



The institutional design of data governance in Brazil: entropy, restrictiveness and institutional grammar

Fernando Filgueiras, Lizandro Lui, Thayná Gomes Rosa & Gabriela Candido Ferreira

To cite this article: Fernando Filgueiras, Lizandro Lui, Thayná Gomes Rosa & Gabriela Candido Ferreira (2025) The institutional design of data governance in Brazil: entropy, restrictiveness and institutional grammar, Policy Design and Practice, 8:1, 64-88, DOI: [10.1080/25741292.2025.2460838](https://doi.org/10.1080/25741292.2025.2460838)

To link to this article: <https://doi.org/10.1080/25741292.2025.2460838>



© 2025 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.



Published online: 11 Feb 2025.



Submit your article to this journal [↗](#)



Article views: 1508



View related articles [↗](#)







View Crossmark data [↗](#)



Citing articles: 1 View citing articles [↗](#)

The institutional design of data governance in Brazil: entropy, restrictiveness and institutional grammar

Fernando Filgueiras^{a,b} , Lizandro Lui^c , Thayná Gomes Rosa^c  and Gabriela Candido Ferreira^c 

^aFederal University of Goiás, Goiânia, Goiás, Brazil; ^bNational School of Public Administration, Brasília, Federal District, Brazil; ^cSchool of Public Policy and Government, Fundação Getulio Vargas, Brasília, Brazil

ABSTRACT

This article analyzes the institutional grammar of data governance in Brazilian municipalities, focusing on the institutional designs that develop in local governments from emerging institutions. The article mapped 27 Brazilian municipalities with more than 500,000 inhabitants that regulated their strategies for implementing the rules included in the General Data Protection Law (LGPD). Using the Institutional Grammar Tool methodology, crossed with restrictiveness and entropy metrics, we analyzed the institutional statements in municipal decrees that define the strategy for implementing governance and data protection in Brazil. Based on the data analyzed, the article concludes that the result of LGPD implementation strategies is to produce institutional diversity that brings new risks to digital transformation projects in governments. The conclusion is that local government organizations tend to produce more restrictive governance solutions, with the potential to create barriers to innovation due to the entropy of regulated objects and stakeholders.

ARTICLE HISTORY

Received 9 April 2024
Accepted 26 January 2025

KEYWORDS

Data governance;
institutional grammar;
restrictiveness; entropy;
data policy

1. Introduction

The digital transformation package has been taking place in Brazil quite intensively. The Federal Government intensively digitized and transformed the public service into a platform structure, cooperating with states and municipalities for a uniform structure of digital government (Filgueiras, Flávio, and Palotti 2019). Furthermore, it has provided an increasing use of artificial intelligence to shape public policy. In Brazilian municipalities, smart city projects have been expanded, with data collection based on public records of digital services and the Internet of Things (IoT). Big data and artificial intelligence shape a new wave of digital transformation based on

CONTACT Lizandro Lui  lizandro.lui@fgv.br, lizandrolui@gmail.com  School of Public Policy and Government, Fundação Getulio Vargas, Brasília.

© 2025 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

information-intensive regimes that support increasing public service automation. These information regimes enhance the capabilities of public agencies and civil society, promoting a more holistic and coordinated conception of public administration (Dunleavy and Margetts 2023). For these information regimes that support government shifts, the intensive use of data is essential to build a holistic view of administration, promoting greater integration and coordination of the various government actions.

Associated with these changes, concerns about the governance of these information regimes, which comprise complex issues, abound among policymakers and regulators. In the case of Brazil, the General Data Protection Law (LGPD) was approved, and the Bill of Artificial Intelligence and other regulatory frameworks are being discussed in addition to previously existing ones, such as the *Marco Civil da Internet*. This article investigates the data protection and data governance regime emerging in Brazilian municipalities.

Since 2018, the country has approved the LGPD to regulate data collection, use, processing, and storage in Brazil, creating a legal framework for data protection and citizens' privacy, new digital rights, and defining principles, responsibilities, actors, permissions, prohibitions, and objectives of data governance in public and private organizations. The LGPD also indicates the regulation of data infrastructures and procedures that public and private organizations must follow to ensure interoperability and anonymization mechanisms and enable innovation with the support of data infrastructures (Belli and Doneda 2023). The right to privacy is also safeguarded internationally through Article 17 of the International Covenant on Civil and Political Rights, which Brazil ratified in 1992, affirming the protection against arbitrary interference. In the national context, the Federal Constitution of 1988 further strengthens this right under Article 5, X and XII, ensuring both privacy and the confidentiality of communications.

Data are strategic assets for governments, industry, and businesses to operationalize digital transformation and promote innovation in practices, processes, and products. In the case of governments, data represents essential resources for them to design public policy aimed at the most diverse fields, such as urban mobility, smart cities, public security, public services, and climate change. In this sense, data governance has become an emerging field of action for policymakers and regulators, being essential for data protection and, at the same time, ensuring innovation mechanisms in the economy, governments, and society through digital technologies (Filgueiras and Raymond 2023).

In the case of Brazilian municipalities, several smart city initiatives have driven the creation of data infrastructures essential for innovation in services and public policy (Michelotto and Joia 2021). Smart city projects require large volumes of stored personal data so that data and automation technologies inform decision-making and policy implementation. Considering the Brazilian federative dynamics, many governance frameworks and policy emerge from the Federal Government sphere and are disseminated to states and municipalities (Souza 2005). In this sense, the data governance framework in Brazil emerges as federal legislation, considering the constitutional powers of the Federal Government, which demands from other subnational entities the implementation of the LGPD to define operational procedures and

strategies for data collection, storage, analysis, and sharing. An essential aspect of implementing any public policy in Brazil is the design of institutions through municipal decrees that define operational governance mechanisms. Considering the Brazilian federative dynamics, the result is that policies are implemented in contexts of broad institutional diversity. In the case of data protection and governance, this diversity is reflected in different LGPD implementation strategies.

In this sense, the present research takes the decrees of Brazilian municipalities as data and proposes a model for analyzing institutional design based on the institutional statements contained therein. In other words, LGPD regulation in municipalities requires operational rules on how they going to design data governance and define procedures to protect public infrastructures, ensure citizens' privacy, and produce innovation mechanisms with the data generated from services and municipal public policy. Considering Brazilian municipalities, a diversity of institutional designs is produced that can vary with greater or lesser complexity and entropy to deal with the problem. This article analyzes the restrictiveness, diversity and entropy of LGPD regulation in Brazilian municipalities.

Methodologically, the analytical lens of the Institutional Grammar Tool (IGT) was initially developed by Crawford and Ostrom (1995) and later improved by Siddiki et al. (2022), with textual analysis techniques adapted from the proposition by Valle et al. (2022). To deconstruct the institutional statements of the LGPD implementation decrees, the article analyzes the legislation of Brazilian capitals and other municipalities with more than 500 thousand inhabitants. Thus, the grammatical elements that inform municipal data protection and governance strategies were classified. In this article, we examine the construction of data protection and governance and its implications for developing public policies, such as projects to establish data infrastructures in municipalities.

Based on this scenario, it is not expected that Brazilian municipalities will create a "new general law on data protection and use" but that they will be able to develop, based on the federal standard, consistent and coherent strategies that enable local governments to protect citizens' data, on the one hand, and to use the data to improve public administration, develop digital transformation and various applications, such as AI, in the other hand. Given that the subnational entities in Brazilian federalism are autonomous entities, the guiding questions are: The problems guiding this research are: (1) what is the design of the strategies municipalities adopt for data governance? (2) What is the linguistic diversity and degree of restrictiveness present in municipal decrees? (3) what are the implications of this design for the effectiveness of data protection in municipal governments in Brazil? The article, due to its exploratory nature, makes two primary contributions to the field. The first, of a practical approach, will enable public management practitioners to assess their institutional arrangements and the rules they have developed concerning data governance. It is considered that the development of data governance strategies through decrees is a crucial factor for ensuring effective implementation of data governance. The proposal presented in this article aims to promote an analytical framework that enables public managers to analyze institutional grammar (which can focus on data governance or any other topic) and understand the levels of institutional restrictiveness and/or diversity involved—whether by examining how a single policy has

become more restrictive and/or diverse over time or by comparing two or more institutional designs. The second contribution of a theoretical perspective advances the methodology of institutional grammar by proposing a new application based on novel approaches.

