What drives local governments' digital transformation in Brazil?

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Abstract. In the context of increasing demands for efficient and equitable public service delivery, digital transformation has become essential for local governments, particularly within federations marked by inequality. This study investigates the factors driving digital transformation in Brazilian municipalities—a country with significant regional disparities and varying administrative capacities. The objective is to identify which economic and technical-administrative variables influence the digital maturity of local governments. Using data from 4,265 municipalities collected in 2023, the study constructs a Digital Transformation Index encompassing technological infrastructure and digital service provision. Multiple linear regression models assess the relationship between digital transformation and variables such as fiscal autonomy, IT expenditures, bureaucratic quality, and mayors' educational profiles. Results indicate that municipal revenue generation and IT spending positively correlate with digital transformation, while reliance on intergovernmental transfers is negatively associated. Additionally, better-educated civil servants and mayors are more likely to lead digitally advanced municipalities. However, when accounting for regional and population size controls, many of these associations lose statistical significance, underscoring the role of broader structural disparities. The findings suggest that economic and human resource capacity are important but insufficient alone; a more coordinated national strategy is necessary to reduce regional inequalities and support local digital transformation.

Keywords. Digital Transformation, Local Governments, Brazil, Fiscal Autonomy, Education, Regional Disparities.
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1. Introduction

Given the increasing complexity of public problems and the evolving expectations of citizens, digital transformation is not merely an option but a necessity for local governments to ensure equitable access to essential services, improve responsiveness and accountability, and ultimately enhance public value in addressing critical societal challenges. In this sense, local governments worldwide are implementing new digital technologies in different policy domains and functions and conducting digital transformation processes (Branderhorst & Ruijer, 2024; Criado & Gil-Garcia, 2019). These new technologies are changing the landscape of public management and local authorities' abilities to create public value and deliver public services (Filgueiras et al., 2019; Mergel et al., 2019).

Digital transformation in the public sector means new ways of working with stakeholders, building new service

delivery frameworks and creating new relationships (Mergel et al., 2019). The focus of digital transformation shifted from internal processes and efficiency gains (e-government) to citizen-driven services, placing the citizen at the center. Adopting new technologies in governments occurs in the context of incremental changes controlled by bureaucratic agents within institutions (Filgueiras et al., 2019; Haug et al., 2024).

Regarding studies on digital transformation in local governments, literature already has important findings. Hong et al. (2022) pointed out that innovation in local governments in South Korea is driven by demand, in which public organizations respond to the needs of citizens. In addition, the study highlighted that electoral incentives motivate local governments to innovate digitally to meet local priorities, that isomorphic pressures matter, i.e., local governments tend to imitate innovative practices of neighbors, and that younger policymakers are more active in innovation. Epstein (2022), when analyzing North American cities, evaluated that the adoption of e-government services between 2014 and 2019 was different, specifically, while earlier adoption was largely driven by larger cities with more resources, by 2019, there was a broader diffusion of e-government across cities of varying sizes. The study found that over time, factors such as population size and broadband access remained significant, but economic variables like municipal wealth lost explanatory power, suggesting that access and infrastructure became more critical than fiscal capacity in determining digital service provision (Epstein, 2022). B. Fan and Pan (2023) analyzed the drivers for Chinese local government strategies and examined the effect of the interaction between IT infrastructure and other organizational resources (financial and human) on e-government performance. The authors found that the interaction between IT infrastructure and financial resources has a positive effect on e-government, while the interaction between IT infrastructure and human resources has a negative effect on e-government performance. Furthermore, they concluded that the effect of the interaction between IT infrastructure and organizational resources (financial and human) on e-government performance increases with decreasing environmental turbulence and increasing environmental complexity.

Moreover, Mergel et al. (2019) and Wilson and Mergel (2022) have pushed researchers to look at digital transformation's social, economic and political aspects from their qualitative research. Mergel et al. (2019) pointed out that external factors and pressures are the main drivers of digital transformation in governments rather than internal factors. Much work has been dedicated to understanding the drivers of digital transformation in local governments worldwide (Epstein, 2022; B. Fan & Pan, 2023; Hong et al., 2022; Mergel et al., 2019; Wilson & Mergel, 2022). Thus, there are indications that the quality of bureaucracies, external demands on government and financial resources are correlated with the process. However, only some studies examined Latin America's context in the digital transformation process (Aguerre & Bonina, 2024; Filgueiras et al., 2019). In this case, we identified a gap in the literature, given that few studies aimed to understand the drivers of digital transformation in Latin American local governments. This article addresses the following research question: What are the drivers of digital transformation in Brazilian municipalities? To address this question, this study aims to analyze the economic and technical-administrative factors associated with digital transformation in Brazilian municipalities, identifying which local government characteristics most significantly influence the adoption of digital technologies and services. Thus, we aim to identify which municipal characteristics are associated with the digital transformation process.

