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Governing in the digital age: The emergence of dynamic smart urban governance modes

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ABSTRACT

There is growing concern that implementing effective governance constitutes a significant element in cities becoming ‘smart’ due to its multidisciplinary, complexity of urban challenges and multi-stakeholder involvement. It is assumed that in smart city initiatives, new governance modes arise through the interplay of technological artefacts and political and social factors, viewed through a sociotechnical perspective. We also argue that traditional urban governance modes help explain emerging modes and the nature of citizen-government interactions. Thus, a combination of the sociotechnical view with the modes of urban governance as a theoretical approach was used to understand the dynamics of emerging governance modes in smart city initiatives. Two cases were studied using a longitudinal qualitative case study and temporal bracketing analysis for an in-depth understanding. Our findings evidenced that the configuration of the elements, governance mode, information and communication technology (ICT) and types of citizen-government interaction varies from one initiative to another and changes over time, across multiple sociotechnical networks in practice, which leads to emerging new governance modes. We highlight that a new understanding of smart urban governance for sustainable development in the digital age needs to be developed as a dynamic process. Moreover, we identified two emerging governance modes and proposed a dynamic approach to investigate smart urban governance in other contexts.

1. Introduction

This article seeks to develop a theoretical and empirical understanding of how new governance modes have emerged in the context of smart cities from a sociotechnical and governance modes perspective. There is growing concern that implementing effective governance modes constitutes a significant element in cities becoming ‘smart’ (Meijer & Bolívar, 2016; Nesti, 2020; Ruhlandt, 2018) due to its multidisciplinary nature, the complexity of the contemporary problems, context-specific solutions and multi-stakeholder environment (Pereira, Parycek, Falco, & Kleinhans, 2018). Local governments concerned with meeting the growing demand for urban services seek to find solutions using different governance modes among government, residents and supporting organisation networks to bolster the capacity to plan and implement initiatives (DiGaetano & Strom, 2003; Pierre, 2011). Many new governance modes are based on ICT, which are centred on communication, interaction, collaboration, and participation in decision-making (Pereira et al., 2018), strengthening the paradigm of

platform governance that brings together sociotechnical systems (Janowski, Estevez, & Baguma, 2018). Besides the classical definition of sociotechnical systems as technical and social subsystems (Bostrom, Gupta, & Thomas, 2009), for this article, sociotechnical systems encompass ICTs, data, and applications embedded with individuals, social and political dimensions to respond to social dilemmas (Janowski et al., 2018; Savaget, Geissdoerfer, Kharrazi, & Evans, 2019). One of these new modes is smart urban governance, defined as a collaboration between citizens and local governments enabled by ICT (Meijer & Bolívar, 2016; Nesti, 2020; Ruhlandt, 2018; Tomor, Meijer, Michels, & Geertman, 2019). This governance mode is considered an evolving and transformative mode of city administration, focusing on innovative governance networks stimulating internal and external government changes. There is an assumption that governance transformation is necessary to make cities smarter and more sustainable (Meijer & Bolívar, 2016).

However, there is still an open discussion about the emerging modes of governance in smart city initiatives (Ruhlandt, 2018) and the

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implications that smart city initiatives bring to urban governance (Nesti, 2020). We assume that there is a new dynamic, influenced by ICTs, in the citizen-government relationships in the context of smart city. A more sophisticated theoretical understanding of sociotechnical interactions between social and governmental entities and ICTs is needed (Meijer & Thaens, 2018). Also, this understanding of smart urban governance needs to be linked to local contextual aspects, including local dilemmas, political-institutional factors, and the predominant modes of urban governance (Ruhlandt, 2018; Tomor et al., 2019; Tomor, Przebyłowicz, & Leleux, 2021).

This article aims to provide an in-depth understanding of how new governance modes are configured in smart city initiatives, advancing the studies of smart urban governance (e.g. Meijer & Bolívar, 2016; Nesti, 2020; Pereira et al., 2018; Ruhlandt, 2018; Tomor et al., 2019; Tomor et al., 2021). We examined two cases in Brazil, Curitiba Collaborates in Curitiba and *Pátio Digital* in São Paulo that were selected regarding the cities' urban history and the distinction between perceived governance modes. Both cases are characterised by the use of ICT and collaboration between the government and social actors. The cities are inserted in the Brazilian federal decentralised and multi-party-political system enabling different governance modes (Marques, 2013).

The theoretical contribution is that smart urban governance emerges from the interplay among technological artefacts, government entities, social actors, and established urban governance modes. This interaction happens over time and can change, both within an initiative or from one smart city initiative to another, which means a dynamic process. A new mode emerges in each smart city initiative which may differ from the traditional urban governance modes prevalent in the local context. We present a comprehensive understanding of this configuration process of new governance modes in a longitudinal analysis based on temporal bracketing (Langley, 1999) composed of detailed event histories, thus describing each city's predominant governance modes as a local contextual factor influencing smart urban governance (Nesti, 2020; Przebyłowicz et al., 2022; Tomor et al., 2021). Modes of urban governance refer to various ways in which individuals and public sector organisations interact (Peters & Pierre, 2012; Pierre, 2011; Stoker, 2018). These relationships determine how cities are governed, how they shape their objectives and goals, and the nature of citizen-government interaction (DiGaetano & Strom, 2003). Additionally, ICT was used to explain the governance dynamics in smart city initiatives, connecting the urban governance modes to the perspective of the sociotechnical network (Kling, McKim, & King, 2003) and the paradigm of platform governance (Janowski et al., 2018) to clarify the formation of governance modes that ICT is helping to configure. For practitioners, this article offers insights into how smart urban governance can be implemented in practice and strengthen collaboration to address diverse policy-domain dilemmas.

2. Towards a theoretical approach for understanding the emergence of governance modes in smart cities initiatives

Our theoretical approach is based on the concepts of governance modes and the perspective of sociotechnical interaction networks to understand the dynamics of emerging governance modes in smart city initiatives. This approach is presented in the following paragraphs starting by describing the concept of the smart city and its new governance modes (Gil-Garcia, Pardo, & Nam, 2015; Mora, Bolici, & Deakin, 2017). Furthermore, we present the conceptualisation of governance and the modes of managerial, participatory and collaborative governance for understanding the different forms of city management and the interactions between citizens and government (DiGaetano & Strom, 2003; Pierre, 2011). Then, we present the definition of smart urban governance and establish a theoretical link with the sociotechnical perspective based on the paradigm of platform governance (Janowski et al., 2018) and sociotechnical networks (Kling et al., 2003) to understand when the social and technical aspects come together to produce an

outcome of interest (Sarker, Chatterjee, Xiao, & Elbanna, 2019).

The concept of a smart city extends beyond implementing ICTs in urban environments. It has been widely used in the fields of public administration, urban planning, and information systems management to describe innovative developments within cities (Albino, Berardi, & Dangelico, 2015; Caragliu, Del Bo, & Nijkamp, 2011; Gil-Garcia et al., 2015; Mora et al., 2017). The term smart city is controversial and criticised in the literature as a self-promotional label and high-tech urban entrepreneurialism (Hollands, 2008). However, Gil-Garcia, Pardo & Nam (2015, p. 79) argue that regardless of the dichotomy between being smart or not, "*smartness should be seen as a continuum in which local government officials, citizens and other stakeholders could think about and implement initiatives that attempt to make a city a better place to live and work*". Smart cities gained prominence among practitioners and academics for two main reasons: first, the influence of technology corporations interested in selling technological solutions to cities (Söderström, Paasche, & Klausner, 2014; Sadowski & Bendor, 2019) criticised as a techno-centric view (Hollands, 2008) even as digital neocolonialism (Mouton & Burns, 2021). Second, the possibility of understanding the city from a holistic perspective, where urban services and citizen-government collaboration are enabled by ICTs (Castelnuovo, Misuraca, & Savoldelli, 2015; Mora et al., 2017). The smart city is also presented as a transformational process of the city administration (Joss, Sengers, Schraven, Caprotti, & Dayot, 2019; Meijer & Bolívar, 2016), where urban development is based on the extensive use of ICTs to promote sustainable development and innovation through participatory governance (Caragliu et al., 2011; Nesti, 2020) in a multi-sectoral, multi-level and multi-actor view (Ruhlandt, 2018). This article is anchored in this second conceptualisation of a smart city. In this regard, new governance modes are anchored on new relationships, processes, and government structures (Gil-Garcia, 2012) centred on communication, interaction, collaboration, and participation in decision-making, thereby facilitating openness and transparency, and promoting direct democracy (Pereira et al., 2018). New modes of governance go beyond the traditional institutions and the classical processes of governing (Bolívar, 2016).

The conceptualisation of governance has been used as a way of governing that assigns a role in policy formulation, administration, and implementation to private economic actors and parts of civil society (Mayntz, 2003; Pierre & Peters, 2005; Stoker, 2018). Governance offers an analytical approach to observing the urban polity and comprehending the nature of citizen-government relations when it comes to collaborative forms of governing (Peters & Pierre, 2012; Stoker, 2018). Scholars have sought to explain patterns of urban governance across various contexts that result in different modes of urban governance (DiGaetano & Strom, 2003; Pierre, 2011). Each mode is grounded in different paradigms, traditional bureaucratic, consumerist, or participatory (Villeneuve, 2016), shaping and reshaping the landscape of citizen-government relationships (Janowski et al., 2018). Governance modes also offer opportunities to identify the extent to which citizens participate in the governing process, its mechanisms and patterns (Przebyłowicz et al., 2022).

