with the knowledge and tools necessary to leverage digital government indicators and datasets for research and policymaking. By the end of the workshop, participants have a better understanding of:

- Role of Digital Government Indicators
    - Gain insights into the importance of measuring digital transformation in the public sector.
    - Identify key international and national indicators that track digital government progress.
- Explore Secondary Data Sources for Research and Public Policies
    - Learn about available secondary data sources, including demand- and supply-side datasets, to analyse digital transformation indicators.
    - Understand how international databases, such as those from the International Telecommunication Union (ITU) and Cetic.br/NIC.br, can contribute to research and policies.
- Apply Data and Indicators to Research and Public Policy
    - Explore practical examples of how datasets have been used to shape public policies in Brazil and other countries.
    - Develop strategies to integrate digital government indicators into academic research and public policies.

4. Format

The workshop is structured as an interactive session and lasts for 1 hour and 30 minutes. The format consists of a plenary session with short presentations by the organizers and continuous Q&A with the audience. The proposed schedule is as follows:

- Session introduction (up to 10 minutes);
- Short presentations by the organizers on each workshop theme (up to 10 minutes per theme);
- Q&A with the audience during the session;
- Closing comments and session summary (10 minutes).

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

Acknowledgement

- **Contributor Statement***: Manuella Maia Ribeiro was responsible for conceptualization, and writing - original draft.
- **Use of AI***: During the preparation of this work, the author used Grammarly in order to correct grammatical errors. After using this tool/service, the author reviewed, edited, made the content their own and validated the outcome as needed, and takes full responsibility for the content of the publication.
- **Conflict Of Interest (COI)***: There is no conflict of interest.

Suggested references for the workshop

Brazilian Network Information Center. (2024). *Meaningful connectivity: Measurement proposals and the portrait of the population in Brazil* (NIC.br Sectoral Studies). CGI.br. https://cetic.br/pt/publicacao/meaningful-connectivity-measurement-proposals-and-the-portrait-of-the-population-in-brazil/

Brazilian Network Information Center. (n. d.). *ICT Electronic Government survey*. https://cetic.br/en/pesquisa/governo-eletronico/

Brazilian Network Information Center. (n. d.). *ICT Households survey*. https://cetic.br/en/pesquisa/domicilios/

International Telecommunication Union. (2022). *Core list of ICT indicators*. https://www.itu.int/en/ITU-D/Statistics/Documents/coreindicators/Core-List-of-Indicators_March2022.pdf

International Telecommunication Union. *ITU Data Hub*. https://datahub.itu.int/

Macaya, J. F., Ribeiro, M. M., Jereissati, T., dos Reis Lima, C., & Cunha, M. A. (2021). Gendering the digital divide: The use of electronic government services and implications for the digital gender gap. *Information Polity, 26*(2), 131 146.

Macaya, J. F. M. (2024, October). Electronic government and meaningful connectivity levels: Who is really positioned to benefit from digital transformation in government? In *Proceedings of the 17th International Conference on Theory and Practice of Electronic Governance* (pp. 425-429).

NICbrvideos. (2021, December 6*). Minicurso 1: Tutorial sobre métodos e ferramentas para análise de microdados de pesquisas TIC - Cetic.br*. https://www.youtube.com/watch?v=7d1bhqtrPGk

Ribeiro, M. M., Soares, D., Macaya, J., & Meyerhoff Nielsen, M. (2024). *Citizen-centered digital government: Approaches for advancing the public sector's use of technologies based on demand-side data*. https://collections.unu.edu/view/UNU:9833

Copyright ©2025 by the authors. This conference paper is published under a CC-BY-4.0 license

This volume presents the proceedings of the 26th Annual International Conference on Digital Government Research (DG.O 2025), a landmark event marking the conference's first edition in South America, hosted in Porto Alegre, Brazil. Bringing together leading scholars and practitioners from 32 countries, this book explores the critical intersections of public administration, technological innovation, and civic engagement. It includes the full versions of the 119 papers presented over four days across 24 thematic tracks, chaired by 63 colleagues. Many served in multiple roles, reflecting the dedication and collaborative spirit that characterize our community. Together, these efforts ensured both the scientific quality and the intellectual diversity of the program.

The theme of DG.O 2025, *Digital Government Fostering Social Cohesion for Reducing Inequalities*, was especially relevant in the Brazilian context and aligned with ongoing international discussions. More than a technological endeavor, digital government represents a powerful means of addressing long-standing social and economic inequalities. In societies characterized by unequal opportunities, fostering social cohesion remains both a pressing challenge and a shared objective. The experiences of Brazil and Latin America highlight the value of inclusive approaches that strengthen participation, trust, resilience, and a sense of belonging. This perspective was reflected throughout the conference program, with tracks and sessions addressing, among other topics:

- Artificial Intelligence, Algorithmic Accountability, and Ethics in Government
- Data-Driven Public Policy, Open Data Ecosystems, and Digital Platforms
- Digital Democracy, E-Participation, and Public Engagement
- Smart Cities, Sustainable Governance, and Urban Social Cohesion
- GovTech, Cybersecurity, Trust, and Digital Public Infrastructure

This volume serves as an interesting resource for researchers, policymakers, and public administrators seeking actionable strategies to leverage digital transformation to build more inclusive, trustworthy, and resilient societies.