Brazil offers a compelling case study for digital transformation research due to its vast and diverse population within a complex federal system, which provides a rich context for observing the phenomena across different levels and allows the examination of the opportunities and challenges of digital transformation implementing initiatives. The complexities of a federal country stem from deep regional inequalities, fiscal dependencies, and varying administrative capacities across municipalities, creating significant challenges for implementing coherent public policies, especially in digital transformation (Alves & Araujo, 2024; Filgueiras et al., 2019; Grin & Abrucio, 2021; Marenco & Cate, 2021) While existing research has primarily focused on the national level (Filgueiras et al., 2019), this study delves into the experiences of local governments by examining local-level challenges and successes, filling a crucial gap in the literature, so this research contributes to understanding the factors driving digital governance in this complex federal system. This study examines the factors driving digital transformation in local governments in Brazil, considering the technical, administrative and financial inequalities between municipalities.

This paper is divided into four sections in addition to the introduction. The second section provides a background and defines the hypotheses, introducing key concepts related to digital transformation in Brazil. The third details the methodology, focusing on data selection and analysis techniques. The fourth presents the results and discussion, aiming to answer the research question and objective by clarifying the drivers of digital transformation in Brazilian municipalities. Finally, the conclusion restates the main findings, acknowledges some limitations, and offers recommendations for future research.

2. Background and Hypothesis' Definition

Brazil began with e-government initiatives in the 1960s by creating SERPRO (public data processing company) in 1964 (Filgueiras et al., 2019), and in the 1970s, another public data processing company was instituted named Dataprev, initially dedicated to the social security sector. Throughout the 1990s and 2000s, incremental progress focused on digitizing administrative processes and routines. From 2016 onwards, there was a significant

institutional change driven by two main factors: (1) the need to respond to the fiscal crisis with greater efficiency and cost reduction, and (2) the influence of the OECD, which advised Brazil with guidelines, case studies and standards to adopt digital transformation policies (Filgueiras et al., 2019). This process culminated in the transition to more comprehensive digital governance based on new norms and paradigms focused on providing services in a federal government platform (GOV.BR) created in 2019.

Despite Brazilian e-government initiatives, research conducted by Przeybilovicz et al. (2018) using 2014 data revealed that most municipalities had limited online services. For instance, over 90% of municipalities lacked online options for obtaining permits, enrolling children in school, or scheduling medical appointments. Furthermore, municipal websites primarily served as information portals. This scenario indicates that, a decade ago, local Brazilian governments' widespread adoption of e-government services was still a significant challenge. The Southeast/South region appeared to be the most advanced in e-government initiatives; conversely, the North and Northeast regions represented the most challenging areas for e-government implementation, revealing a significant disparity in ICT infrastructure and use, poverty, and limited access to technology. These factors hinder the development and adoption of online government services, leaving many of the population underserved (Przeybilovicz et al., 2018).

Internationally, the discussion about government as a platform began at the end of the 2000 decade (O'Reilly, 2011). Since then, a new conception of government and its role in society has emerged and changed over the last few decades. While influential in recent decades, the New Public Management (NPM) paradigm has been criticized for its limitations. Osborne et al. (2013) argued that NPM's focus on internal processes and the application of manufacturing-based theories inadequately addresses the unique characteristics of public services. Instead, they advocated for a "public service-dominant" approach. This approach emphasizes the service-oriented nature of public services, prioritizing citizen co-production, strategic orientation, marketing, and operational management. By recognizing citizens as active participants in service delivery, this approach seeks to provide a more relevant framework for contemporary public management challenges.

A crucial aspect of this revised approach is recognizing the inter-organizational nature of public service delivery. Osborne et al. (2013) highlighted the critical role of coordination and collaboration among organizations involved in service provision. This insight becomes particularly relevant in the context of digital transformation. The successful integration of ICT in the public sector hinges on overcoming significant challenges, including the technical capacity to implement ICT, the perceptions of public managers regarding transparency, efficacy, and accountability, and the persistence of data silos within public administration. These silos, exacerbated by a lack of coordination and limited political-institutional capacity for change (Wilson & Mergel, 2022), hinder the effective digital transformation of public services. As Filgueiras et al. (2019) emphasized, digital transformation necessitates robust policy coordination among various organizations to ensure coherent service delivery aligned with the priorities and objectives of each entity. This requires effective negotiation and agreement among agencies that often operate autonomously, thereby emphasizing the importance of inter-organizational collaboration for successful digital transformation in the public sector.

Given the extensive territorial inequality in Brazil, in other words, uneven distribution of resources, infrastructure, public services, and development opportunities across the country's different geographic regions and municipalities, some municipalities (mainly state capitals and large regional centers) have a greater administrative capacity linked to local government, more significant funding, and more pressure from society to digitize services. Meanwhile, most Brazilian municipalities are small (less than 20,000 inhabitants), and incorporating ICT tools has historically lagged behind (Przeybilovicz et al., 2018). Therefore, the provision of services offered by local governments via the platform is challenged, given the existing heterogeneities. In this sense, given the recent induction of the Brazilian federal government through Decree nº 12.069/2024 to the process of digital transformation of subnational entities (Brazil, 2024), one wonders what can explain the fact that some municipalities have adopted tools to offer services via the platform while others have not?