Cities can be governed under different and coexisting governance paradigms and modes, and the literature has proliferated with several different positions and perspectives (e.g., DiGaetano & Strom, 2003; Pierre, 2011; Villeneuve, 2016). For the purpose of this article, the governance modes are used as an analytical approach for observing the contextual aspects of the cities, such as the objectives, the role of government and citizens and the nature of interactions between the government and external actors (Pierre, 2011; DiGaetano & Strom, 2003; Villeneuve, 2016; Osborne, 2006; Bryson, Crosby, & Bloomberg, 2014; Fischer, 2012; Bryson, Crosby and Stone, 2006; Sørensen & Torfing, 2009; Ansell & Gash, 2008). In particular, this article focuses on three modes, managerial, participative and collaborative, arguing that they can help understand the differences in citizen-government relations and their dynamics (Table 1).

Table 1
The characteristics of urban governance modes.

	Managerial	Participative	Collaborative
Objective	Delivering services through efficient and rational decisions in urban management using managerial techniques and expertise to achieve specific policy goals	Creating an inclusive and participative relationship between citizens and the government in urban policies decision-making	Creating a collaborative environment where stakeholders work together, share knowledge, and collectively contribute to urban policies and projects
Government role	Service provider focusing on the efficient and effective administration of urban affairs	Involving citizens in decision-making processes and ensuring meaningful participation in shaping urban policies and projects	Facilitator of collaborative processes among various stakeholders
Citizen role	Client or consumer of public services	Participant in the decision-making process	Collaborator to co-create solutions for complex problems
Citizen-government relationships	Top-down approach administration takes a leading role in decision-making and policy formulation, with citizens being recipients of services and policies	Multilateral dialogue with the citizen and the administration sharing responsibility for the overall success of the encounter	Partnership and co-creation between citizens and the administration to co-create solutions to urban challenges

Source: adapted from [Pierre, 2011](#); [DiGaetano & Strom, 2003](#); [Villeneuve, 2016](#); [Osborne, 2006](#); [Bryson et al., 2014](#); [Fischer, 2012](#); [Bryson, Crosby and Stone, 2006](#); [Sørensen & Torfing, 2009](#); [Ansell & Gash, 2008](#).

The managerial mode is grounded in the new public management or market governance ([Osborne, 2006](#)), anchored in the consumerist paradigm ([Villeneuve, 2016](#)), which focuses on providing public services by the government to fulfil the citizens' needs ([DiGaetano & Strom, 2003](#)). This mode emphasises the effectiveness or efficiency of government policy and programmes ([Pierre, 2011](#)) and technical experts dominate the relations ([Bryson et al., 2014](#)), which is considered a technocratic perspective. Participative governance tried to reinvent the citizen role into active decision-making participation ([Villeneuve, 2016](#)). This mode is related to the theory of participatory democracy and the relationships are based on trust and reciprocity ([Fischer, 2012](#)), emphasising deliberative practices and dialogue between the government and citizens for the benefit of the public good ([Bryson et al., 2014](#)). For example, in participatory budgeting cases, residents deliberate the government investment according to their needs ([Fischer, 2012](#)). Collaborative governance brings multiple stakeholders together in common forums with public agencies to engage in consensus-oriented decision-making and active co-creation ([Ansell & Gash, 2008](#)). Public agencies are typically the initiators or instigators of collaborative governance ([Bryson, Crosby and Stone, 2006](#)), while non-state actors actively co-produce services ([Sørensen & Torfing, 2009](#)). The nature of the relationship is characterised by self-regulation, partnership, and mutual trust ([Ansell & Gash, 2008](#)). This governance mode is anchored under the democratic, participatory paradigm ([Villeneuve, 2016](#)).

[Janowski et al. \(2018\)](#) use the perspective of governance ([Villeneuve, 2016](#)) to analyse the effects on sustainable development, including a sociotechnical view, the platform governance paradigm, where the difference with earlier paradigms is the ability of citizens, enabled by the government, make development decisions and actions. According to the authors, the platform paradigm can encompass all previous modes of governance, but it is closer to the participatory paradigm. The platform governance “*enabled by advances in methods and applications of digital technology, is tapping into assets, resources and competencies that exist within government and across the society, organising them into common development platforms and using them to orchestrate collective action and pursue collective goals*” ([Janowski et al., 2018](#), p. 2). Platform governance can be related to different concepts and stages of digital technologies application ([Janowski, 2015](#)), empowering citizens and other non-state actors to contribute directly to sustainable development ([Janowski et al., 2018](#)). In this article, the platform paradigm is linked with smart urban governance, defined as technology-enabled collaboration between citizens and governments to advance sustainable development ([Meijer & Bolívar, 2016](#); [Nesti, 2020](#); [Pereira et al., 2018](#); [Tomor et al., 2019](#); [Tomor et al., 2021](#)).

Smart urban governance involves using ICTs and changes in routines, collaborations and actors' roles in the public domain ([Meijer & Thaens, 2018](#)). Smart urban governance using ICT-based tools and openness can increase citizen engagement and support the development of new

governance modes for the smart government ([Pereira et al., 2018](#); [Webster & Leleux, 2018](#)), which require complex interactions between governments, citizens and other stakeholders ([Pereira et al., 2018](#); [Ruijter et al., 2023](#)) to achieve sustainable development ([Jurado-Zambrano, Velez-Ocampo, & López-Zapata, 2022](#)). Hence, citizen participation, open government and co-creation initiatives are vital to promoting more inclusive and solid institutions ([Scholl, 2021](#)). However, there is scepticism regarding the smart urban governance outcome's long-term sustainability, the social impact and scalability of digital co-creation, and the possibility of increasing the techno-economic divide between tech haves and tech have-nots as an adverse effect ([Tomor et al., 2019](#)). Considering a sociotechnical perspective, the smart urban governance understanding should be complemented with various instruments, policies and practices sensitive to how cities function ([Kitchin, 2014](#)). Understanding the management of cities involves studying the governance of smart cities as a complex process ([Meijer & Bolívar, 2016](#)) and recognising the nature of sociotechnical governance ([Janowski et al., 2018](#); [Meijer & Thaens, 2018](#)).

In addition to governance modes, a sociotechnical network perspective is often considered fundamental to understanding how the social and technical aspects come together to create a more humanised society using digital technologies ([Sarker et al., 2019](#)). The socio-technical perspective is often regarded as potentially malleable ([Kling & Courtright, 2003](#)) and configurational ([Meyer, Tsui, & Hinings, 1993](#)) in how the social and the technical are linked, allowing researchers to embrace it differently based on their particular phenomenon of investigation, accepting variations of sociotechnical relationships ([Sarker et al., 2019](#)). Based on the arguments that smart city and smart urban governance are sociotechnical systems (e.g., [Sadowski & Bendor, 2019](#); [Meijer & Bolívar, 2016](#); [Meijer & Thaens, 2018](#)), we expand the understanding of this phenomenon, bringing together social structures and material infrastructure, political institutions and hopes and aspirations ([Sadowski & Bendor, 2019](#)).

This article uses the conceptualisation of sociotechnical interaction networks, “*a network that includes people, equipment, data, diverse resources, documents and messages, legal arrangements and enforcement mechanisms and resource flows*” ([Kling et al., 2003](#), p. 48) to identify the broad set of actors that shape the project and its implementation ([Dutton, 2012](#)), particularly when the network reaches what is called choice points, where decisions about the adoption, use and reuse of ICTs are taken ([Cruz & Meyer, 2012](#)). The analysis goes through heuristics proposed by [Kling et al. \(2003\)](#), identifying a relevant population of system interactors, the main interaction groups, the incentive structures, excluded actors and unwanted interactions, existing communication forums, choice points, resource flows, and the map that points to sociotechnical characteristics. These heuristics and governance modes provide a comprehensive guideline for analysing the emergence of sociotechnical networks in the city and focusing on understanding the

interactions of the various actors.