2. Theoretical background

2.1. Data governance and institutions

Data governance is a set of different instruments, laws, and regulations combined to ensure data privacy, data protection, and the correct use of a data infrastructure to support digital development. In this complex set, data privacy refers to the rights and expectations of individuals to control how their personal information is collected, used, and shared. Data protection refers to practices to protect people and organizations against unauthorized access or potential data leaks (Whitford and Yates 2023). Finally, data infrastructure refers to the physical environment where data is collected, stored, processed, and shared (Kitchin 2022). Data governance is about exercising authority and control over data management (Abraham, Schneider, and Vom Brocke 2019; Benfeldt, Persson, and Madsen 2020; Kuzio et al. 2022). Data governance aims to implement a data agenda by maximizing the value of assets and carrying out risk management by collecting, storing, using, and sharing data between different public and private actors (Janssen et al. 2020).

Although data governance has always been an essential dimension over the last few decades, it now assumes higher importance in companies and government organizations. In contemporary times, data is obtained through surveillance structures, the use of public records, and structures fed by citizens (Kitchin 2022), which makes it a resource whose exploitation is essential to sustain business models designed on platforms (Frischmann and Selinger 2018). The movement of collecting, storing, and sharing data is essential for technological development, constituting an essential new infrastructure for businesses, governments, and industry (Kitchin 2022).

Because they represent shared resources, data infrastructures are political objects requiring policies to deal with dilemmas that emerge (Mattioli 2017). Firstly, it is necessary to convince data holders to share commodities, develop expertise, face challenges related to intellectual property, and make efforts to prepare and qualify databases for the use and reuse of information. These data infrastructures require different technical aspects related to cybersecurity, creating APIs for data sharing, technical storage requirements, and creating instruments to protect the citizens' and users' privacy on different platforms. Data governance, however, is not restricted to technical aspects only. It also involves negotiation, defining institutional designs related to data collection and access, and enabling management between different stakeholders.

In this context, data infrastructures require governance mechanisms based on two layers. The first layer refers to the technical dimension, where decisions regarding technical instruments for data protection, operational collection and sharing requirements, and procedures regarding use and reuse are defined. The second layer refers to the political and social dimension, which concerns the protection of the privacy

of citizens and consumers, negotiation and empowerment over who, when, where, and under what circumstances can access and share data, as well as the definition of obligations, permissions, and situations in which data can be used to build digital solutions (Khatri and Brown 2010).

Thus, data governance requires institutional mechanisms that shape action situations referred to rules and norms of an operational and political nature. Data governance is an emerging topic from which it is possible to examine the construction of policies aimed at data governance. In the next section, we examine the emergence of data governance in Brazilian municipalities concerning these two layers.

2.2. Local governments and emerging data governance – the Brazilian case

Collecting and exploiting data generated by local governments have enormous potential to support solutions enabling smart city construction (Madison, Sanfillippo, and Frischmann 2023; Kitchin 2022; Allam and Dhunny 2019). However, errors in data governance and the instruments that collect it compromise policy objectives, aggravating frustration regarding the design of smart cities (Drapalova and Wegrich 2020). Furthermore, data governance in smart cities requires the strengthening of accountability instruments, mainly dedicated to increasing transparency and responsibilities of agents who manage data infrastructures (König 2021). Smart cities require robust and manageable data infrastructures to develop new policy instruments based on digital technologies (Silva, Khan, and Han 2018). Institutional frameworks are essential to define standards and mechanisms that directly affect the actions of data holders and managers, building action-to-function situations of the stakeholders' roles, their interrelationships, articulations of value, and governance principles (Micheli et al. 2020).

In the case of Brazil, the approval of the LGPD was essential to establish procedures for data processing, create regulatory mechanisms to protect the privacy and freedom of citizens and ensure compliance with constitutional norms and definitions of strategies for governments and corporations. It is important to clarify that in the dynamics of Brazilian federalism, municipalities have territorial and legislative autonomy, representing a process of decentralization that does not essentially depend on state organizations. Because the LGPD is a general law of the Republic, municipalities have full autonomy to regulate the functioning and operation of the LGPD within their jurisdiction. As Filgueiras and Lui (2023) indicate, there have been significant advances in the LGPD in four key areas.

First, the LGPD established regulations that align with constitutional principles, creating a framework that protects citizens' rights regarding their data and their ability to make decisions about personal information. The LGPD introduced new civic rights covering various aspects of the digital world. Secondly, the LGPD defined clear principles for treating and protecting data and privacy, establishing a hierarchy of public values that guide work with data, covering the collection, storage, processing, and sharing of information.

Thirdly, the LGPD established the principles for data governance, determining the roles and responsibilities of actors involved in managing digital infrastructures. It introduced the figures of the data controller and the data custodian, covering the

public and private sectors. Furthermore, the LGPD established the National Data Protection Authority and the National Council for the Protection of Personal Data and Privacy as regulatory bodies, guaranteeing civil society's representation and consultative structures for disseminating good data governance practices.

Finally, the LGPD defined rules for data processing, covering procedures, permissions, prohibitions, security standards, communication processes, and international data transfer. That is, it defined operational standards that concern different topics, such as authorization for the use of identified data when applied in public security operations, requirements for sharing scientific data, or prohibitions on the use of data by children and adolescents.

There are already studies concerned with understanding the emergence and implementation of the LGPD at the federal level (Filgueiras and Lui 2023). However, how Brazilian municipalities regulated the LGPD and defined strategies for implementing the institutional framework has not yet been investigated. Considering that Brazil is governed in a federative context with more centralized tones (Arretche 2012), the Union is responsible for defining general laws related to the issue of data. Therefore, it is up to states and municipalities in Brazil to implement the law by defining operational requirements on how they will act to achieve data policy objectives and requirements.

It is based on the assumption that projects aimed at development related to the concept of smart cities, as well as a varied set of public policies on privacy, transport, education, and public security, depend on the collection, storage, and massive use of data (Allam and Dhunny 2019). In this sense, understanding how municipalities implement this law is justified. It is not expected that municipal governments will innovate to propose a new data protection law, but rather that they will translate the LGPD guidelines into practical strategies to guide the management of their data infrastructure and ensure protection mechanisms and compliance with fundamental rights. Based on the LGPD implementation, municipalities are expected to design their strategic guidelines for managing data infrastructures.

3. Research design and analytical frames

3.1. Institutional grammar tool

This article seeks to understand Brazilian municipalities' strategies for managing their data infrastructures. These strategies are contained in institutions that emerge from the LGPD and contain institutional statements that shape data governance. Therefore, we use the Institutional Grammar Tool (IGT) methodology to verify the institutional designs of emerging data governance in Brazilian municipalities. The municipal decrees implementing the LGPD can be understood as shared strategies by local governments to address data governance. In this case, the structuring of municipal LGPD decrees is a *sine qua non condition* for the construction of policies aimed at using and reusing data and privacy protection, as well as disseminating policies among Brazilian municipalities. We aim to understand how municipalities define strategies to achieve the data governance objectives set out in the LGPD.

The concept of strategy used in this article comes from Ostrom's (2005) thinking. According to Ostrom (2005), institutions comprise shared strategies, norms, and rules. The author defines rules as shared prescriptions - in the sense that they impose obligations, restrictions, or enable possibilities mutually understood and predictably applied in particular situations by agents responsible for monitoring conduct and imposing sanctions. Regarding norms, they are prescribing actions to actors at a constitutional level, more oriented to the structure of values and rights that inform action. Strategies are perceived as plans those individuals make within the structure of incentives produced by rules, norms, and expectations of the likely behavior of others in a situation affected by relevant physical and material conditions. As defined by the author, "[I] will use the term strategy instead of rule for individual action plans. Rules, in the sense of precept, are part of the generally accepted moral structure of a community" (Ostrom 2005, p.17).

IGT is, therefore, an institutional analysis method that understands the design of institutions through their institutional statements. These institutional statements make up a grammatical syntax that identifies the elements that make up an institution. According to Siddiki (2014), an institutional statement refers to the shared linguistic constraint or opportunity that prescribes, allows, or advises actions or outcomes for actors. Institutional statements are spoken, written, or tacitly understood in a way that is intelligible to actors in an empirical setting. Crawford and Ostrom (1995) constructed a grammatical syntax based on the acronym ADICO. Table 1 below specifies and summarizes the elements of institutional grammar.

From a practical point of view, classifying institutional statements based on the proposed syntax allows us to understand the strategy adopted by municipal entities. The classification of institutional statements makes it possible to identify the role reserved for citizens, the companies, the municipal public authorities, what governance structures were built, and what functions each agent is responsible for within action situations determined based on the LGPD.