Thus, this study analyzes the relationship between the economic (H_1, H_2 and H_3) and technical-administrative (H_4 and H_5) dimensions of digital transformation in local governments in Brazil. The hypotheses underlying this research and its rationale are outlined as follows.

2.1 Fiscal autonomy and digital transformation

B. Fan and Pan (2023) argued that the interaction between IT infrastructure and organizational resources, mainly financial and human resources, significantly impacts e-government performance, specifically that financial resources positively enhance the effect of IT infrastructure. In the Brazilian case, local governments' tax revenue collection depends on the current economic structure. By law, the central and state governments transfer a fixed portion of resources to local governments (Alves & Araujo, 2024). Most of these allocations are restricted to designated purposes such as health services, education, etc., limiting their availability for digital transformation initiatives. Therefore, municipalities with thriving economic activity can collect more resources and become less dependent on state and Union

transfers but, for the most part, have fewer opportunities to expand the tax base. Based on it and B. Fan and Pan's (2023) proposition, it can be argued that the municipality's fiscal autonomy can affect its digital transformation capacity, taking to the first hypothesis:

H_1. Municipalities with greater fiscal autonomy from federal and state transfers exhibit higher levels of digital transformation.

2.2 Budget expenditures and digital transformation

Budget expenditures provide a key indicator of the financial resources dedicated to e-government initiatives, covering areas such as IT infrastructure, personnel training, and cybersecurity (Z. Fan et al., 2020; Reddick, 2006). The development and upkeep of such infrastructure demand significant financial resources (B. Fan & Pan, 2023; Z. Fan et al., 2020; Salim et al., 2022), inadequate funding can hinder the ability to address technical challenges, upgrade systems, and respond to evolving digital needs (Z. Fan et al., 2020; Osah & Pade-Khene, 2020; Stier, 2015). Governments may struggle to deliver efficient and effective public services without sufficient investment (Welch & Feeney, 2014). In Brazil, municipalities are responsible for financing a wide range of public policies, such as basic health care, education, and social assistance, among others. Investment in technology and digital transformation is one of the priorities that municipalities already need to address. Furthermore, more resources can be required to constrain the capacity to attract and retain skilled IT professionals, which is essential for ensuring the smooth operation of e-government systems.

In other words, governments can allocate substantial funds towards IT investments by generating adequate revenue. This enables them to embrace innovative technologies, expand the scope of e-government services, and improve overall service delivery (Z. Fan et al., 2020; Osah & Pade-Khene, 2020; Reddick, 2006; Stier, 2015). Increased financial resources empower governments to explore new opportunities, such as developing sophisticated data analytics capabilities and implementing advanced cybersecurity measures (Mukhopadhyay et al., 2019). Moreover, sufficient funding can facilitate the training and development of public servants, enhancing their digital literacy and capacity to leverage technology effectively (B. Fan & Pan, 2023). Ultimately, revenue generation empowers governments to create a more responsive, efficient, and citizen-centric e-government ecosystem. In this context, we present the second hypothesis:

H_2. Municipalities with higher revenue generation demonstrate greater levels of digital transformation.

2.3 IT expenditures and digital transformation

The successful implementation and maintenance of e-government initiatives rely on robust IT infrastructure (B. Fan & Pan, 2023); it provides the essential technological backbone that enables governments to deliver efficient and accessible public services. Regarding the technological dimension, IT infrastructure or technological capacity is a significant predictor of e-government service provision (Savoldelli et al., 2014; Welch & Feeney, 2014).

By investing in IT infrastructure, municipalities can streamline processes, reduce administrative costs, and enhance transparency and accountability (Hilhorst et al., 2022; Scholta et al., 2019). A well-developed IT infrastructure facilitates the integration of various government systems, enabling seamless data sharing and collaboration (Janssen et al., 2009). This, in turn, improves decision-making and allows for more informed policy development.

Investing in IT infrastructure empowers municipalities to embrace technological advancements and innovate in service delivery (Z. Fan et al., 2023). By adopting emerging technologies like artificial intelligence, machine learning, and blockchain, governments can automate tasks, improve service quality, and enhance citizen experiences. A strong IT infrastructure also enables municipalities to adapt to changing circumstances, such as natural disasters or economic crises. By leveraging digital tools, governments can respond quickly and effectively to challenges, ensuring business continuity and maintaining essential services (Z. Fan et al., 2023). It takes us to the following hypothesis:

H_3. Municipalities with higher IT expenditures exhibit greater levels of digital transformation.