3. Research approach and methods

In-depth longitudinal case studies were used to identify the dynamics of emerging governance modes in smart city initiatives. According to [Walsham \(1993\)](#), it is an appropriate strategy for conducting research in the qualitative tradition. We chose the qualitative case study approach ([Stake, 2005](#)) because this strategy offers an opportunity for an in-depth study and provides insights from the cases that can inform and contribute to theoretical explanations. The processual technique, temporal bracketing, as proposed by [Langley \(1999\)](#) was used to analyse data in successive periods, enabling an examination of how actions in one period lead to changes in the context that subsequently affect actions in later periods. The technique also facilitates inductive and deductive theorising, enriching our explanations. Consistent with this strategy, the cases were selected due to their theoretical relevance in providing empirical data to elaborate explanations about emerging governance modes and for practical reasons that allowed accessing of necessary data to conduct a longitudinal study. The data were collected through interviews, observations, and document collection, providing a comprehensive and in-depth understanding of the cases. The data analysis consisted of temporal bracketing to identify the sequence of events, using concepts from the literature to guide the analysis, namely, the heuristics of [Kling et al. \(2003\)](#) and modes of urban governance. Kling's heuristics have been proven helpful in sociotechnical studies (see [Kreeger & Harindranath, 2017](#); [Letch & Carroll, 2008](#); [Taylor-Smith & Smith, 2016](#)), as the governance modes have been used to understand the cities context (see [Nesti, 2020](#); [Przeybilowicz et al., 2022](#); [Tomor et al., 2021](#)). The strength of our approach lies in linking temporal bracketing, Kling's heuristics, and governance modes, all within the context of an in-depth longitudinal study involving two pertinent cases to observe the emergence of governance modes.

One or a few cases may be sufficient to produce valuable insights because of its internal replication of successive phases, although the explanations will have moderate generality ([Langley, 1999](#)). What is aligned with our research objective and supported by [Stake \(2005\)](#), while the findings may not be generalisable in a statistical sense, they can offer valuable insights that contribute to theoretical understanding. [Langley \(1999\)](#) recognises temporal bracketing as a perspective involving mutual shaping, enabling an understanding of the configuration of the sociotechnical interaction networks and identifying the events resulting in the emergent governance modes over time, as applied in other studies (see [Pozzebon & Pinsonneault, 2005](#); [Chan, Hackney, Pan, & Chou, 2011](#); [Iannacci, Seepma, De Blok, & Resca, 2019](#)).

3.1. Case selection

The cases analysed were the Curitiba Collaborates in Curitiba and *Pátio Digital* in São Paulo, Brazil. In the last two decades, many smart city initiatives have been implemented nationwide ([Cunha, Przeybilowicz, Macaya, & Santos, 2016](#)) but these two initiatives were selected based on theoretical considerations related to the research question and practical concerns of access and timing. Regarding the theoretical considerations, first, these cases were selected because they offer evidence of citizen-government collaboration and the use of ICT in shaping smart urban governance. By working together and leveraging the use of ICT, governments and social actors help to configure new modes of governance responsive to local dilemmas, thus, studying these cases allows a better understanding of how different governance modes emerge and evolve. Second, as suggested by [Stake \(2005\)](#), the cases are instrumental in offering an understanding of smart city governance once both cities are recognised nationally and internationally for their efforts to implement smart city initiatives. Curitiba received awards, including the Connected Smart Cities Award for best governance in 2015 and the smartest city in Brazil in 2018. The city of São Paulo has received

recognition, such as the smartest city in Brazil in 2018 by the national ranking *Cidades em Movimento*, second in the Connected Smart Cities 2018 ranking and first in the 2020 edition. Both cities are listed in the Cities in Motion Index 2022. Third, the cases offer an opportunity to develop a longitudinal study to learn about the historical context of the cases and observe, in quasi-real-time, the configuration of the socio-technical networks. As pointed out by [Ruhlandt \(2018\)](#) in his recommendation for future research, longitudinal qualitative studies can advance the perception of smart urban governance by recognising the changing dynamics of such highly complex sociotechnical systems and provide valuable insights to sharpen causal models of components.

Regarding the practical concerns, both cases provided the opportunity to in-depth and directly observe the unfolding of events over time without many restrictions on access. We had access to conduct interviews with pivotal government and social actors involved, observe events like hackathons, and formal and informal meetings, follow WhatsApp and Telegram citizen groups, analyse project documents, and on-site visits to capture a diversity of perceptions for triangulation. As suggested by [Stake \(2005\)](#) and [Pozzebon \(2004\)](#), our interaction with the initiatives is characterised as intensive with the Curitiba Collaborates from 2016 to 2019 and the *Pátio Digital* from 2017 to 2018.

3.2. Data collection

The data were collected through semi-structured interviews, gathering documents, and conducting non-participant observation from 2016 to 2019. The interviews provided empirical material to understand in-depth the roles and dynamics of the citizen-government interaction. Fifteen interviews with Curitiba Collaborates participants were conducted between November and December 2016 and October 2018. For *Pátio Digital*, seven interviews were conducted between October and November 2018, and we had access to nine interviews conducted by other researchers between October and December 2017 ([Silveira, Lima, & Kühn, 2017](#)), totalling sixteen interviews. Documents describing the initiatives, laws and regulations, news published in the press and academic works produced on the cases were gathered, with 29 documents about Curitiba Collaborate and 21 about *Pátio Digital*. The documents helped to identify time frames, events, and practices that crystallised in the process. We consulted official government websites and followed the discussion groups on message apps, the Code for Curitiba for three years and the *Pátio Digital* for six months. We also collected data using non-participant observation to understand the interaction dynamics between the actors. One author participated as an observer in the third edition of the hackathon promoted by Curitiba Collaborates, in a meeting of the citizens' group, and the *Pátio Digital Currículo Digital* platform launch ([Table 2](#)). The participants were informed about privacy and anonymity, and that the research was approved by the research ethics committee of the researchers' home institution. They provided written informed consent for the interview and the audio recording.

3.3. Data analysis

In keeping with the qualitative approach, we pursued a temporal bracketing analysis, which involves reporting stories about what happened, who did what, and when, in a succession of events, activities, and ordered choices within the phases over time. Additionally, evidence was gathered to examine how the context affects these processes, the consequences for the future, and other relevant variables ([Langley, 1999](#)). Furthermore, the heuristics proposed by [Kling et al. \(2003\)](#) were applied for the structured identification of the involved actors, formed groups, excluded actors, unwanted interactions, incentives, debate spaces, use of technology, and relevant points of choice to determine the sociotechnical interaction networks. Governance modes were also used to analyse the relationships and roles of the government and citizens. The analysis was conducted in three stages:

In the first stage, the interviews were transcribed and entered into

Table 2
Case study data collected.

Case	Instrument	Data	Period
Curitiba Collaborates	Interview	- 5 public managers - 5 citizens from Code for Curitiba - 3 university professors	Nov-Dec/2016
	Non-participant observation	- 10 observation hours of the hackathon's third edition - 3 observation hours of the Code for Curitiba meeting - 3 years following the WhatsApp group of Code For Curitiba	Nov-Dec/2016 Dec/2016–2019
	Project documents	- Data of the participants of the three editions of the hackathon - Open data policy - Project description - Governance Standard and ICT Policy - 2014-17 Multi-Year Plan - 2017-20 Government plan	Nov-Dec/2016 Nov/2018
	Internet material	- Facebook pages of Code for Curitiba and “ <i>Busão Curitiba</i> ” - News published in the local press and on the official website of the City Hall	Nov/2016 to Dec/2018
	Interview (2° round)	- 2 public managers	Oct/2018
	Interview	- 4 public managers - 1 primary school teacher - 2 citizen project collaborators	Oct-Dez/2018
Pátio Digital	Non-participant observation	- 2 observation hours of the event “ <i>Currículo Digital</i> ” - 6 months following the Telegram group of the <i>Pátio Digital</i>	Jun-Dec/2018
	Project documents	- Project documents description - Masters's degree dissertation (Da Silveira, Lima e Kühl, 2017) - Academic article authored by the project leaders	Nov/2018
	Internet material	- <i>Pátio Digital</i> Portal - News published in the local press and on the official website of the City Hall	Jun-Dec/2018
	Material provided by other researchers	- 7 public managers interviews - 2 citizens project collaborators interviews - Non-participant observation of citizens' workshops	Oct-Dec/2017

Atlas.ti® software for coding based on Kling's heuristics and governance modes. In the second stage, an analytical framework was created to identify the events in each year and the precedents. The results of stage one served as input to the analytical framework, and document analysis was used to determine the year of events. A longitudinal data analysis that coincides with the municipal administration 2013–16, in which the main actions of the project took place, was conducted to reconstruct detailed event histories of Curitiba Collaborates. Only data collected from a secondary source were utilised from 2017 to 19. To analyse the events of *Pátio Digital*, the longitudinal data analysis began in 2013 with the 2013–16 government of São Paulo and 2017–18, halfway administration of the new government turn. This six-year longitudinal period was necessary to understand the events that influenced the creation of *Pátio Digital* in 2017. The final stage of the analysis involved identifying the points of temporal bracketing that played a pivotal role in shaping the emergent modes of governance in each case. This process included drafting the network to visually represent these findings.

4. Findings: the emergent modes of smart urban governance

This section presents the results of the temporal bracketing analysis of the two cases, beginning with a description of the city context and the specific case, then a narrative of the sequence of events, the configuration of sociotechnical interaction networks, and the phases that result in the emerging governance modes. By describing the context of each city and specific case, we aim to provide a comprehensive understanding of the factors and conditions that contribute to the emergence of different governance modes for a more nuanced analysis of the sociotechnical interaction networks that develop, revealing the complex interplay between social actors and technological artefacts that shape smart urban governance.