Many studies use this methodological approach (Siddiki et al. 2022). However, most studies using IGT are descriptive about categorizing institutional grammar (Dunlop, Kamkhaji, and Radaelli 2019). In addition to the IGT, we analyzed the diversity, entropy and restrictiveness of the strategies designed in Brazilian municipalities and their linguistic complexity (Valle et al. 2022).

3.2. Research procedures

The research combined the database worked from the IGT analytical lens with Shannon's index for information theory and subsequently adapted for research in different areas (Shannon and Weaver 1949). Several researchers worldwide have dedicated themselves to analyzing laws and decrees using quantitative methods. For example, Al-Ubaydli and McLaughlin (2017) dedicated themselves to creating a numerical database called Regdata, which comprises specific regulations for each industry in the United States and federal regulations from 1997 to 2012. In the same vein, McLaughlin, Strosko, and Jones (2019) presented an analysis of regulatory restrictions in Canadian provinces through Regdata Canada. In Brazil, Valle et al.

Table 1. Syntactic elements of institutional grammar.

Syntax Elements	Concept
Attribute	The attribute component captures the actor responsible for a given institutional statement, explicitly or implicitly. In other words, to whom or what is attributed an action. Furthermore, in some statements, an attribute and its properties may be presented together.
Deontic	deontic is an operator component based on the modal operations used in deontic logic to distinguish prescriptive from non-prescriptive statements. The complete set of deontic operators, D, consists of P permitted, O obligatory, and F prohibited.
Aim	The aim is to describe an active part in an action situation to which an institutional statement refers. In other words, which action of the attribute is mandatory, permitted, or required?
Object	The object is defined as the receiver of an action (described by the aim) and executed by the actor (described by the attribute). Objects can be animate and inanimate entities in institutional statements, and each statement can contain multiple objects.
Condition	The condition indicates the set of variables that define when and where an institutional statement applies. For example, the conditions for an institutional statement may indicate when it applies, such as during certain weather conditions, at a defined time, or a specific step in some process.
Or else	The final component of our institutional syntax is the consequence that an institutional statement attributes to detect noncompliance with the other components of that statement. Sometimes, the consequence specifies a range of possible punishments if a rule is not followed.

Source: Siddiki et al. (2011).

(2022) developed a regulatory flow analysis tool called RegBR, which applied quantitative methods to analyze federal legislation. The developed framework can classify normative acts and quantify regulatory documents' restrictiveness, popularity, influence, and linguistic complexity.

In this sense, this research adapted the metrics of restrictiveness and linguistic diversity (Valle et al. 2022) to analyze the decrees that implement the LGPD in Brazilian municipalities with more than 500,000 inhabitants. The data was collected in January 2023. According to population projections by the Brazilian Institute of Geography and Statistics (IBGE) in January 2023, out of 54 Brazilian municipalities with over 500,000 inhabitants or that are state capitals, decrees were found in only 27. These 27 municipalities implemented the LGPD and defined operational data governance strategies. After deconstructing the decrees of each of the 27 municipalities, we built a database with 905 institutional statements constituting the research corpus. For the analysis, we used manual coding of all municipal decrees. After placing them all in a spreadsheet, we manually separated the components using the ADICO framework proposed by Crawford and Ostrom (1995) and improved by Siddiki et al. (2011) and Siddiki et al. (2022) for analysis of institutional grammar. The classification was made by 2 independent researchers and endorsed by the working group. The table attached at the end of this text contains the details of the empirical material analyzed.

Brazil is a Federative Republic composed of a federal government (Union), states, and 5,568 municipalities, each endowed with political and administrative autonomy. While the General Data Protection Law (LGPD) was enacted by the Union, it is the responsibility of subnational governments to regulate and adapt the law to their specific local interests and needs. In this context, we examined the official websites of eligible cities, seeking decrees aimed at implementing the LGPD. Upon identifying the decrees, all paragraphs of the municipal laws that elaborated their provisions

Table 2. Classification of institutional statements of LGPD municipal regulations.

Components	Categories
Attribute	<ul style="list-style-type: none"> • Boards, commissions, or equivalent organizations • Citizens and users • Civil society organizations • Companies • Controllershship • Data controller • Data manager • Data operator • Federal government • ICT Directorate and similar • International organizations • Municipal governments • Ombudsman • Prosecutor's Office • Regulatory agency • State governments • Too many servers
Deontic	<ul style="list-style-type: none"> • Permission • Obligation • Prohibition
Aim	<ul style="list-style-type: none"> • Revocation/Cancellation • Authorization • Certification and compliance • Competence • Data collection and processing • Data sharing • Monitoring • Rights • Standardization
Object	<ul style="list-style-type: none"> • Governance • Management and processes • Natural resources • Product • Service
Condition	<ul style="list-style-type: none"> • Determined deadlines and conditions • Indefinite terms and conditions
Consequence	<ul style="list-style-type: none"> • Fines • Suspension of activity

Source: own elaboration.

were systematically organized into a spreadsheet. This allowed for the extraction of institutional components, based on the ADICO framework, into separate cells. The linguistic structure of formal decrees in Brazil, written in Portuguese, follows the same logic as the decrees analyzed in the literature that has been studying the subject (generally written in English) in their ability to assign attributes, deontic operators, aims, objects, conditions, and consequences. This similarity facilitated the operationalization of the framework following the methodological approach proposed by Siddiki, Basurto, and Weible (2012).

Understanding this *empirical corpus*, we deconstructed all institutional statements into sentences to then identify their syntactic elements and classify them according to the categories in Table 2. This means that a single decree - in this case, regulating data governance under the LGPD - contains several institutional statements. Each institutional statement was analyzed separately and decomposed into its syntactic elements. In the style of Brazilian legislation, each sentence represents an institutional statement. Deconstructing institutional statements through their syntax makes it

possible to identify which subjects are attributed to the rules, deontic operators, aims, objects, conditions, and consequences that inform the institutional architecture of data governance in Brazilian municipalities. Subsequently, we adapted the Shannon index with the aim of including the classification of legislative text possible from the IGT for grammatical analyses based on metrics concerning restrictiveness and entropy.

All the decrees were analyzed and coded by two different researchers. The results were compared and the divergences of understanding resolved. It was identified that there was a limited range of attribute types present in the municipal decrees, as well as deontic operators, aims, objects, conditions and consequences. The categorizations presents in [Table 2](#) were constructed in view of the greater recurrence of these terms in the municipal decrees.

After handling municipal decrees through the IGT, all institutional statements were analyzed in their restrictiveness. Thus, it was possible to carry out a restrictiveness analysis by adapting the Valle et al. (2022) metric to the research according to the following formula:

$$\text{Restrictiveness} = \frac{\sum \text{Restrictive institutional statements}}{\sum \text{Institutional statements}}$$

Restrictiveness corresponds to words defined in a regulatory context that indicate obligations or prohibitions. Therefore, to determine restrictive institutional statements, the element “deontic operator” of the IGT was used; that is, in the classification of the deontic operator, the statement was determined as an obligation (Valle et al. 2022). The restrictiveness metric is measured based on the total number of occurrences of restrictive words in a set of institutional statements within the body of the normative act (Valle et al. 2022). Therefore, the restrictive words classified and organized from the IGT were counted and, subsequently, divided by the total number of institutional statements from the set of decrees of Brazilian municipalities. This calculation was applied to each municipal decree. It provided a metric for the average number of restrictive words per normative acts in capitals and municipalities larger than 500 thousand inhabitants per region.

The importance of measuring restrictiveness is that can help to indicate how much the institutional framework enables or encourages a more accessible data collection and sharing process between municipal organizations or creates restrictions that imply administrative burdens that impede digital innovation. We admit that it is not a determining factor “if X, then Y”, however, it serves as an important analytical indicator.

The second metric used was the entropy of the attribute, aim, and object elements. For this analysis, the methodology used by Valle et al. (2022) to calculate the entropy of the laws was adopted. In information theory, entropy is the average measure of information and uncertainty in a given communication (Shannon and Weaver 1949). In this case, the greater the entropy, the greater the linguistic complexity of the institutional statements identified in the investigation. The Shannon index is based on information theory and is commonly used to measure entropy in categorical data (Shannon and Weaver 1949). This last way of using it is a

suggestion by Margalef (1958). In this sense, the Shannon entropy index formula is defined as:

$$D_j = -\sum_{i=1}^n P_{i,j} \cdot \log_2(P_{i,j})$$

With D_j represents the entropy (diversity) of municipality j . In other words, it indicates the level of uncertainty or variety of terms found in the decrees of municipality j . $P_{i,j}$ represents the proportion (relative frequency) of category i in municipality j . This means that $P_{i,j}$ indicates how often category i appears in the decrees of municipality j , relative to the total number of categories. i is an index that varies from 1 to N , representing each specific category (for example, attribute, objective, object). N is the total number of different categories considered in the analysis. The summation symbol Σ indicates that we must sum all the values of $P_{i,j} \cdot \log_2(P_{i,j})$ for all categories i .