2.4 Local government bureaucracies and digital transformation

From a Weberian perspective, we can argue that municipalities with higher bureaucratic quality – measured by the level of formal schooling of municipal bureaucrats (Grin & Abrucio, 2021; Marenco & Cate, 2021; Segatto et al., 2022) – are more likely to implement digital transformation initiatives successfully. A well-structured and efficient bureaucracy provides a solid foundation for technological advancements. By streamlining processes, improving communication, and fostering innovation, bureaucratic quality enables organizations to effectively leverage technology to enhance service delivery, citizen engagement, and overall operational efficiency.

Well-educated and well-trained public servants are essential for effective digital transformation; beyond technical skills,

they bring analytical and problem-solving abilities needed to integrate new technologies into public services (Mergel et al., 2019; Zhu & Zhang, 2019). Continuous training keeps staff updated on evolving tools, data protection laws, and cybersecurity (Hilhorst et al., 2022). Additionally, trained bureaucrats increasingly take on roles like digital service designers, driving innovation (Melin et al., 2024). These "digital champions" help overcome internal resistance and improve project implementation (Wilson & Mergel, 2022) while their expertise reduces errors and builds citizen trust (B. Fan & Pan, 2023).The quality of the bureaucracy in the subnational context and its role in conducting public policies (including digital transformation) has been explored in Brazil and internationally (Grin & Abrucio, 2021; Melin et al., 2024). Despite the challenges in its measurement due to multiple factors, in Brazil, the Brazilian Institute of Geography and Statistics (IBGE) periodically collects information on the professional qualifications of bureaucrats in local governments. Following IBGE's proposition, years of formal study will be the proxy to measure the quality of bureaucracy.

We hypothesize that a strong workforce with expertise and training is essential for designing, implementing, and maintaining digital solutions. Municipalities can accelerate their digital transformation journey and reap the associated benefits by optimizing the interplay between bureaucratic quality, financial resources, and human capital. Based on these assertations, we present the hypothesis:

H_4. Municipalities with higher bureaucratic quality demonstrate greater levels of digital transformation.

2.5 Mayors' profiles and digital transformation

There is a consensus that older individuals are less likely to engage with digital technologies, exhibit lower trust in e-government services than younger generations, and, consequently, are less inclined to adopt e-government practices (Faber et al., 2020; Ruano De La Fuente, 2014). In this sense, it is possible to assume that younger mayors are more digitally savvy and open to innovation, making them more likely to embrace technology-driven solutions. Additionally, their higher education levels equip them with the knowledge and skills necessary to understand and navigate the complexities of digital governance (B. Fan & Pan, 2023).

Also, younger mayors are more likely to cater to the working population's needs, who often prefer digital interactions for convenience and efficiency (Budding et al., 2018). By prioritizing e-government initiatives, these mayors can enhance citizen engagement, streamline services, and improve overall governance. It is also worth noting that the influence of top-down pressures from higher levels of government can incentivize local leaders to prioritize digital transformation (Z. Fan et al., 2020; Yun & Opheim, 2010). By controlling factors such as the mayor's age, tenure, and previous experience, it is possible to isolate better the impact of youth and education on digital transformation efforts (Zhu & Zhang, 2019). In this scenario, we present the last hypothesis:

H_5. Municipalities led by younger mayors with higher levels of education exhibit greater levels of digital transformation.

3. Methods

3.1 Data Selection

The Regional Center for Studies on the Development of the Information Society (Cetic.br) is a department of the Brazilian Internet Information and Coordination Center (NIC.br), created in 2003 and linked to the Brazilian Internet Steering Committee (CGI.br) (CGI.BR, 2023). For decades, the organization, in partnership with the Brazilian Institute of Geography and Statistics, has developed research and produced data and analyses that support public policies and strategies for creating the information society, ICT use, digital transformation and internet accessibility in the country.

Since 2017, CETIC has consistently engaged all subnational governments in Brazil to generate data on technology adoption and digital transformation processes in municipal administrations. We utilized the Cetic.br database containing data from Brazilian municipalities collected in the 2023 survey. Although Brazil comprises 5,570 municipalities, the survey received responses from only 4,265 of them, constituting our sample.

The dependent variable in this study is Digital Transformation, constructed based on indicators encompassing the dimensions of Technological Infrastructure and Digital Service Provision in local governments (APPENDIX A), with data extracted from the CGI.BR – Comitê Gestor da Internet no Brasil (2023). As independent variables, we utilized indicators that measure economic and technical-administrative dimensions, as presented in Table 1. In this research, variables associated with information technology governance in city halls were measured, such as the presence of specific IT sectors, the development of strategic planning, the adoption of information security measures, the application of data protection policies and the training of civil servants on the General Personal Data Protection Act (LGPD). These elements form part of the dimension known as Technological Structure.

On the other hand, in the Digital Public Services dimension, actions aimed at digital transformation in municipal administrations were considered, including the provision of digital services through applications for citizens, integration with the Gov.br single login, and the provision of digital solutions for issuing documents, invoices, slips, registrations and online appointments.