4.1. Curitiba collaborates context

Curitiba is the capital of Paraná, a state in the southern region of Brazil, with a population of 1.8 million inhabitants (2022), annual per capita GDP of approximately US\$ 8700, the fifth largest economy among

the 5570 Brazilian municipalities and tenth in the human development index. Curitiba is internationally known for innovations in the areas of mobility, urban planning and sustainable development, particularly its sustainable urban public transport (Mercier, Duarte, Domingue, & Carrier, 2015). Curitiba can be classified under the consumerist governance paradigm and managerial mode of urban governance, where traditionally citizens are rarely encouraged to get involved with the urban planning process (Follador, Duarte, & Carrier, 2018; Irazábal, 2017). The city's notoriety is due to detailed urban planning from the 1970s led by a group of technicians of the Curitiba Research and Urban Planning Institute (in Portuguese Instituto de Pesquisa e Planejamento Urbano de Curitiba - IPPUC). The same political group governed the city with a strong connection with the technicians for over thirty years. The military regime also considered Curitiba a development model city (1964 to 1985), hence the governance tools and policies are described and sometimes criticised as technocratic, where the citizens are considered consumers of good public transportation services (Irazábal, 2017; Lara, 2010; Mercier et al., 2015). In 2023, the city hall has 16 secretariates and approximately 25,500 employees.

Curitiba's 2013–16 government launched initiatives for a new collaborative governance mode with external actors. The Secretariat of Information and Technology (SIT) led the Curitiba Collaborates initiative with two objectives: promoting transparency and providing data sources for application developers. From the availability of open datasets, the SIT team realised the need to encourage the use of data by society. First, the city administration and local universities signed cooperation agreements to use data in academic research. Also, three hackathons were held in 2014, 2015 and 2016 to develop smart solutions based on data from the municipality, with more than 450 participants. The 2015 and 2016 hackathons were supported by “Code for Curitiba”, a group of civic hackers, self-defined as “a technology-focused community, fostering the civic innovation ecosystem to improve the quality of life across Brazil” (Code for Curitiba Facebook, 2016). This group became a key actor, and government actions stimulated the formation of a collaborative environment in the city based on open data.

4.2. The emergence of smart governance for data-based innovation

Three sociotechnical interaction networks characterise the smart governance mode in the Curitiba Collaborates initiative. The “1. Government Network” reveals the internal government strengthening process and is divided into two phases: “1.1 SIT Design” and “1.2 SIT Implementation”. The “2. Data Subsidy Network” presents the policy implementation and availability of open datasets in three phases: “2.1 Awareness”, “2.2 Opening”, and “2.3 Usage”; both emerged in the same period. The “3. Collaboration Network” emerges from the interaction of government and external actors and is divided into three phases: “3.1 Approach”, “3.2 Engagement”, and “3.3 Smart Governance for Data-Based Innovation”. The last period of Curitiba Collaborates is characterised by network fragmentation with the SIT dismantling, the demobilisation of data opening and external resistance (see Fig. 1).

4.3. January 2013 – December 2014: government and data subsidy networks

The “1. Government Network ” started in 2013 by establishing the Secretariat of Information Technology (SIT), the “1.1 SIT Design” phase, hiring personnel and designing programmes to digitalise services, leading to “1.2 SIT Implementation” phase developing policies, plans and strategies, for instance, the smart city and the governance policies. There was a favourable political context, the election of a centre-left political group anchored in a participatory governance agenda, expressed as a government pillar in the four-year plan to “expand and encourage society’s participation in the various municipal public communication channels, improve management instruments and the ability to meet the demands of the population and provide transparency in the application of

resources public” (Pluriannual Plan 2014–2017).

Despite the objective of implementing this participatory governance, this agenda received little attention to the detriment of other demands. In March 2013, a group of students developed a mobile app showing buses’ positions and approximate arrival times using the geolocation information of the buses available on the Urbanisation of Curitiba Company (URBS) website, which controls the city’s public transport management. In less than 48 h, there were more than 1000 visits to the website and more than 400 downloads of the application “Busão Curitiba”. As the usage of the data was not foreseen, the URBS reaction was to overthrow the system, causing an impasse with the students, “We were collecting geolocation data through a website provided by URBS, giving due credits in the app. [...] URBS decided to make it difficult and cut everyone’s access to this data. They sacrificed their service so the ‘Busão Curitiba’ app would not use this information. [...] We do not steal, hack or damage any property of URBS; we only use the information it has released on the web” (Facebook Busão Curitiba). Meetings were held in the city hall to find a solution to the impasse “and there was a whole discussion about it: no, wait a minute, we have to open access, solve the problem” (SIT Manager - 1). The decision was to open the datasets and the application returned to operation. This event was the turning point for the “2. Data Subsidy Network” and “2.1 Awareness” phase prioritising the open data agenda in city hall, “and from there, we had already been working and accelerated the issue of having a formal open data policy” (SIT Manager - 2).

In 2014, the “2.2 Opening” phase started with city hall launching the open data portal as the official channel for publicising datasets, “We had a first movement that was to open the bases; we needed to improve the process of opening bases and increase the demand on them” (SIT Manager - 1). In October of the same year, city hall published the Open Data Policy that guides the procedures for opening the databases and establishes the role

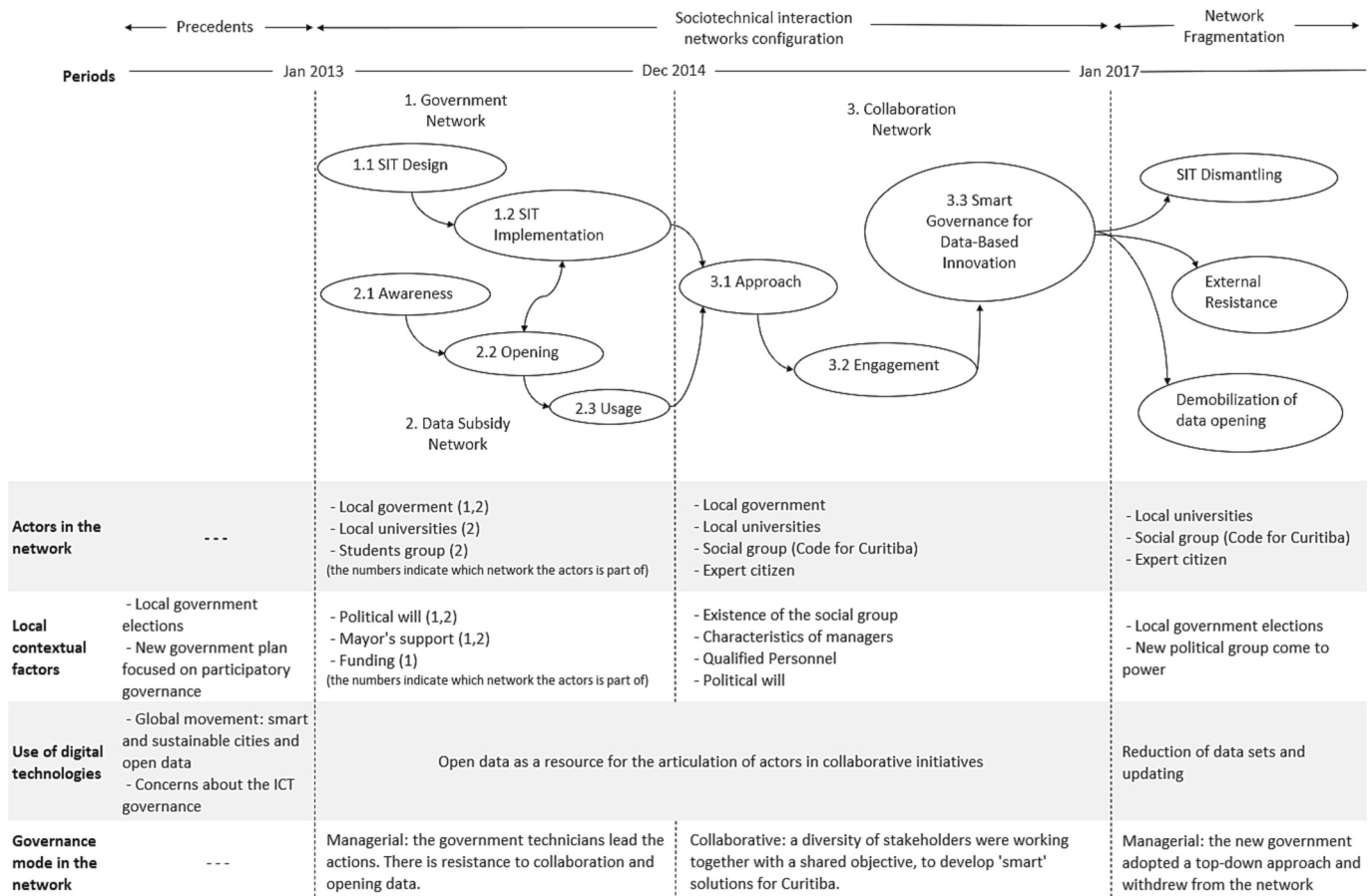


Fig. 1. Sociotechnical interaction networks of Curitiba Collaborates.

of database managers, *“It reinforces the government commitment to transparency in public management, promoting a more open and responsible government”* (Curitiba City Mayor in an interview in 2014). After publishing the open data policy and datasets available, the SIT managers identified the need to stimulate its “2.3 Usage” by starting a new phase: *“We started to work on some articulations, the idea of doing the hackathon came up to make the bases available and stimulate the use”* (SIT Manager - 1). The way found was to establish partnerships with local universities, promote hackathons and strengthen cooperation with social groups, particularly with Code for Curitiba, *“What we observed was that if we only opened the datasets, the use of data would not happen automatically, so I would have to have actions articulated by the administration and orchestrated by it to generate this demand”* (SIT Manager - 1). However, there was still internal resistance, *“We were having some difficulty in making the city managers understand the importance [of open data], in gaining access to some datasets, a certain resistance to granting access. So, we held a seminar with all the database managers in the city hall”* (SIT Manager - 1); the seminar aimed to sensibilise the public managers about the open data agenda.