Furthermore, the base-2 logarithm (\log_2) is used in the entropy formula because, in information theory, entropy is commonly measured in ‘bits’ (binary units). The base-2 logarithm reflects the binary nature of information processing, where each decision reduces uncertainty by a factor of two. The multiplication by -1 is necessary because the entropy formula involves probabilities, which are always between 0 and 1. The logarithm of a number between 0 and 1 is negative. Therefore, multiplying by -1 ensures that entropy is expressed as a positive value, reflecting the overall uncertainty or diversity in the system.

Shannon entropy, calculated based on the probability of occurrence of each symbol within a data set (Shannon 2001), was employed to analyze the attribute, aim, and object elements within the institutional syntax for each institutional statement present in the municipal decrees. In terms of word diversity in these decrees and the scope of this study, the symbols represent words that correspond to the classifications of attribute, object, and aim. Therefore, the more distinct words that appear for each classification in the municipal decrees and the more evenly they are distributed, the higher the entropy value, reflecting an increased linguistic complexity of institutional statements. A higher entropy value thus indicates a greater variety of terms or actors involved in data governance, for instance.

The relevance of calculating entropy in the context of data governance lies in the notion that more complex municipal decrees involve a broader array of actors and actions. Consequently, it is based on the premise that the higher the entropy within a data governance system in Brazilian municipalities, the more comprehensive and robust the governance strategy becomes. Furthermore, in terms of the restrictiveness of governance, it is critical to assess the limits that local governments impose regarding data governance policies. Understanding these constraints helps delineate the scope of governance and the strategic depth achieved by municipal administrations.

4. Results

4.1. Restrictiveness

In order to calculate the restrictiveness index, the number of restrictive institutional statements was used, which, as previously mentioned, are those classified as

“obligations” in the deontic operator category. Table 3 reports the frequencies of the deontic operator category.

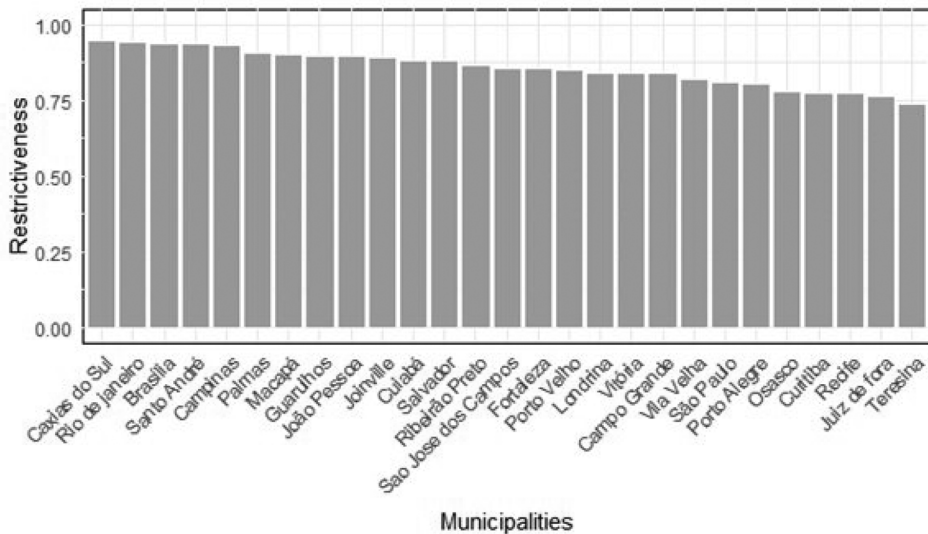
The results of the restrictiveness analysis of LGPD regulations offer insights into the number of restrictive institutional statements of the decrees in each municipality. The scale of values for analysis ranges from 0 to 1, where 0 indicates the lowest level of restriction, and 1 indicates the highest level. The following Graph 1 visually illustrates the results obtained.

When analyzing the results, it is possible to notice patterns marked by high levels of restrictiveness. Municipal strategies for data governance tend to determine obligations and prohibitions for the actors to whom they are assigned. This fact is notable when observing that even in municipalities with apparently lower indices concerning the others, these values are still above 0.70. In other words, all municipalities have at least 70% restrictiveness in their decrees, defining more restrictive strategies that can create obstacles to innovation. Thus, this observation is relevant when highlighting that municipal decrees referring to the LGPD in Brazil have an institutional grammar of data governance focused on implementing obligations centered on a logic of control. In this sense, the results demonstrate that municipalities place less emphasis on defining permissions, prioritizing the imposition of obligations.

Table 3. Frequency of the deontic operator category in all municipalities.

Category	Frequency
Obligation	781
Permission	97
Prohibition	27

Source: Own preparation.



Graph 1. Restrictiveness of LGPD regulations in Brazilian municipalities.

Source: Own preparation.

4.2. Attribute entropy

About the attribute, that is, the actor to whom the institutional statement is addressed, the initial analysis focused on identifying the actors present in the regulations and the frequency of their occurrences. The values in the [Table 4](#) demonstrate these frequencies based on data added from all municipalities.

When examining [Table 4](#), it becomes evident that the municipal public administration holds most of the responsibilities in the statements, playing a central role in the municipalities' data governance strategy. Furthermore, it is possible to notice an emphasis on the public administration and its bodies in general, with a relatively smaller presence of citizens and companies as empowered actors to participate as stakeholders in data governance.

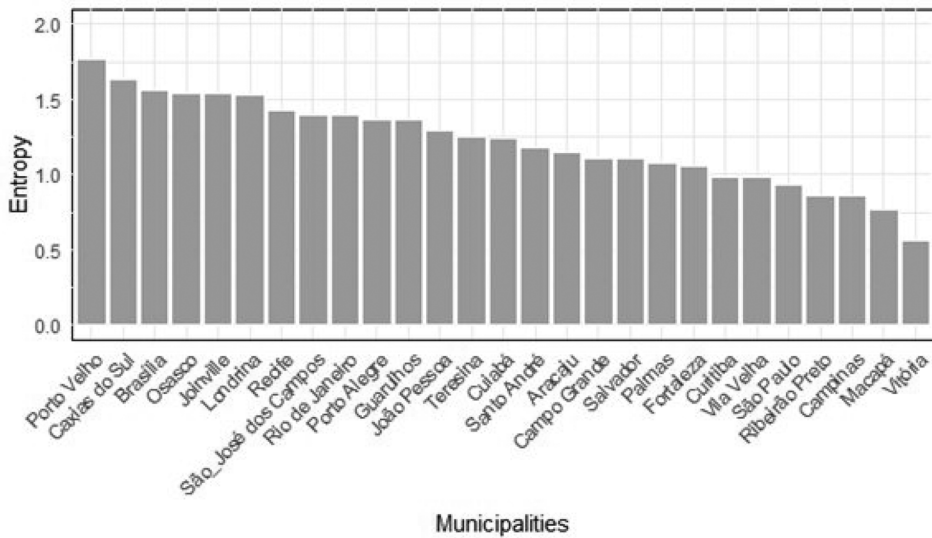
After analyzing the actors present, the Shannon Index was calculated to measure the actors' entropy in each municipality's decree. In this approach, values are scaled from 0 to 1: the closer to 1, the greater the entropy, and values greater than 1 indicate high entropy, while values close to zero reflect low entropy. The following [Graph 2](#) represents the results obtained:

According to the graph, it is possible to observe that municipalities such as Brasília, Caxias do Sul, Porto Velho, and Recife have values above 1. This entropy suggests that the decrees of these municipalities encompass a significant variety of actors, which can be interpreted as more participatory and comprehensive concerning data governance design. While including a significant variety of actors in data governance can be seen as a democratic and representative approach, it also brings substantial challenges related to the efficiency and effectiveness of governance, such as conflicts of interest. As more actors are empowered in data governance, there is an increased likelihood of conflicts of interest. However, this challenge is not necessarily insurmountable. Conflicts of interest are part of governance, and it is essential to recognize and address them in a transparent and responsible manner in order to produce a balance between representation and the inclusion of all stakeholders. For example, municipalities with values closer to 1, such as Aracaju, Campo Grande,

Table 4. Frequency of the attribute category in all municipalities.