Tab. 1 – Overview of Regression Model Variables

Variable	Type	Description	Source	Dimension
Digital Transformation	Dependent	An index measuring the degree of technological infrastructure and digital service provision	CETIC	Technological and digital public services
IT Expenditures	Independent	Measures of how much the municipality spends on IT	Brazilian Government Accounting and Fiscal Information System (Siconf)	Economic
Intergovernmental Transfers	Independent	Measures of how dependent or autonomous the municipality is on revenues from the Union and State	System of Information on Public Budgets in Health (SIOPS)	
Municipal Revenues	Independent	Measures of how much financial resources come from own revenues	System of Information on Public Budgets in Health (SIOPS)	
Bureaucratic Qualification	Independent	Measures the percentage of the municipal bureaucracy with higher education	Gov. Munic – Laboratory of Applied Research	Technical-Administrative
Local Management	Independent	Measures the local management of the municipality	Superior Electoral Court (TSE)	

Source: From the authors.

In the economic domain, we considered Information Technology (IT) expenditures, which reflect municipal spending in this area, using data from the Brazilian Government Accounting and Fiscal Information System (Siconf), which compiles financial information from all areas of municipal public administration. We also included intergovernmental transfers, which measure the proportion of resources received by municipalities from state and federal governments and municipal revenues, with data collected from the Health Public Budgets Information System (SIOPS).

In the technical-administrative dimension, we utilized the variable of bureaucratic qualification, which measures the percentage of municipal civil servants with higher education, using information from Gov.Munic – UFRGS Applied Research Laboratory. Finally, we analyzed aspects related to the administrative management of municipal governments, including data on the gender and age of mayors collected from the Superior Electoral Court (TSE). These variables provide a comprehensive basis for understanding the factors influencing Digital Transformation in municipalities.

3.2 Analysis Technique

We constructed the dependent variable (Digital Transformation) using indicators from two main dimensions: Technological Infrastructure and Digital Service Provision in local governments. The data was extracted from the CGI.BR (2023), conducted by Cetic.br. For its construction, we employed binary factor analysis due to the binary nature of the analyzed indicators.

After correlation analysis, the selected indicators were grouped into three factors per dimension to estimate the specific weights for each variable (Medeiros et al., 2023). The process of constructing the Digital Transformation variable followed the steps: analysis of the correlation matrix; selection of the factorial method; extraction and determination of the number of factors; factor rotation; interpretation of factors; and computation of factor scores (Siqueira et al., 2015).

Binary factor analysis was chosen based on *a priori* criterion, which predefines the number of factors retained. For factor rotation, we decided on the VARIMAX method due to its ability to maximize the variance of factor loadings, making it suitable for interpreting the underlying structure of the variables. After extracting the factor loadings, we applied the obtained weights to the data of the 4,265 municipalities, assigning a score to each observation. This score resulted in a scale from 0 to 11, where lower values indicate lower Digital Transformation and higher values indicate higher Digital Transformation at the local level.

Based on the Digital Transformation variable, we used multiple linear regression to test our hypotheses. In Equation 1, $DigTransf_i$ is the index that reflects the degree of adoption of technologies and digital services in subnational governments based on Technological Infrastructure and Digital Service Provision indicators. Then, we use the determinants that drive the digital transformation process in Brazil.

Equation 1: Digital transformation index

$$DigTransf_i = \alpha + \beta\, TI\_Exp_i + \gamma\, Inter\_Transf_i + \delta\, Mun\_Rev_i + \eta\, BurQuali_i + \theta\, Gender_i + \lambda\, Age_i + \mu\, Education_i + Region * Pop\_Size$$

Our study proposes the following independent variables: TI_Exp_i, $Inter\_Transf_i$, Mun_Rev_i, $BurQuali_i$, $Gender_i$, Age_i, $Education_i$, and the interaction between Region and Population size as control variables. The first three variables correspond to the economic dimension. TI_Exp_i measures the municipalities' capacity to invest in technological infrastructure. High expenditures indicate a higher priority, and resources allocated to technological modernization may be directly related to the level of Digital Transformation. The variable $Inter\_Transf_i$ analyzes the proportion of resources originating from state and federal transfers, measuring the municipality's dependence on other levels of government. Finally, the variable Mun_Rev_i measures the local tax collection capacity, a crucial indicator of financial autonomy.

Regarding the technical-administrative dimension, $BurQuali_i$ measures the percentage of municipal civil servants with higher education and indicates the quality of human capital available in public administration. A more qualified bureaucracy tends to adopt and implement technologies more efficiently, favoring Digital Transformation. Finally, the variables $Gender_i$, Age_i and $Education_i$ measure the profile of the mayors and offer insights into political leadership and its openness to innovation.