At the beginning of the formation of the emergent mode of governance, between 2013 and mid-2014, when it involved “1. Government Network” and “2. Data Subsidy Network”, the predominant governance mode perspective was managerial, *“the holistic view of the project was an SIT responsibility”* (SIT Manager - 1). Decision-making was centralised in the SIT, with the technical teams developing the plans and smart city strategy without external actors, civil society, and private sector involvement. The URBS and other public agencies' reaction and resistance to opening the datasets also illustrated Curitiba's prevailing technocratic and top-down view, whereby the government departments considered themselves the data owner.

4.4. December 2014 – January 2017: collaboration network

The “3. Collaboration Network” around open data began at the end of 2014. The “3.1 Approach” phase started when SIT signed cooperation agreements with three universities and invited the Code for Curitiba group to use SIT's physical space for its meetings. There was a “3.2 Engagement” phase between the government, the Code for Curitiba group, universities and the innovation ecosystem, *“they are all engaged in this purpose of civic and non-civic entrepreneurship, coworking, innovation, and startup, that share the same ambitions and ideas”* (SIT Technician - 3). The external actors worked with city hall data, and as datasets were used or requested, new sets were made available by city hall in an interactive process, thus fostering collaboration.

Whilst *“they [Code for Curitiba] held their events here at the city hall for two months, we brought representatives from the areas to discuss issues, so it is an essential partnership”* (SIT Manager - 2). Code was the leading partner in organising the hackathon events in 2015 and 2016, however, the SIT centralised many decisions, *“We helped to organise it, but we didn't have much voice. [...] We managed to open many datasets before the hackathon, a web service format that will facilitate the creation of projects [...] I, as Code, would have liked to have been more of a part of the strategic planning.”* (Code for Curitiba Leader - 1).

The interactions led to a change in the managerial governance mode in the network to collaborative governance, *“[the interaction with external actors] just break this kind of corporatist view, I know everything, I know what to do, I know what is best, I do it my way and in my time”* (SIT Manager - 2). External actors also perceived this change in the government positioning, *“there was this openness on the part of the Secretariat of Information and Technology”* (Professor - Local University - 1). Other local contextual factors also contributed to the formation of the collaborative governance in the network, the mayor's support, the political will for the actions of Curitiba Collaborates to be put into practice, qualified personnel in the SIT team and funding availability. The skills and competence of external actors were also mobilised, and the individual characteristics of the SIT managers, and their vision of building

platforms in Curitiba in partnership with the community, *“We try to work and bring; the practical observation of collaborative development of things”*. (SIT Manager - 2).

There is sociotechnical interaction in this arrangement of Curitiba Collaborates, technology represented by open data, enabling the formation of a network between actors. This encourages the opening of new datasets and the use/development of applications, *“Today, I would say that the strongest thing that brings this together is the availability of data, information and services, the access to city hall data and services...”* (SIT Manager - 2), what we call “3.3 Smart Governance for Data-Based Innovation”. However, this governance mode is still limited in terms of reaching ordinary citizens, as the network is restricted to the so-called innovation ecosystem, citizens with technological skills, students, software developers, and social groups focused on technology, *“It does not empower citizens, it did not empower citizens to participate in projects, which is a great difficulty”* (Code for Curitiba Leader - 1).

4.5. January 2017 - afterwards: network fragmentation

After the municipal elections in 2016, a centre-right political group traditionally influential in the city returned to the government. In 2017, it started the “SIT Dismantling” that lost its status as a government secretariat and the “Demobilisation of Data Opening” agenda. At the end of 2018, the number of datasets available was less than in 2016. In a message in the Code for Curitiba message group, one of the leaders commented in January 2019, *“I realised that open data on municipal health are out of date since November 2017”*. Even with the government's withdrawal from the governance network, external actors and the innovation ecosystem remained active, with 120 participants attending weekly meetings and planning new projects. The stage characterised by the “External Resistance” of the ecosystem points to the importance of empowering external actors and sharing responsibilities in governance for the continuity of smart city initiatives. It also shows that the governance network was fragmented without a government presence, evidencing that government has the role of network inducer. Moreover, technology has a role in catalysing the social actors in the governance of smart cities.

4.6. Pátio Digital context

São Paulo is the most populous city in Brazil, with 11,5 million inhabitants (2022) and a GDP per capita of US\$ 10,400. It is the largest city economy in the country and occupies the fourteenth position in the human development index. The city hall had 22 secretariats and about 134,000 employees in 2023. São Paulo was governed from 1975 to 2000 by a single hegemonic centre-right political group which developed infrastructure policies, urban services and large urban projects conducted by a technical community, although influenced by both the interests of the hegemonic political group and private companies (Empinotti, Budds, & Aversa, 2019; Marques, 2013). Therefore, the predominant mode of governance in São Paulo is considered managerial with influence from the private sector (Marques, 2013), characteristics of the consumerist governance paradigm (Villeneuve, 2016). Although there are tensions with social movements, the most critical local development strategies remain centralised within the government and are influenced by the same economic forces (Empinotti et al., 2019). There was an opening for more participatory governance in the 2000s with the alternation of power with centre-left political groups.

Pátio Digital was an initiative of the Municipal Secretariat of Education (*Secretaria Municipal de Educação - SME*) that, through strengthening transparency, social participation and developing new technologies, brought together different civil society groups to improve education policies in São Paulo. Monthly meetings, development of innovative solutions and partnerships for research are some of the initiatives that make up *Pátio Digital*, which was structured around three pillars: transparency and open data, government-society collaboration

and technological innovation. This initiative launched “Prato Aberto”, an application to consult school meal menus developed by a team of citizens outside the public administration. Other actions included the research cooperation programme with universities and the opening of SME data. In November 2018, *Pátio Digital* became SME’s Digital Transformation Strategy using the collaborative development methodologies tested in the project.

4.7. The emergence of network governance for smart solutions co-creation

Four sociotechnical interaction networks were identified that characterise the emerging governance mode in the *Pátio Digital* initiative. The “1. Open Governance Network” covers the period from 2013 to December 2016, involves the “1.1 Open Government” and “1.2 Data Subsidy” phases and deals with implementing an open, transparent and “1.3 Participative Governance” agenda in São Paulo City Hall led by a political group of centre-left elected in 2012. The second is “2. Government Network” between December 2016 and July 2017, which presents the “2.1 SME Re-design” and the “2.2 Partnerships” phases that took place. The “3. *Pátio Digital* Network” emerged between July 2017 and October 2018, describing the actions of “3.1 Network Governance for Smart Solutions Development”. Finally, “4. Digital Transformation Network” began in November 2018 when *Pátio Digital* evolved into “4.1 SME Digital Transformation Strategy” (see Fig. 2).

4.8. January 2013 – December 2016: open governance network

To understand *Pátio Digital*’s emerging governance mode, it is essential to look at the events that began in 2013 when the “1.1 Open Government” phase started. The government plan for 2014–17 was founded on the principles of participation and transparency. In 2013, the municipality of São Paulo established *São Paulo Aberta*, an initiative

to coordinate and promote open government actions managed by the Open Government Inter Secretarial Committee consisting of thirteen municipal secretariats and a municipal technology company. Several open government actions were consolidated by the *São Paulo Aberta* initiative, including the creation of a technological tool for dialogue between society and the city hall, the establishment of the Municipal Technological Innovation Laboratory (LabProdam), the Open Government Agents Programme, the creation of the Mobility Innovation Laboratory (MobLab), and the promotion of events such as the hackathon on mobility and *Café Hacker*. Additionally, the Comptroller General of the Municipality (CGM) was established in 2014 to focus on actions aimed at combating corruption, promoting integrity in administration, e-transparency, and open data, framing the “1.2 Data Subsidy” phase.