Category	Frequency
Municipal public administration	464
Boards, commissions, or equivalent organizations	103
Data manager	96
Companies	40
ICT Directorate and similar	26
Data Controller	25
Controllership	21
Too many servers	21
Data Operator	18
Prosecutor's Office	17
Citizens and users	10
Regulatory agency	4
Federal government	1
State governments	0
Civil society organizations	0
International organizations	0

Source: Own preparation.



Graph 2. Entropy of the attribute in Brazilian municipalities.
Source: Own preparation.

and Cuiabá, may suggest this balance, as they have a moderate diversity of stakeholders.

Therefore, the results suggest that the actors' diversity can vary significantly between municipalities, reflecting different approaches to data governance in this regard. There are also municipalities with lower values, such as Vitória and Macapá, which indicate less complexity. Furthermore, it is possible to infer that most municipalities have a data governance strategy that is not restricted to specific actors but has a diversity of attributes.

4.3. Aim entropy

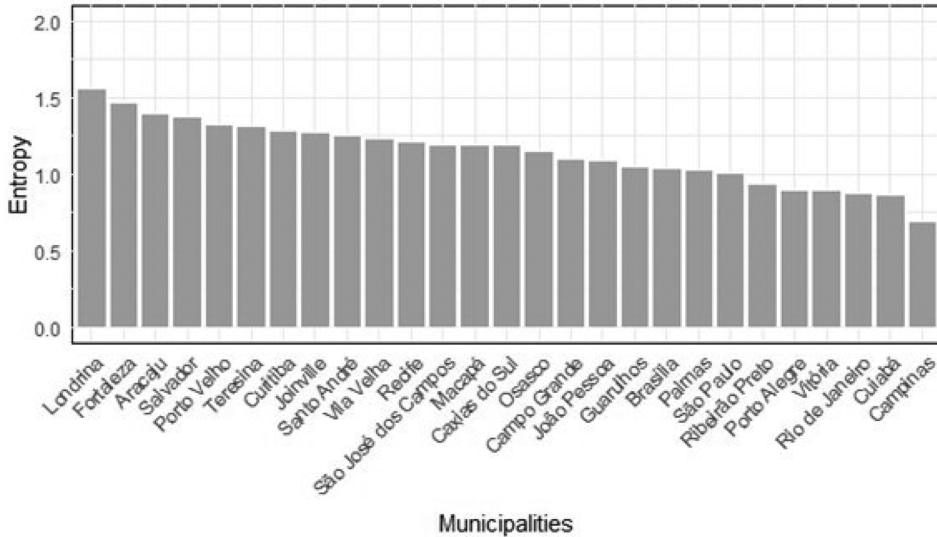
The aim represents the action that the institutional statement intends to regulate. In this case, first observing the frequency of regulation aims in Table 5, the competence category is the most frequent aim, appearing 440 times. This frequency suggests that municipalities are focusing on establishing standards and guidelines related to the competencies of actors involved in data governance, such as regulators, civil society, and sectors responsible for implementing regulations. Furthermore, the categories "certification and compliance" and "standardization" are frequent. This frequency indicates that municipalities are concerned with ensuring compliance of data processing practices with the standards established by the LGPD and promoting the standardization of procedures and requirements necessary to comply with the regulations.

As for the entropy of the aim, in Graph 3, it is possible to identify variations in complexity between municipalities. For example, municipalities such as Fortaleza, Teresina, and Porto Velho present aim entropy values above 1, indicating a broader and more diversified approach in defining the points to be regulated. Brazilian

Table 5. Frequency of the aim category in all municipalities.

Category	Frequency
Competence	440
Certification and compliance	123
Standardization	113
Authorization	34
Data sharing	28
Data collection and processing	18
Rights	17
Monitoring	6

Source: Own preparation.

**Graph 3.** Entropy of the aim category in Brazilian municipalities.

Source: Own elaboration.

municipalities seek to cover a broader range of regulatory actions related to data governance.

On the other hand, municipalities such as Campinas, Porto Alegre, and Vitória have aim entropy values below 1, which indicates a greater concentration on specific topics and a more focused approach to regulating certain aspects of the LGPD.

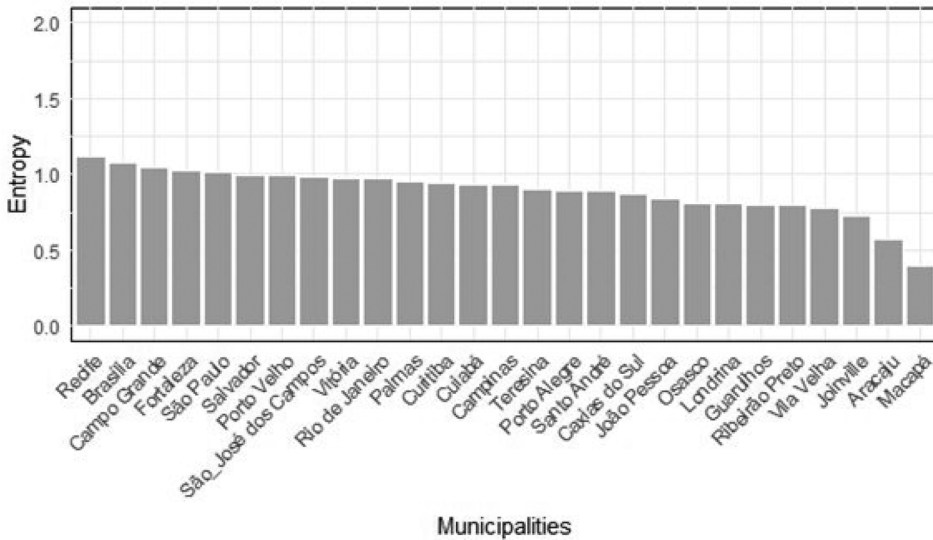
4.4. Entropy of the object

In the IGT classification, the object component refers to the recipient of an action performed by the actor, described in the attribute. Therefore, by observing the frequency of this category, it is possible to understand what is being directly affected or regulated by the actions proposed in municipal decrees. In the context of the decrees that regulate the LGPD in municipalities, it is notable that the object “management and processes” is the most cited; municipalities direct their regulatory efforts to establish procedures, protocols, and policies regarding the data management and governance processes (Table 6).

Table 6. Frequency of the object category in all municipalities.

Category	Frequency
Management and processes	514
Service	207
Governance	139
Product	2

Source: Own preparation.

**Graph 4.** Entropy of the object category in Brazilian municipalities.

Source: Own elaboration.

The differences in entropy among Brazilian municipalities concerning the object represent an interesting analysis point. The object represents the element that receives the actors' action and connects to the aim. Higher entropy values, as found in municipalities such as Recife, Brasília, Campo Grande, and Fortaleza, indicate a more comprehensive and detailed nature of the regulation. The value of the object's entropy indicates the value of elements of responsibility attributed to the actors in the regulatory context of data governance. As the results found in Table 4 suggest, the municipalities' strategies can be more comprehensive and detailed according to the entropy of the objects. Low entropy values, such as in the municipality of Macapá, for example, indicate that data governance frameworks are less comprehensive and less detailed, with fewer objects identified, and depend on the actors' responsibility in the process (Graph 4).

Generally, the LGPD regulatory decrees in the municipalities investigated are more focused on establishing strict bureaucratic control and defining compliance procedures and management duties rather than adopting a practical governance approach to protecting personal data and promoting innovation. These decrees emphasize compliance with the LGPD at the expense of building strategies to strengthen data security, use data in public policies, improve data quality, establish data collection, storage, and processing guidelines, and promote information sharing.

5. Discussion

5.1. *Innovation versus bureaucracy in data governance*

The relationship between innovation and bureaucracy produces contradictory behaviors concerning organizational objectives and has already been widely discussed in the literature (Thompson 1965). The literature highlights the need for governance mechanisms that balance regulatory instruments and innovative behavior within public and private organizations (Aghion, Bergeaud, and Reenen 2023). Although control measures are necessary for data governance, given the risks associated with digital innovations, administrative burdens create barriers to innovative behavior. Digital technologies applied in governments can potentially reduce administrative burdens for citizens (Arendsen et al. 2014). However, when dealing with data infrastructures, new bureaucratic burdens are created with the aim of control, directly impacting the behavior of innovation agents. Although bureaucracy can be, in many situations, a source of innovation (Kattel, Drechsler, and Karo 2022; Kelman 2005), the restricted understanding of data governance tends to hinder the use of data infrastructure, particularly by governments. The tradeoff between innovation and control strongly characterizes the design spaces that support the procedures and strategies adopted in data governance.