To better isolate the relationship between the independent variable of interest and the dependent variable and get a more accurate and precise understanding of the proper relationship between them, we added two variables to the model to control the characteristics of the municipalities: the region in which the city/town is located (North, Northeast, Midwest, South and Southeast) and population size, the number of inhabitants in the city/town.

4. Findings and Discussion

When analyzing the level of Digital Transformation in 4,265 Brazilian municipalities in 2023, we observed that the economic dimension became a driver for the innovation process in public administration (Table 2). Alternatively, the three selected variables were statistically significant, with one exhibiting an inverse relationship and two displaying direct relationships.

There is a negative relationship between intergovernmental transfers and digital transformation; for every unit increase in intergovernmental transfers, the digital transformation (dependent variable) decreases by 0.012334 units. That is, as government transfers rise, digital transformation tends to decline, which confirms the H1, higher levels of intergovernmental transfers are associated with lower levels of digital transformation among municipalities.

We identified a positive relationship between municipal revenue generation and digital transformation; for every unit increase in municipal revenue, the digital transformation increases by 0.030738 units. Based on this, we accept H2, which states that municipalities with higher revenue generation tend to invest more in digital transformation. In other words, financial resources are essential to enable investments in technologies and digital infrastructure.

This relationship is directly associated with the level of IT expenditure at the municipality level. Also, a positive relationship was found between IT expenditures and digital transformation; for every unit increase in municipal IT expenditures, the digital transformation increases by 1.318e-08 units. In this regard, we accept H3, affirming that municipalities that allocate a portion of their expenditure to IT have a more advanced digital transformation process locally.

When considering all variables in a full model while accounting for municipal characteristics, we observed a loss of statistical significance for all the economic variables (intergovernmental transfers, municipal revenue generation and IT

spending). However, a positive relationship was found between region and population size; municipalities located in the Midwest region, with a population between 50,000 and 100,000 inhabitants, are positively associated with digital transformation. Similar results were found for Northeast, Southeast, and South Brazilian municipalities.

Tab. 2 – Economic dimension (descriptive statistics)

		Economic Dimension				
		Estimate	**Std. Error**	**t value**	**Pr(>|t|)**	**Full Model** (Pr(>|t|)
TI Expenditures[1]		1.318e-08	3.921e-09	3.361	0.000832 ***	0.47115
Municipal Revenues[2]		0.030738	0.003642	8.44	<2e-16 ***	0.52735
Intergovernmental[2] Transfers		-0.012334	0.001962	-6.286	3.59e-10 ***	0.27679
Region * Population[2] size						
Midwest	50001 até 100000 habitantes					0.03207 *
Northeast	50001 até 100000 habitantes					0.03794 *
Southeast	50001 até 100000 habitantes					0.00398 **
South	50001 até 100000 habitantes					0.03589 *
Number of cases		[1]624 observations	[2]4.265 observations	[2]4.265 observations	[2]4.265 observations	[2]4.265 observations

Source: From the authors.

Our analysis indicated a significant relationship between the economic variables when assessed individually. However, in the full model, this relationship loses statistical significance, suggesting a weak relationship between variables such as investment in ICT, municipal revenue collection capacity, and capacity to generate revenue (which can be understood as less financial dependence on other subnational entities). The weakening in the full model's statistical significance may be attributed to the shared variance among the predictors and the broader scope of the dependent variable, encompassing both ICT infrastructure and the provision of digital services. In this sense, although parsimoniously, we can argue that in Brazil, similarly to China, fiscal capacities are essential for the digital transformation in local governments (Z. Fan et al., 2020, 2023). However, our results do not allow for strong corroboration of the hypotheses put forward in this study.

Brazil's municipalities have undergone countless transformations over the last thirty years since the 1988 Federal Constitution gave them more significant responsibilities and administrative, political and financial autonomy. Municipalities have become the central federal unit to which the implementation and provision of public policies, especially social welfare policies, is directed. The new attributions increased both the demands for professionalization of municipal management and the need to establish democratic or popular control of public action (Segatto et al., 2022).

Nevertheless, the level of financial autonomy of Brazilian local governments is highly varied. Some municipalities, generally those with larger populations, have a greater capacity to collect taxes and make investments, while others are almost exclusively dependent on constitutional transfers from the state and federal governments (Marenco & Cate, 2021). In this sense, we identified that the Brazilian federation's inequality also affects municipalities' ability to carry out digital transformation.

The research by Przeybilovicz et al. (2018) showed that 10 years ago, ICT use and digital transformation in Brazil were very precarious. Despite South and Southeast regions presenting more ICT adoption and digital transformation initiatives due to their economic development processes, Brazilian states exhibited a high level of homogeneity, demonstrating that besides existent inequalities, there has been a growing increase in the use of technology by local governments and a greater supply of services via the platform. Therefore, the federal government's recent push, implemented by the National Digital Transformation Strategy, published in 2024, towards digital transformation is expected to stimulate increased adoption of these tools by Brazilian municipalities, ultimately narrowing regional gaps.