Between 2013 and 2014, a participative environment was established within the Municipality that involved external actors and public administration and the use of open datasets, with events like hackathons and *Café Hacker* becoming platforms for discussion and community engagement. *São Paulo Aberta*’s actions and programmes exemplify the “1. Open Governance Network” implementation aimed at strengthening citizen participation, social control, transparency, integrity, and technological innovation. The availability of open data sustaining the creation of innovation laboratories like LabProdam, MobLab, and *Café Hacker* exemplifies the formation of a sociotechnical interaction network operating under a participatory governance paradigm. By the end of 2016, city hall developed a Pilot Plan of five Open Government commitments for 2017 and the SME began adopting open government principles to collaborate with society to address educational dilemmas. The SME underwent an internal re-design to adapt to these principles before creating *Pátio Digital*.

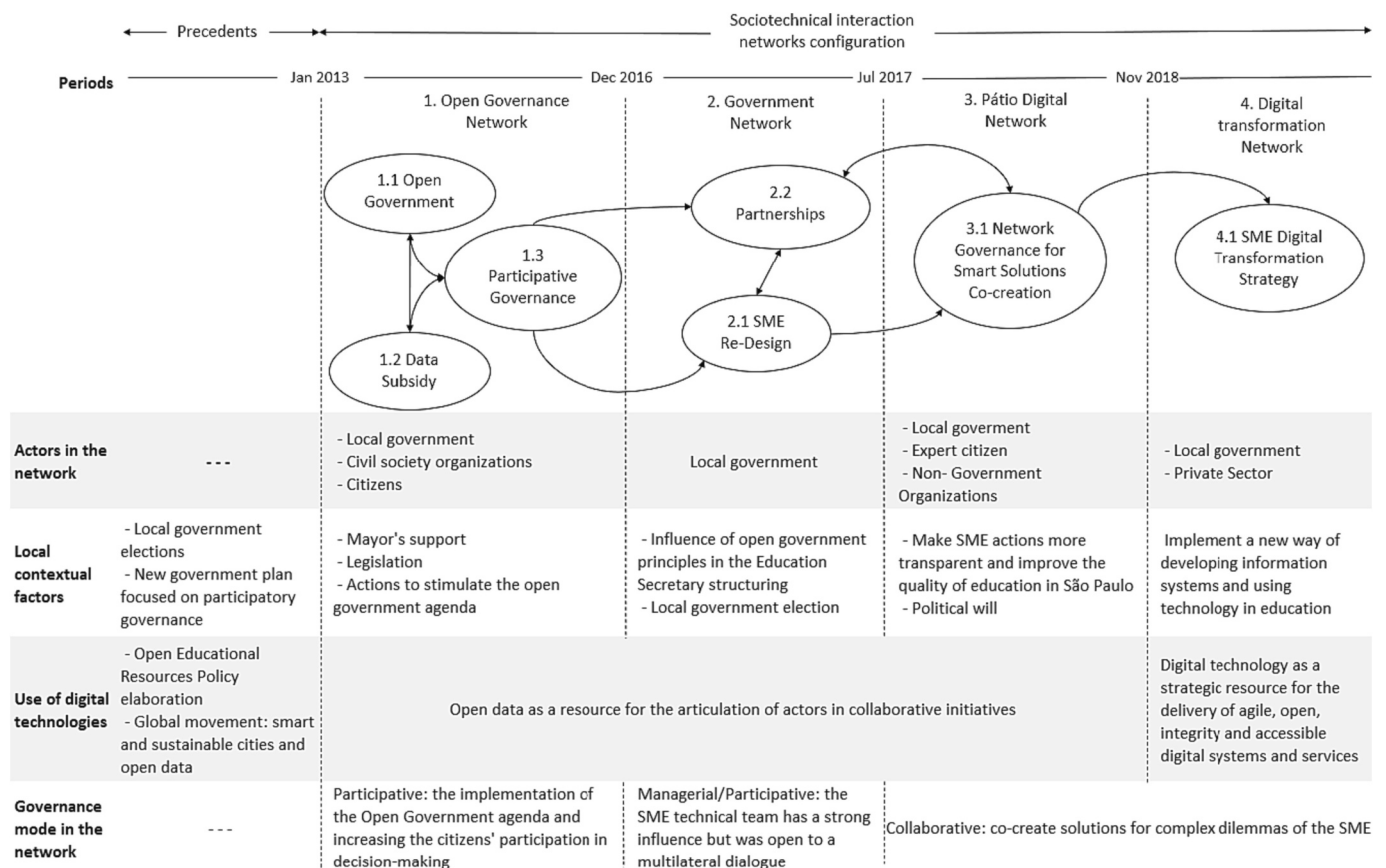


Fig. 2. Sociotechnical interaction networks *Pátio Digital*.

4.9. December 2016 – July 2017: government network

The “2. Government Network” started with the “2.1 SME Re-Design” phase in 2016, reorganising the attributions and functioning of the Secretariat, establishing several new departments focused on transparency, open data, and collaboration and inviting experienced public employees to manage these new areas, “So, it was already in the secretariat's plans to set up internal control coordination and work with transparency. When I arrived and brought my previous experience, finally, I designed a work plan that proposed an active transparency policy, among other things” (Pátio Digital Manager - SP5). Also, the open data and transparency policies and their action plans within the scope of the SME were instituted at the end of 2016. A new Committee for Transparency and Open Data was created, comprising the Internal Control Coordination, the Technology Coordination and the Center for Educational Information. However, during the “2.1 SME Re-Design” phase, the initial internal discussions were characterised by the lack of dialogue with actors outside the government, indicating the overlap between the managerial governance, with a strong influence of SME technical team and participative governance, partially involving citizens. One of the first actions with the interaction of external actors was organising a *Café Hacker* event promoted by SME in collaboration with the CGM. The event held in December 2016 discussed data usage, “At *Café Hacker*, people can participate in the process of opening data. And then, in the case of education, there were almost 100 people and, organisations, researchers. People came to give their opinion on the design of this transparency policy. Including which data to open” (Pátio Digital Manager - SP5).

After the new government's election in 2016, the city maintained its commitments to the Open Government Partnership (OGP) and initiated the “2.2 Partnerships” phase, leading to the creation of Pátio Digital. This initiative aimed to improve and enhance the performance of cities' innovation laboratories, making them more accessible to social participation, innovation, and open data usage as outlined in the OGP Action Plan São Paulo City in 2017. The Secretary of Education's political support was essential to put Pátio Digital's actions into practice, “Many things had already been rehearsed, thought out, but not yet implemented. And then, when the secretary became aware of this, it was very much in line with this line that he has already been adopting [...] let's put this at the forefront [...] And then, in fact, he turned this into one of the management priorities. (SME Manager - SP6).

4.10. July 2017 – November 2018: Pátio Digital network

In July 2017, the SME officially launched “Pátio Digital”, starting a new network in which the government proactively encouraged citizens to participate in discussions and present ideas, co-create solutions in hackathons and open meetings, known as “3.1 Network Governance for Smart Solutions Co-creation”. The events occurred at *Casa do Pátio Digital*, an exclusive space for the project and addressed various topics, such as exploring the bases of education, blockchain, tutorials for using the datasets, and students' transportation and meals, “The idea of the open meeting is for us to present some efforts that are being made within the management in this line of open government and that sometimes are not visible, so it is really open to dialogue. The interaction between public employees and citizens does not exist in everyday life” (Pátio Digital Manager - SP5). Based on the internal discussion and with the community, it was decided that “the first cycle of open innovation was for the development of a technology solution focused on the transparency of school meals” (Pátio Digital Manager - SP5).

SME offers 2.2 million meals daily in 3.2 thousand schools for around 995 thousand students. However, these data were not open, so parents and students could not consult the daily meal menu, nor was it possible to monitor whether private suppliers delivered the meal in accordance with the contract with the SME. In partnership with Unesco, the software development community was called to propose applications, resulting in the development of the “Edu” chatbot to inform parents and

students of the daily menu in public schools. Other cycles focused on students' transportation and an online waiting list for daycare vacancies. The Pátio Digital team also took on the challenge of building a digital platform for the São Paulo city curriculum developed collaboratively with the school community and citizens, “I saw that they wanted the experience we had in education and to know how important it would be [...]. So that was my first big passion, and I wanted to keep working on that.” (School Teacher - SP2). The emergence of the Pátio Digital project and the adoption of open government principles by the SME in São Paulo led to the creation of a collaborative governance mode that involved social actors in developing solutions for education policies. Data availability and digital technology solutions played a crucial role in creating a sociotechnical interaction network that brought together citizens, academia, startups, and other stakeholders to work together towards a common goal. Although the Pátio Digital Network also benefits the participation of expert citizens with ICT skills who are well-educated and indirectly excludes the citizens without this background.