Thus, this article aimed to demonstrate through the use of the IGT analytical lens (Siddiki et al. 2012; Siddiki and Frantz 2022) the designs of action strategies formulated by the Brazilian municipalities concerning data governance pushed by the LGPD. The components of institutional grammar provide a basis for the analysis of restrictiveness, which made it possible to understand patterns based on a dimension of bureaucratic data control. The research findings indicate that the objects of municipal data governance strategies are focused on a control process rather than building institutional conditions for innovation in a safe and reliable way. This article sought to advance the way in which institutional grammar is analyzed, a field that has been strongly consolidated based on the work of Siddiki et al. (2022) among others, with textual evaluation metrics proposed by Valle et al. (2022). Although we recognize the limitations of this approach, we believe it is in the interest of the practical and theoretical field to advance this approach that aims to decompose the grammar of institutions. In general, the LGPD regulatory decrees in the municipalities are more focused on establishing strict bureaucratic control and defining compliance procedures and management duties rather than adopting a practical governance approach to protecting personal data and promoting innovation. These decrees emphasize compliance with the LGPD at the expense of building strategies to strengthen data security, use data in public policy, improve data quality, establish data collection, storage, and processing guidelines, and promote information sharing. The tendency is for Brazilian municipalities to create more restricted information regimes, with barriers to data sharing due to control mechanisms that hinder the advancement of digital transformation. Although data infrastructures can be used for many purposes, access to them is restricted and entropic, with little access by different stakeholders. Although digital governments require intensive information regimes that expand state capabilities (Dunleavy and Margetts 2023), the design of

data governance can represent a barrier to government innovation. The balance between access and sharing of data for various purposes of governments, industry and business, on the one hand, and the protection of data and privacy of citizens, on the other hand, is essential in the design of institutions.

As bureaucrats are influential in the policy agenda, they create control-oriented procedures with the aim of configuring perspectives and implementation strategies (Baekgaard, Mortensen, and Seeberg 2018). In the case of Brazilian municipalities, the creation of procedures that emerge with the implementation of the LGPD in local public administrations reveal a perspective focused on a control dynamic, in the context of procedures aimed at auditing and compliance. Compliance is an engine of bureaucratic logic (Olsen 2008). The implementation of the LGPD in Brazil follows a bureaucratic engine, creating conditions for data governance agency aimed at an ideal of compliance and not at supporting innovation processes.

The entropy of the objects of the decrees indicates concerns of a managerial and administrative nature and is silent concerning innovation processes. In summary, the institutional data protection architecture in Brazilian municipalities focuses more on compliance and control with the LGPD. On the contrary, municipal LGPD implementation strategies need to promote a comprehensive strategy that aims to improve data security, the use of data in public policies, and the involvement of several relevant actors in formulating and implementing data protection to build infrastructures and innovation processes. This directly impacts how public policies, such as those linked to smart city plans, have developed. In other words, it is identified that the current institutional framework of municipalities needs more support for the construction of critical infrastructures that favor the process of innovation and promotion of smart city plans.

5.2. Institutional diversity

Based on the analysis of the institutional frameworks established by the 27 municipalities to define LGPD implementation strategies, it was possible to investigate the institutional grammar of data governance and privacy in these Brazilian municipalities. Considering Brazil's federative structure and, therefore, the responsibility of municipalities to adjust their data governance practices under the new LGPD requirements is an essential step toward analyzing a complex case.

The results demonstrate institutional diversity among Brazilian municipalities in response to the requirements and rules transcribed in the LGPD. Institutional diversity expressed in municipal decrees implementing the LGPD results from economic, political, and regional differences between municipalities. This result corroborates Ostrom's (2005) argument that there are multiple ways how viable institutional arrangements are created and recreated by various communities in various situations. Brazilian municipalities are unequal in terms of administrative capacity, which influences policy decision-making differently (Marenco and Cate 2021). Brazilian municipalities have produced heterogeneous information regimes with distinct characteristics that favor the control of data infrastructure and not its sharing by multiple stakeholders. This article does not investigate policymakers' motivations for choosing institutional design. However, the analysis makes it possible to identify how data

governance in federative countries, such as Brazil, produces entropic views that complicate this governance issue. The tendency to reinforce compliance in the data governance structure reduces the coordination dynamics, creating a hierarchical governance scheme based on command and control.

Likewise, the analysis of frequency in institutional statements, combined with the calculation of Shannon entropy, made it possible to measure the diversity of actors present in data governance in municipalities. Regarding the municipalities' data governance strategy, it was possible to suggest through the results generated that the diversity of actors can vary significantly between municipalities. Most have a data governance strategy with a diversity of attributes, demonstrating openness to the participation of civil society organizations, industry representatives, and business organizations. Other strategies constitute more closed data governance systems, with few external agents' interactions and low entropy. Furthermore, the results corresponding to the actions that the institutional statement intends to regulate focus on establishing standards and guidelines related to the competencies of the entities involved in data governance and the conformity of data processing practices with the standards established by the LGPD.

The results demonstrate that it is possible to identify a diversity of institutional designs, creating heterogeneity in municipalities' responses to the LGPD rules. This heterogeneity of responses from Brazilian municipalities tends to increase the entropy of data governance, making it a source of constant social dilemmas, public choice, and collective action problems. For example, examining municipal decrees, there needs to be answers on dealing with international data flow or risk analysis processes for data sharing between public and private organizations. The heterogeneity verified by the high entropy of data governance objects can produce inconsistent responses and growing dilemmas for society, such as data leaks, opacity in processing personal data, surveillance structures, or even difficulties in establishing open data.

Data governance is about exercising authority and control over data management (Abraham, Schneider, and Vom Brocke 2019). In addition, data governance aims to implement a data agenda, maximizing the value of assets and carrying out risk management through the collection, storage, use and sharing of data between different public and private agents (Janssen et al. 2020). In the case of this research, it was identified that the actual exercise of authority over data varies between municipal administrations, with a tendency to be monocratic and centralized in the state. Lastly, the institutional arrangement makes it difficult to maximize the value of the data, since it favors establishing bureaucratic control over it.

Brazilian municipalities regulated the LGPD without coordination instruments to solve problems beyond the municipal sphere itself. The lack of coordination between local actors means data governance tends to be entropic and institutionally diverse. Locally evolved institutional arrangements in Brazilian municipalities tend to complicate data governance. The problem is that data governance is a transboundary problem, as data is collected and stored globally (Filgueiras and Almeida 2021). The institutional grammar of data governance in Brazil teaches us that governance, in an ideal arrangement, must be multilevel and contain designs that favor experimentation, learning, change, and adaptation. This differs from what happens in Brazilian municipalities as we do not identify in this process of regulation and construction

of municipal decrees a dialogue between stakeholders, accompanied by complex, redundant and layered institutions.

From a theoretical point of view, analyzing the institutional grammar of data governance in Brazilian municipalities allows us to analyze how institutions become complex and disordered and produce modes of governance based on a choice of compliance as a bureaucratic engine of command and control relationships.

5.3. Future research

The research allowed us to verify that the grammar established by Brazilian municipalities regarding data governance is quite limited in terms of the variety of actors that can participate in the process of collecting, using, and processing data and that it presents characteristics endogenous to the State, being, in turn, highly restrictive. Future research will be able to understand, through in-depth interviews and participant observation, the internal processes of building policies aimed at the use of data and protecting citizen privacy and how the actors responsible for building municipal policies interact with the imposed rules.

The institutional framework formulated by Brazilian municipalities to regulate the LGPD also reveals the strategies developed to build a data protection and privacy system for citizens and use this data to build public policies and projects aimed at smart cities. Future studies may focus on other cities located in Latin America and the global south to verify how data is used in the construction of public policies to promote comparative analyses of different types of institutional frames. Likewise, future research should indicate the dynamics of data governance design with the aim of understanding the different dynamics that policymakers and bureaucrats adopt and why a more restrictive and entropic result is achieved.