The state and regional inequalities demonstrated the result of a policy that, until this year, had not been coordinated nationally by the federal government. Thus, the different degrees of technological development and technology incorporation depend on each municipality's financial and technical capacities, which vary significantly among the more than 5,000 existing municipalities in Brazil. Only in 2024, with the National Digital Government Strategy, did the Brazilian Federal Government propose efforts to induce digital transformation in municipalities (Brazil, 2024), with the potential to reduce existing regional inequalities.

Focusing on the technical-administrative dimension (Table 3), only two variables regarding education (i.e., bureaucracy and mayors' qualifications) were statistically significant. This indicates that the qualifications of civil servants and mayors are positively correlated with digital transformation. Specifically, a higher proportion of civil servants with higher education levels is statistically associated with more advanced digital transformation processes; for every unit increase in education level, the dependent variable increases by 0.3548 units. In this regard, we accept H_4, which states that higher education levels are directly associated with digital transformation.

Also, municipalities led by mayors with completed university degrees tend to exhibit a significantly higher level of digital transformation than those led by mayors with only a completed elementary education. In other words, for every unit increase in education level, the dependent variable increases by 0.22957 units. However, the age and gender of the mayor are not associated with the digital transformation process. According to the findings, H_5 is partially accepted.

Tab. 3 – Technical-administrative dimension (descriptive statistics)

		Technical-administrative Dimension				
		Estimate	**Std. Error**	**t value**	**Pr(>|t|)**	**Full Model (Pr(>|t|)**
BurQuali[1]		0.3548	0.1415	2.507	0.0122 *	0.184316
GenderMale[2]		-0.01314	0.07553	-0.174	0.862	0.759449
University degree[3]		0.22957	0.09939	2.310	0.0209 *	0.405024
Age_Young_Adults		0.01571	0.08944	0.176	0.861	0.921839
Age_Elderly		0.05415	0.05992	0.904	0.366	0.913676
Region * Population size[3]						
Midwest	20001 até 50000 habitantes					0.048374 *
Northeast	100001 até 500000habitantes					0.023354 *
Number of cases		[1]4.265 observations	[2]3740 observations	[3]2368 observations		[1]4.265 observations

Source: From the authors.

When controlling municipal-level characteristics, we observed a negative association between the digital transformation process and cities in the Midwest region, with populations ranging from 20,000 to 50,000. More specifically, these municipalities demonstrate a decline of -0.6832 units in the digital transformation index. Furthermore, the reduction in the digital transformation index is more substantial for municipalities located in the Northeast region, amounting to -1.195137 units.

Our analysis indicated a significant relationship (even if faintly) between the bureaucracy quality and the mayor's university degree in digital transformation when assessed individually. However, the mayor's age, gender and age group did not show statistical significance. Yet, in the full model, this relationship loses statistical significance, suggesting that

there is a relationship — albeit weak — between variables. As pointed out, this weakening in the full model can also be attributed to the shared variance between the predictors and the broader scope of the dependent variable, encompassing both ICT infrastructure and the provision of digital services.

Investigations conducted in other countries have shown that age and gender can significantly influence technology adoption. For instance, studies in Korea found that younger policymakers are more likely to be active innovators (Hong et al., 2022). Similarly, research in Australia revealed that the manager's gender plays a crucial role in technology adoption (Alam et al., 2022). Alam et al. (2022) identified that female managers are more likely to leverage social networking platforms than their male counterparts. Furthermore, Onozaka and Nemoto (2023) highlighted that countries with higher female representation in the middle to senior management positions exhibit greater integration of digital technologies and more sophisticated ICT tasks performed by women.

However, our findings in Brazil did not reveal a significant impact of the mayor's age and gender on the adoption of technologies by local governments to offer platform services. This suggests that while these factors may be crucial in other contexts, their influence may vary significantly across different cultural, social, and political environments. These data reinforce the idea that in Brazil, factors associated with the bureaucracy and the mayor's formal education are more relevant to adopting digital technologies, and sociodemographic characteristics matter less – although the strength of this correlation is lost in the full model. The fact that the model adopted showed no statistical difference between men and women may be because most mayors in Brazil are men, reinforcing gender inequality in access to local political careers.

5. Conclusions and Recommendations

This study contributes to academic literature and public managers by identifying the drivers of digital transformation in local governments in Brazil. The research results converged with part of the scholarly literature, mainly on cultural aspects of digital transformation (Mergel et al., 2019). We also found that economic dimensions such as tax revenue capacity, investment in ICT, and less dependence on central and state government funding are important factors in leveraging digital transformation in the Brazilian local contexts, such as the bureaucracy and mayors' education levels. Nonetheless, the statistical significance became weakened in the full model (adopting the control variables).