4.11. November 2018 - afterwards: digital transformation network

In November 2018, the SME decided to institutionalise Pátio Digital as the “4.1 Digital Transformation Strategy”, starting a new phase and network. This ensured that the Pátio Digital principles were incorporated into the overall SME strategy of promoting the delivery of agile, open, complete and accessible digital systems and services, strengthening transparency and developing collaborative processes with society. The media highlighted the “most ambitious and pioneering model ever made by a Brazilian government to work with agile and collaborative methods” (InforChanel, 2019). To achieve the status of Digital Transformation Strategy, some key points are listed, such as starting with small projects and short-term deliveries and following incrementally and evolutionarily, “We managed to make deliverables feasible, and that worked with the methodology that we proposed, and that has a very positive visibility, and that opens the door for us to expand” (SME Manager - SP3). This strategy brings all the collaborative construction features of Pátio Digital but with a greater scope: the development of all new SME information systems must follow the methodology of Pátio Digital, characterised as a governance mode for the collaborative development of technology solutions. The evolution of Pátio Digital illustrates how smart city initiatives that involve collaboration and the use of ICTs in an innovative way can be dynamic processes, “I think it's kind of dynamic, I think it changes” (SME Manager - SP4). The innovative character of Pátio Digital involves the development of technology solutions and the collaborative and agile process, simultaneously breaking with the established institutional culture and traditional software development methods.

5. Discussion: the dynamics of emerging smart urban governance modes

This longitudinal study was designed to produce an in-depth understanding of the dynamics of emerging governance modes in smart city initiatives (Meijer & Bolívar, 2016; Ruhlandt, 2018). From the perspective of governance paradigms (Villeneuve, 2016) and the modes (DiGaetano & Strom, 2003; Pierre, 2011), different governance modes result from diverse dilemmas and political contexts, with formal and informal political relationships between government and citizens determining how cities are governed (Pierre, 2011). Platform governance brings a new understanding as a sociotechnical system (Janowski et al., 2018) and smart urban governance is one of these transformative modes (Meijer & Bolívar, 2016).

Based on these concepts, urban governance modes can help explain how smart city initiatives are governed. Analysing the cases, it was possible to identify two emerging modes of governance of smart city initiatives: Smart Governance for Data-Based Innovation and Network Governance for Smart Solutions Co-creation, which are characterised in terms of objectives, government and citizens' roles, nature of

interactions between citizen-government (Bryson et al., 2014; DiGaetano & Strom, 2003; Pierre, 2011) and the role of technology, thus adding the perspective of the governance platform paradigm (Janowski et al., 2018) and sociotechnical networks (Kling et al., 2003) (Table 3).

The Curitiba administration was marked by a managerial mode of governance (Irazábal, 2017) under a consumerist paradigm (Villeneuve, 2016), where the local government acts as a centralising actor or leading organisation and manages the city direction (Bryson et al., 2014; Pierre, 2011) for over three decades. In the 2012 elections, the political group that ascended to the government directed public administration towards the inclusion of citizens in city management (Follador et al., 2018; Przebilowicz et al., 2022), indicating a move to participative governance. Curitiba Collaborates is one of SIT's actions where a governance mode emerges and illustrates a way of governing smart city initiatives that brings multiple stakeholders together in common forums with public agencies (Ansell & Gash, 2008) to engage in data-based innovation under a participatory governance paradigm (Villeneuve, 2016).

The *objective* identified in this mode of governance is *fostering a collaborative environment to promote innovation and explore smart solutions based on open data*. The public administration's vision is to incentivise social actors to appropriate open data, identify the city's problems and find innovative solutions. In this sense, the *role of the government* is to *induce* the sociotechnical network and *facilitate openness*. Engagement and articulation between the social actors ultimately result in the innovation ecosystem from an *active and shared responsibility role in the network*. The innovation ecosystem plays a leading role in the sociotechnical network and extrapolates from the initiative to the city level. Both the government and citizen roles have some similarities with the collaborative governance mode (Ansell & Gash, 2008) but are different from managerial (Pierre, 2011) and participative modes (Fischer, 2012).

The type of *citizen-government relationship* is *collaborative in complex and dynamic cooperation emerging from sociotechnical interactions over time*. There is evidence of a process in which the government initiated the steps towards internal strengthening, data openness, establishing closer ties with external stakeholders, and engaging actively, culminating in a new relationship characterised by mutual benefits and positive outcomes for all actors involved. These characteristics go beyond the managerial, participative and collaborative modes of governance (Bryson et al., 2014; DiGaetano & Strom, 2003; Fischer, 2012; Osborne, 2006; Pierre, 2011; Villeneuve, 2016), usually defined as top-down, multilateral and partnership, respectively, and do not mention the

dynamism. In smart urban governance, the relations are dynamic, bringing social actors to the centre of the discussions and promoting empowerment, involving them in the planning and execution of tasks and sharing responsibility, as happened with the involvement of Code for Curitiba in the organisation and realisation of the hackathons. *ICT plays a prominent role* in the emerging governance mode. In the Curitiba Collaborates case, the open datasets are strategic assets with a preponderant influence in the configuration of sociotechnical networks (Kling et al., 2003), catalysing the social actors in the governance of smart cities.

São Paulo was governed by a hegemonic political group for over two decades (Empinotti et al., 2019) under a managerial governance mode (Marques, 2013). In 2013, a political group oriented to participative governance assumed the city government and started the implementation of the open government agenda. Many initiatives were implemented to strengthen participation, transparency and innovation in the city administration, resulting in *Pátio Digital* implementation at the SME.

Pátio Digital's emerging governance mode, the network for smart solutions development, aims to *co-create solutions to address educational policy-domain dilemmas*. The government assumed a *proactive role in promoting communication and interaction*. In this emerging mode of governance, the *citizen's role* is to *collaborate and co-create*, social actors are involved from the ground up, and in some cases, they are responsible for developing the tools, such as the chatbot 'Edu'. The *citizen-government relationship* is also *collaborative and dynamic, emerging from sociotechnical interactions over time*. The characteristics of this emerging governance mode are closely related to collaborative governance (Ansell & Gash, 2008; Sørensen & Torfing, 2009). The novelty is related to breaking the usual paradigm of developing technology solutions in the sphere of government, usually with long cycles, deliveries at the end of the cycle and without the participation of citizens in the design of technological solutions and systems, and the sociotechnical interaction enabled by ICTs usage. *ICT plays an inductive role in the network*, as the network would not have been set up without open data. ICT-based solutions are also output from co-creation. Furthermore, other technical elements, such as the innovation methodology, also influenced the formation of the governance mode. Both cases illustrate the possibility of ICTs to *configure new paradigms* and incite a successor of the bureaucratic, consumerist and participatory governance highlighted by Janowski et al. (2018) in urban governance (DiGaetano & Strom, 2003; Pierre, 2011), particularly in smart city initiatives. It also illustrates the importance of data in smart city initiatives, as pointed out by authors such as Meijer (2017) and Ruhlandt (2018). This demonstrates that digital technologies are challenging the existing governance modes to become more transformative in city management (Meijer & Bolívar, 2016; Pereira et al., 2018).

In both cases, there is an adverse outcome, the exclusion of ordinary citizens. Some of the participation mechanisms used by the Curitiba Collaborates and *Pátio Digital*, like hackathons, open meetings and *Café Hacker* events, involve mostly expert citizens, highly skilled ICT people, undergraduate students, and professors. The sociotechnical network is unbalanced and benefits this citizen group, a consequence that has already been addressed in studies of sociotechnical systems (Sawyer & Jarrahi, 2014) and that continues to emerge in smart city initiatives even when they propose to be open to participation. The exclusion can result in citizen discontent with smart cities (van Twist, Ruijter, & Meijer, 2023) and compromise the sustainability of co-creation outcomes over time (Tomor et al., 2019), exemplifying that even though smart urban governance has been desirable (Meijer & Bolívar, 2016), unintended consequences can compromise its benefits, or create new patterns of citizen participation, like contestation (Przebilowicz et al., 2022).

Our first theoretical contribution is to the urban governance field, identifying two governance modes characterised in terms of objectives, the roles assigned to government and citizens, and the type of citizen-government relationship (DiGaetano & Strom, 2003; Pierre, 2011). The second theoretical contribution is the evidence that the

Table 3
Characteristics of the emergent modes of governance in smart cities initiatives.

	Curitiba Collaborates	<i>Pátio Digital</i>
Governance mode	Smart Governance for Data-Based Innovation	Network for Smart Solutions Development
Objective	Fostering a collaborative environment to promote innovation and explore smart solutions based on open data	Co-creating smart solutions through collaboration to address specific dilemmas
Government role	Inducer of the formation of the collaboration network and facilitating data openness	Proactive in forming the collaborative development network promoting communication and interaction
Citizen role	Active in the collaboration network sharing responsibilities in governance for the continuity of smart city initiatives	Collaborate and co-create in the network responsible for developing smart solutions
Citizen-government relationships	Collaborative in complex and dynamic cooperation emerging from sociotechnical interactions over time	
ICT role	A strategic asset that modifies the sociotechnical network catalysing the social actors in the governance of smart cities	An output of collaboration and an inductor of co-creation in the sociotechnical network

predominant modes of urban governance in the city help to explain interactions in smart urban governance, as identified by Nesti (2020) and Przebilowicz et al. (2018, 2022). There is empirical evidence in the two case studies that adopting more participative (Fischer, 2012) and collaborative governance (Ansell & Gash, 2008; Sørensen & Torfing, 2009) anchored in a participatory governance paradigm (Villeneuve, 2016) encouraged both cities to develop smart city projects with society. We reinforce the argument that understanding how the smart city initiative is governed is necessary to understand the rules that guide the actors' behaviour and how the nature of the relationship between government and external actors (Meijer & Bolívar, 2016; Nesti, 2020; Ruhlandt, 2018). Finally, the main theoretical contribution of this work is to the field of smart urban governance studies (Meijer & Bolívar, 2016; Nesti, 2020; Pereira et al., 2018; Ruhlandt, 2018; Tomor et al., 2019; Tomor et al., 2021). Our results identify that new modes of governance are configured in smart city initiatives dynamically, which change over time and from one initiative to another. The characteristics of two emerging modes of governance identified in the case studies related to smart urban governance, alongside the urban managerial, participative, and collaborative governance modes, are summarised in Table 4 to highlight the differences and dynamism.