This research has limitations regarding its descriptive nature, which does not allow for the verification of a robust hypothesis. The exploratory nature of the research makes it possible to indicate hypotheses according to the discussion above, but not to test them in order to formulate a theory on data governance in multilevel contexts. From a practical point of view, this research enables scanning the reality of data governance strategies in Brazilian municipalities. This enables the National Data Protection Authority to coordinate efforts in a multi-level instantiation, in order to ensure compliance with regulatory policies and bench learning to improve institutional framework of data governance. Future studies could also analyze how, in federative countries like Brazil, state and municipal strategies influence each other and how objectives, instruments and modes of governance can develop in an interdependent manner.

Although this study is still descriptive, since only some Brazilian municipalities have established a strategy for implementing the LGPD, the corpus can be expanded and analyzed with the help of machine learning to identify tuples and pairings between the elements of the institutional grammar. There are already efforts in this direction in the literature (Sewerin et al. 2023). For example, we can identify and deepen the responsibilities of the actors by pairing attributes and aims or by pairing aims and objects in order to identify the regulatory nature of data governance. This strategy would allow for the deepening of analysis and the practical deployment of data governance in all Brazilian municipalities, constituting a monitoring and

reciprocal learning panel for municipalities to deal with problems and dilemmas related to data governance at the local, regional or national level. The project's next phase will be to establish a mechanism for collecting all available decrees in all municipalities and train a machine learning model to decompose the elements of the municipal grammar of data governance.

6. Conclusions

Regarding the questions posed in this article, it is identified that the design of the strategies adopted by municipalities is highly self-referenced to the municipal bureaucracy, reserving little space for establishing governance that involves a wide diversity of stakeholders. Regarding the entropy of municipal decrees, it is identified that institutional statements are highly restrictive, making it difficult to use this data to promote privacy and use of this data for policy design and projects aimed at smart cities.

This study aimed to explore aspects of the institutional grammar of data governance in Brazilian cities to discuss how specific institutional frameworks affect governance patterns. This research objective is motivated by the growing recognition that different cities have different institutional grammars aimed at collecting, using, and sharing data, directly affecting the construction of smart cities and data-based policy construction. The present study was based on analyzing the institutional grammar of the main Brazilian municipalities to understand how institutional frameworks were presented in terms of diversity, restrictiveness, and entropy.

This study presents an innovative approach incorporating the institutional grammar tool with restrictiveness, diversity, and entropy analysis techniques. This integration allows for the effective combination of an established framework for institutional design analysis (Siddiki et al. 2022) with advanced information analysis techniques (Valle et al. 2022). This proposal aligns with other initiatives in the field (Kosti 2024) to employ text-mining techniques to analyze public policies to understand institutional change and dimensions focused on regulation. In this specific case, we made progress in understanding the institutional aspects of Brazil's data governance. In the case of Brazilian municipalities, we identified that a high level of restrictiveness marks the institutional frameworks. Regarding the entropy of the attribute, the decrees are highly focused on defining obligations for the state body itself, presenting few opportunities for the insertion of non-state actors, technology and innovation companies, and social participation.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The authors would like to thank Federal District Research Support Foundation (Fundação de Apoio a Pesquisa do Distrito Federal – FAP DF) for funding the research. Grant number: 00193-00000256/2023-65.

Data availability and ethical considerations

The data used for this research are public and available on the websites of Brazilian municipal governments. The database with institutional statements and the script containing the crossings carried out are available on demand.

ORCID

Fernando Filgueiras  <http://orcid.org/0000-0001-9570-8113>

Lizandro Lui  <http://orcid.org/0000-0002-9276-247X>

Thayná Gomes Rosa  <http://orcid.org/0009-0000-9871-7322>

Gabriela Candido Ferreira  <http://orcid.org/0009-0008-6270-4915>

References

- Abraham, R., J. Schneider, and J. Vom Brocke. 2019. "Data Governance: A Conceptual Framework, Structured Review, and Research Agenda." *International Journal of Information Management* 49: 424–438. <https://doi.org/10.1016/j.ijinfomgt.2019.07.008>.
- Aghion, P., A. Bergeaud, and J. V. Reenen. 2023. "The Impact of Regulation on Innovation." *American Economic Review* 113 (11): 2894–2936. <https://doi.org/10.1257/aer.20210107>.
- Allam, Z., and Z. A. Dhunny. 2019. "On Big Data, Artificial Intelligence, and Smart Cities." *Cities* 89 (1): 80–91. <https://doi.org/10.1016/j.cities.2019.01.032>.
- Al-Ubaydli, O., and P. A. McLaughlin. (2017). "RegData: A Numerical Database on Industry-specific Regulations for all United States Industries and Federal Regulations." *Regulation & Governance*, 11 (1): 109–123.
- Arendsen, R., O. Peters, M. Hedde, and J. Dijk. 2014. "Does e-Government Reduces Administrative Burden of Business? An Assessment of Business-to-Government Systems Usage in Netherlands." *Government Information Quarterly* 31 (1): 160–169. <https://doi.org/10.1016/j.giq.2013.09.002>.
- Arretche, Marta. (2012). *Democracia, federalismo e centralização no Brasil*. Rio de Janeiro: Editora FIOCRUZ..
- Baekgaard, M., P. B. Mortensen, and H. S. Seeberg. 2018. "The Bureaucracy and the Policy Agenda." *Journal of Public Administration Research and Theory* 28 (2): 239–253. <https://doi.org/10.1093/jopart/mux045>.
- Belli, L., and D. Doneda. 2023. "Data Protection in the BRICS Countries: legal Interoperability through Innovative Practices and Convergence." *International Data Privacy Law* 13 (1): 1–24. <https://doi.org/10.1093/idpl/ipac019>.
- Benfeldt, O., J. S. Persson, and S. Madsen. 2020. "Data Governance as a Collective Action Problem." *Information Systems Frontiers* 22 (2): 299–313. <https://doi.org/10.1007/s10796-019-09923-z>.
- Crawford, S. E., and E. Ostrom. 1995. "A Grammar of Institutions." *American Political Science Review* 89 (3): 582–600. <https://doi.org/10.2307/2082975>.
- Drapalova, E., and K. Wegrich. 2020. "Who Governs 4.0? Varieties of Smart Cities." *Public Management Review* 22 (5): 668–686. <https://doi.org/10.1080/14719037.2020.1718191>.
- Dunleavy, P., and H. Margetts. 2023. "Data Science, Artificial Intelligence and the Third Wave of Digital-Era Governance." *Public Policy and Administration: 1–30*. <https://doi.org/10.1177/09520767231198737>.
- Dunlop, C., J. Kamkhaji, and C. Radaelli. 2019. "A Sleeping Giant Awakes? The Rise of the Institutional Grammar Tool (IGT) in Policy Research." *Journal of Chinese Governance* 4 (2): 163–180. <https://doi.org/10.1080/23812346.2019.1575502>.
- Filgueiras, F., and A. Raymond. 2023. "Designing Governance and Policy of Disruptive Digital Technologies." *Policy Design and Practice* 6 (1): 1–13. <https://doi.org/10.1080/25741292.2022.2162241>.