There has been a change of focus in public administration theories in the last decade, where the focus has moved away from the idea of the internal efficiency of public administration and endogenous discussions in organizations to a primary focus on offering services and creating value for citizens (Osborne et al., 2013; Panagiotopoulos et al., 2019). The creation of public value through the provision of services has become one of the main mantras of digital transformation. However, we must still understand how digital transformation creates public value (Mergel et al., 2019). Our research highlighted significant advancements in many Brazilian local governments while exposing persistent inequalities. Disparities in ICT investment capacity, tax collection, and bureaucratic quality directly impact the provision of digital services. These factors, in turn, influence public value creation through service delivery. For digital transformation policy to develop effectively, policymakers need to pay attention to the characteristics of local governments.

The digital transformation in Brazil has been a dynamic and challenging process, driven by the growing need to adapt to new technologies and the pursuit of greater efficiency and competitiveness. In this context, the Brazilian regulatory framework has evolved to accompany this transformation, creating various laws to foster innovation, protect personal data, and ensure cybersecurity (Filgueiras et al., 2019). The Brazilian federal government recently redesigned its general data use and protection law, instituting new guidelines for all Brazilian public administration agencies, including local governments. Alongside this, Brazil's central government is also driving digital transformation by gradually creating and coordinating efforts so local governments, based on federal incentives, can develop strategies to offer services via platforms (Brazil, 2024).

Finally, the study's relevance relies on its being the first to analyze local governments and examine the determinants of digital innovation in the public sector in Brazil. This research significantly contributes to the existing literature by providing valuable insights into the Brazilian context (Filgueiras et al., 2019). By investigating the factors that influence the adoption of digital technologies in Brazilian municipalities, this study helps to understand the unique challenges and opportunities local governments face to modernize public services and improve service delivery to citizens. The results of this research can inform policy decisions, guide the development of targeted interventions, and contribute to the broader discourse on digital governance and public sector innovation in Brazil. Furthermore, analyzing the context of a country in the Global South adds knowledge to the international scientific community, joining forces with other researchers.

One of the main research limitations is secondary data. Despite CETIC, which is responsible for collecting data on the use of ICT and digital transformation in Brazilian municipalities, there is always a percentage of non-response to the survey. Moreover, the research yielded varying responses for each variable, as anticipated, given the use of multiple

databases. Secondly, we employed a quantitative approach, relying heavily on numerical data and statistical analysis and risking overemphasizing measurable variables while neglecting crucial aspects such as subjective experiences, emotions, citizen-state relationships, and cultural contexts. Consequently, this research could not qualitatively capture the primary drivers of ICT adoption and online service provision in Brazilian municipalities. Our findings indicated that economic (fiscal autonomy, tax revenue collection, ICT investments) and technical-administrative dimensions (bureaucracy and mayor's education) influenced digital transformation in Brazilian municipalities. However, further research is warranted to investigate the motivations and perceptions of local managers.

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Data/Software Access Statement

All the data used in this research is available at: https://www.cetic.br/pt/pesquisa/governo-eletronico/.

Contributor Statement

Lizandro Lui: Conceptualization, Funding acquisition, Project administration, Supervision, Writing – Original Draft and Writing - Review & Editing; **Rafael Barbosa de Aguiar:** Conceptualization, Writing – Original Draft and Writing - Review & Editing; **Lídia Nicole dos Santos ten Cate:** Data Curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – Original Draft and Writing - Review & Editing; **Samuel de Melo Barbosa:** Data Curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – Original Draft and Writing - Review & Editing.

Use of AI

During the preparation of this work, the authors used Grammarly in order to check grammar, spelling and writing. After using this tool/service, the authors reviewed, edited, made the content their own, validated the outcome as needed, and take full responsibility for the content of the publication

Conflict Of Interest (COI)

There is no conflict of interest.

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Appendix A

Tab. 3 – Description of the indicators that constitute the Digital Transformation variable

Indicator	Description	Dimension
C1	Does this municipality have a dedicated IT department or division?	Technological
C1G_A	Has this municipality formally adopted an IT master plan or strategy?	
C1G_B	Does this city hall have a formally established information security plan?	
F5A	Is there a designated individual or team responsible for data privacy and compliance with the General Data Protection Law (LGPD) within this municipality?	
F5C	Have any of the employees in the city hall's IT department or area received any training, course, or workshop offered by the city hall regarding the General Data Protection Law (LGPD)?	
I1B_1_C	Has this city government made any mobile applications developed in-house for citizen use available within the past 12 months?	
D10	Does the city government offer any online services that citizens can access using the federal government's single sign-on system, Gov.br?	
H1P_A	Does the city government's website offer a service that allows users to generate tax bills or other payment slips?	Digital Public Services
H1P_C	Does the city government's website offer a service that allows users to issue electronic invoices?	
H1P_F	Does the city government's website offer a service that allows users to issue documents such as licenses, certificates, permits, and others?	
H1P_G	Does the city government's website offer a service allowing users to register or enroll for contests, courses, and schools?	
H1P_H	Does the city government's website offer a service that allows users to schedule appointments for consultations, services, and other matters?	