We added a description of the role of ICT in helping to configure new governance modes. ICT induces co-creation and catalyses social actors in smart urban governance, eventually challenging existing governance modes. The findings present empirical evidence that the platform governance paradigm empowers citizens and other non-state actors to contribute directly to sustainable development (Janowski et al., 2018), contributing to the continuity of smart city initiatives.

Based on these findings, we propose an approach to analyse and understand smart urban governance in different contexts (Fig. 3). Generally, smart city initiatives are introduced to address complex city challenges and policy-domain dilemmas. The configuration of urban governance modes, ICT and local context factors will result in types of citizen-government interaction that can vary from one initiative to another, emerging in multiple sociotechnical governance modes and resulting in specific outcomes. This process should be analysed over time to identify the changes and their configuration.

6. Conclusions

This work sought to contribute to the smart urban governance literature by understanding the configuration of governance modes in smart city initiatives adopting a theoretical approach based on urban governance modes and sociotechnical interaction networks. Two governance modes were identified, illustrating the configuration of new governance modes as a dynamic process that emerges from socio-technical interactions over time. Smart urban governance involves dynamics of change in complex sociotechnical systems (Meijer & Bolívar,

2016; Pereira et al., 2018; Ruhlandt, 2018) but few studies have investigated empirically (Meijer & Thaens, 2018), with little attention paid to urban governance modes to understand when governance became 'smart' (Nesti, 2020) from the addition of ICT (Janowski et al., 2018). This research bridges those gaps by offering an in-depth study of two cases that connect governance modes and sociotechnical interaction networks through an inductive-deductive process-based theorisation, enriching the explanations (Langley, 1999). In conclusion, governance in the digital era, or under the platform governance paradigm (Janowski et al., 2018), means dealing with new governance modes that emerge in different network configurations over time and in each new smart city initiative. Based on the characteristics of smart urban governance, a dynamic approach was proposed that considers the urban governance mode, the role of ICTs, and local contextual factors to understand the collaboration between citizens and the government mediated by the use of ICTs. Moreover, a methodological approach was applied to capture this complex dynamic, combining sociotechnical interaction networks and modes of urban governance as a conceptual approach to guide the research. Observing citizen-government interactions from the perspective of governance and the role of technology in sociotechnical interaction networks over time allowed us to capture the evolution of these interactions, bracketing in successive periods to shed light on the emergence of new interaction patterns, culminating in new governance modes. This methodological approach also allowed us to show that smart urban governance is dynamic and configured from the interplay between technological artefacts and individuals, government entities and citizens, and it changes over time.

This research also illustrated that traditional modes of urban governance predominant in the cities help understand citizen-government interactions, contributing to the smart city literature, expanding the discussion about the concept and presenting it as a sociotechnical system. In this regard, new governance modes are anchored on relationships enabled by technological artefacts, with the interaction between government and citizens based on cooperation to produce outputs and outcomes promoting city innovation. These results were limited to explaining the interactions based on the modes of governance, so other contextual factors may also have an influence. This study focused on understanding smart city initiatives in which there is an interaction between social actors, government, technology and collaboration but the dynamics of interactions may differ in smart city projects that do not have this collaborative focus and do not involve the participation of multiple actors.

Despite anchoring our research in the qualitative tradition that seeks to generate explanations and not generalisations, a more significant number of empirical cases could have expanded our findings. Future research should explore other cities in different localities with different urban governance modes to understand how they reflect on the governance modes of smart city initiatives using our proposed dynamics of

Table 4
Characteristics of smart urban governance.

Governance mode	Managerial	Participative	Collaborative	Smart Urban Governance
Objectives	Delivering services using managerial techniques	Making the relationships inclusive and participative	Creating a collaborative environment	Managing the dynamism of complex cooperation processes, dealing with various stakeholders, establishing new relationships, and implementing novel processes
Government role	Service provider	Involving citizens in decision-making	Facilitator of collaborative processes	Proactive inducer of the network between various stakeholders, including new relationships, fostering communication, interaction, collaboration and facilitating openness
Citizen role	Client or consumer of public services	Participant in the decision-making	Collaborator to co-create solutions	Engaged in the collaboration network, actively sharing responsibilities in governance and collaborating to the continuity of smart city initiatives while also co-creating and contributing to the development of smart solutions within the network
Citizen-government relationships	Top-down approach	Multilateral dialogue	Partnership and co-creation	Dynamic collaboration that changes over time emerging from complex sociotechnical interactions mediated by digital technologies
ICT role	–	–	–	A strategic asset that modifies the sociotechnical network induces co-creation and catalyses social actors in smart urban governance, eventually challenging existing governance modes

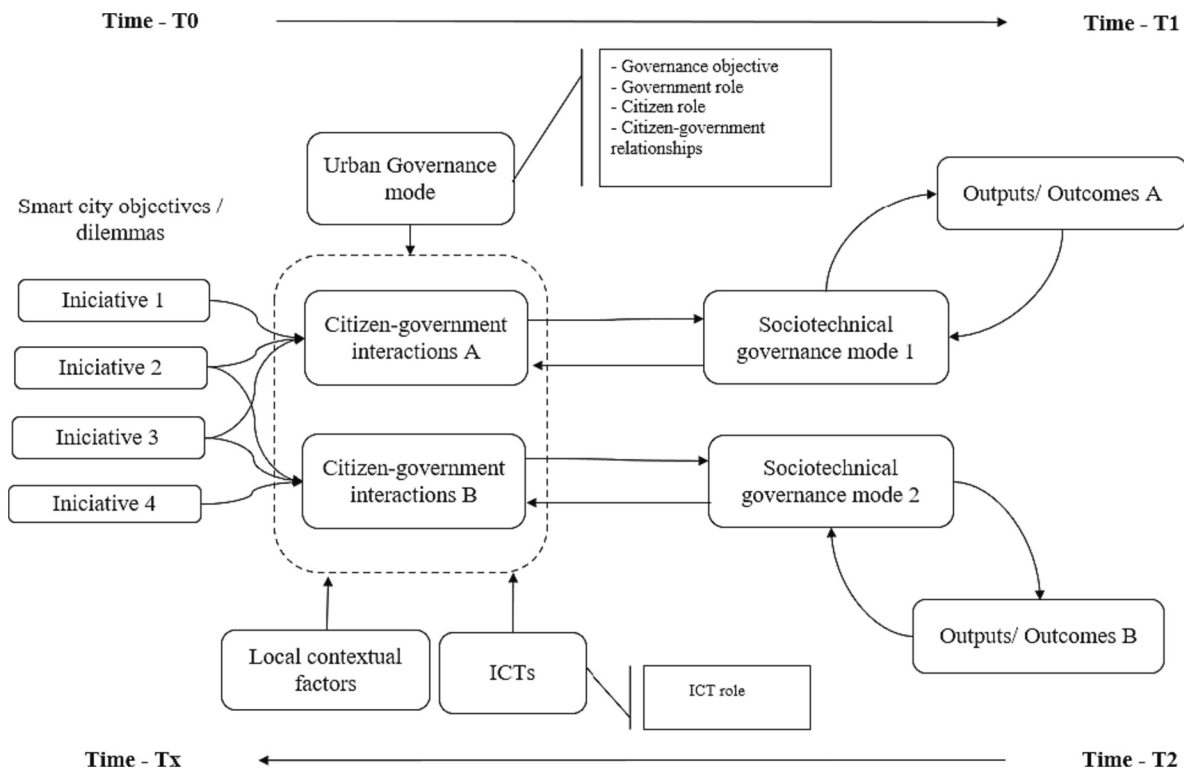


Fig. 3. Dynamics of smart urban governance approach.

smart urban governance approach to expand the explanations and build comparisons. Also, comparative case studies would add the dimension of government structure and institutional framing to enrich case analysis of cities across different countries with different institutional structures and contexts (see Tomor et al., 2021). A mixed-methods strategy could also be applied combining qualitative and quantitative data to generate explanations and statistical generalisations.

Smart city initiatives need time to promote changes and for academic discussion to take place, therefore, we conducted a longitudinal and temporal bracketing analysis. However, our temporal dimension was restricted to a methodological category, with time used as a methodological dimension to analyse the configuration of the governance network. Therefore, we recommend that future longitudinal studies on governance in smart cities add the dimension of time as a theoretical dimension.

Author statement

We certify that all authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Grammarly in order to correct grammar, punctuation and spelling. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

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