- Filgueiras, F., and L. Lui. 2023. "Institutional Grammar as a Tool for Analyzing Institutional Design." *Brazilian Journal of Social Sciences* 38 (111): 1–38. <https://doi.org/10.1590/3811032/2023>.
- Filgueiras, F., and V. Almeida. 2021. *Governance for the Digital World: Neither More State nor More Market*. London: Palgrave.
- Filgueiras, F., C. Flávio, and P. Palotti. 2019. "Digital Transformation and Public Service Delivery in Brazil." *Latin American Policy* 10 (2): 195–219. <https://doi.org/10.1111/lamp.12169>.
- Frischmann, B., and E. Selinger. 2018. *Re-Engineering Society*. Cambridge: Cambridge University Press.
- Janssen, M., P. Brous, E. Estevez, L. S. Barbosa, and T. Janowski. 2020. "Data Governance: Organizing Data for Trustworthy Artificial Intelligence." *Government Information Quarterly* 37 (3): 101493. <https://doi.org/10.1016/j.giq.2020.101493>.
- Kattel, R., W. Drechsler, and E. Karo. 2022. *How to Make a Entrepreneurial State: Why Innovation Needs Bureaucracy*. New Haven: Yale University Press.
- Kelman, S. 2005. *Unleashing Change: A Study of Organizational Renewal in Government*. Washington: Brookings Institute.
- Khatri, Vijay, and Carol V. Brown. 2010. "Designing Data Governance." *Communications of the ACM* 53 (1): 148–152. <https://doi.org/10.1145/1629175.1629210>.
- Kitchin, R. 2022. *The Data Revolution: A Critical Approach to Big Data, Open Data, and Data Infrastructures*. Cambridge: Polity Books.
- König, P. 2021. "Citizen-Centered Data Governance in the Smart City: From Ethics to Accountability." *Sustainable Cities and Society* 75: 103308. <https://doi.org/10.1016/j.scs.2021.103308>.
- Kosti, N. 2024. "Conceptualization and Measurement of Regulatory Discretion: Text Analysis of 120 Years of British Legislation." *Regulation & Governance* 18 (3): 761–779. <https://doi.org/10.1111/rego.12516>.
- Kuzio, J., M. Ahmadi, K. C. Kim, M. R. Migaud, Y.-F. Wang, and J. Bullock. 2022. "Building Better Global Data Governance." *Data & Policy* 4: e25. <https://doi.org/10.1017/dap.2022.17>.
- Madison, M. J., M. Sanfillippo, and B. Frischmann. 2023. "Smart Cities and Knowledge Commons." In *Governing Smart Cities and Knowledge Commons*, edited by B. Frischmann, M. J. Madison, and M. Sanfillippo. Cambridge: Cambridge University Press.
- Marenco, A., and L. T. Cate. 2021. "Municípios São Todos Iguais? Decisões Sobre Gasto, Orçamento e Políticas Públicas em Governos Locais." *Revista de Sociologia e Política* 29 (77): 1–23. <https://doi.org/10.1590/1678-987321297701>.
- Margalef, R. 1958. "Information Theory in Ecology." *International Journal of General System* 3: 36–71.
- Mattioli, M. (2017). "The Data-pooling Problem." *Berkeley Technology Law Journal*, 32 (1): 179–236.
- McLaughlin, P. A., S. Strosko, and L. Jones. (2019). *RegData Canada: A Snapshot of Regulatory Restrictions in Canada's Provinces*. Mercatus Center, George Mason University, Regulatory Snapshot.
- Micheli, M., M. Ponti, M. Craglia, and A. B. Suman. 2020. "Emerging Models of Data Governance in the Age of Datafication." *Big Data & Society* 7 (2): 1–15. <https://doi.org/10.1177/2053951720948087>.
- Michelotto, F., and L. A. Joia. 2021. "The Social Representation of Smart Cities: A View from Brazil." In *Electronic Government. EGOV 2021. Lecture Notes in Computer Science*, edited by H. J. Scholl, J. R. Gil-Garcia, M. Janssen, E. Kalampokis, I. Lindgren, and M. P. Rodríguez Bolívar, vol. 12850. Cham: Springer. https://doi.org/10.1007/978-3-030-84789-0_16.
- Olsen, J. P. 2008. "The Ups and Downs of Bureaucratic Organizations." *Annual Review of Political Science* 11 (1): 13–37. <https://doi.org/10.1146/annurev.polisci.11.060106.101806>.
- Ostrom, E. 2005. *Understanding Institutional Diversity*. Princeton: Princeton University Press.

- Sewerin, S., L. H. Kaack, J. Küttel, F. Sigurdsson, O. Martikainen, A. Eshaki, and F. Hafner. 2023. "Towards Understanding Policy Design through Text-as-Data Approaches: The Policy Design Annotations (POLIANNA) Dataset." *Scientific Data* 10 (1): 896. <https://doi.org/10.1038/s41597-023-02801-z>.
- Shannon, C. E. 2001. "A Mathematical Theory of Communication." *ACM SIGMOBILE Mobile Computing and Communications Review* 5 (1): 3–55. <https://doi.org/10.1145/584091.584093>.
- Shannon, C. E., and W. Weaver. 1949. *The Mathematical Theory of Communication*. Urbana-Champaign: University of Illinois Press.
- Siddiki, S. 2014. "Assessing Policy Design and Interpretation: An Institutions-Based Analysis in the Context of Aquaculture in Florida and Virginia, United States." *Review of Policy Research* 31 (4): 281–303. <https://doi.org/10.1111/ropr.12075>.
- Siddiki, S., and C. Frantz. (2022). "The Institutional Grammar in Policy Process Research." *Policy Studies Journal*, 50 (2): 299–314.
- Siddiki, S., C. M. Weible, X. Basurto, and J. Calanni. 2011. "Dissecting Policy Designs: An Application of the Institutional Grammar Tool." *Policy Studies Journal* 39 (1): 79–103. <https://doi.org/10.1111/j.1541-0072.2010.00397.x>.
- Siddiki, S., T. Heikkilä, C. M. Weible, R. Pacheco-Vega, D. Carter, C. Curley, A. Deslatte, and A. Bennett. 2022. "Institutional Analysis with the Institutional Grammar." *Policy Studies Journal* 50 (2): 315–339. <https://doi.org/10.1111/psj.12361>.
- Siddiki, S., X. Basurto, and C. M. Weible. 2012. "Using the Institutional Grammar Tool to Understand Regulatory Compliance: The Case of Colorado Aquaculture." *Regulation & Governance* 6 (2): 167–188. <https://doi.org/10.1111/j.1748-5991.2012.01132.x>.
- Silva, B. N., M. Khan, and K. Han. 2018. "Towards Sustainable Smart Cities: A Literature Review of Trends, Architectures, Components, and Open Challenges in Smart Cities." *Sustainable Cities and Society* 38: 697–713. <https://doi.org/10.1016/j.scs.2018.01.053>.
- Souza, C. 2005. "Federalismo, Desenho Constitucional e Instituições Federativas no Brasil Pós-1988." *Revista de Sociologia e Política* 24 (24): 105–121. <https://doi.org/10.1590/S0104-44782005000100008>.
- Thompson, V. A. 1965. "Bureaucracy and Innovation." *Administrative Science Quarterly* 10 (1): 1–20. <https://doi.org/10.2307/2391646>.
- Valle, L. M., S. G. Dantas, D. G. Silva, U. S. Dias, and L. M. Monastério. 2022. "RegBR: A Novel Brazilian Government Framework to Classify and Analyze Industry-Specific Regulations." *PLoS One* 17 (9): e0275282. <https://doi.org/10.1371/journal.pone.0275282>.
- Whitford, A. B., and J. Yates. 2023. "Surveillance and Privacy as Coevolving Disruptions: reflections on "Notice and Choice." *Policy Design and Practice* 6 (1): 14–26. <https://doi.org/10.1080/25741292.2022.2086667>.

Appendix A. Description of decrees. Source: the authors.

DATABASE - DECREES					
State	Municipality	Decree Number	URL (decrees)	Date of Promulgation	Average Size (number of articles)
PE	Porto Velho	N° 18.310	URL	01/08/2022.	18 articles
TO	Palmas	N° 2.213	URL	22/06/2022.	18 articles
AP	Macapá	N° 815	URL	03/02/2022	16 articles
ES	Vitória	N° 20628	URL	07/04/2022	23 articles
ES	Vila Velha	N° 146	URL	26/05/2022	24 articles
SP	São Paulo	N° 59.767	URL	15/09/2022	19 articles
SP	São José	N° 18.855	URL	12/08/2022	18 articles
SP	Santo André	N° 17.744	URL	13/08/2022	21 articles
SP	Ribeirão Preto	N° 09	URL	27/04/2022	24 articles
SP	Osasco	N° 13.637	URL	19/12/2022	31 articles
SP	Guarulhos	N° 38145	URL	17/07/2021	25 articles
SP	Campinas	N° 21.903	URL	14/01/2022	8 articles
RJ	Rio de Janeiro	N° 49558	URL	06/10/2021	11 articles
RS	Porto Alegre	N° 21.838	URL	09/01/2023	26 articles
RS	Caxias	N° 21.641	URL	14/07/2022	23 articles
SC	Joinville	N° 44.844	URL	25/11/2021	26 articles
PR	Curitiba	N° 326	URL	17/02/2021	21 articles
PR	Londrina	N° 214	URL	24/02/2021	22 articles
MG	Juiz de Fora	N° 309	URL	14/08//2021	23 articles
MG	Cuiabá	N° 8.617	URL	17/09/2021	18 articles
DF	Distrito Federal	N° 42.036	URL	27/04/2021	29 articles
MS	Campo Grande	N° 14.719	URL	29/04/2021	16 articles
BA	Salvador	N° 35.299	URL	28/03/2022	16 articles
SE	Aracaju	N° 07	URL	22/12/2021	17 articles
PB	João Pessoa	N° 9792	URL	30/08/2021	20 articles
PE	Recife	N° 35583	URL	25/04/2022	15 articles