

# Critical junctures and events in the trajectory of information modeling in Curitiba

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Although it is a promising theory for understanding complex ongoing political processes, historical institutionalism has rarely been used to address urban management and urban planning issues. We aim to (re)construct the trajectory of management and dissemination of communication and information technologies (ICTs) in Curitiba to identify critical junctures and events. Methodologically, it is a case study based on documents and discourse analysis. The results show that Curitiba used to be avant-garde in technological diffusion but today it develops more responsive than anticipatory actions; over time, the role of technology diffusion and management shifted from the urban management and planning structure to the direct municipal administration structure; technological initiatives have always taken place and are taking place sharply and decentrally for the consolidation of an ecosystem; the ideals of forming a digital or a smart city were motivators of Curitiba's current situation. The ideology underlying the game of politicians and party affiliations has been put aside in alignments of local groups to carry out technological adjustments; and that the management and diffusion of ICTs remain controversial in political disputes. The conclusion is that the political-technology dyad has absorbed the impacts of critical events, resulting in the remodeling of municipal institutions and organizations linked to the management and diffusion of ICTs that also need to deal with the game of interests and external pressures.


**Keywords:** ICTs; historical institutionalism; urban planning; urban management.

## Conjunturas e eventos críticos na trajetória da modelagem da informação em Curitiba

Embora seja uma teoria promissora para compreender complexos processos políticos continuados, o institucionalismo histórico tem sido pouco utilizado em questões de gestão e planejamento urbano. Assim, o objetivo deste estudo é (re)construir a trajetória de gestão e difusão de tecnologias de comunicação e informação do município de Curitiba para identificar conjunturas e eventos críticos. Metodologicamente, utilizam-se os procedimentos de levantamento documental e análise de discurso. Os resultados mostram que Curitiba foi vanguardista na difusão tecnológica, mas hoje desenvolve ações mais responsivas do que antecipativas; com o passar do tempo o protagonismo da difusão e gestão tecnológica se deslocou da estrutura de gestão e planejamento urbano para a estrutura da administração municipal direta; as iniciativas tecnológicas sempre ocorreram e vêm ocorrendo acentuada e descentralizadamente para a consolidação de um ecossistema; os ideais de formação de uma cidade digital ou uma cidade inteligente foram motivadores da conjuntura mais recente; a ideologia subjacente ao jogo dos políticos e das filiações partidárias parece ter sido posta de lado em alinhamentos dos grupos locais para realizar ajustes tecnológicos; e que a gestão e a difusão de TIC's se mantém controversa nas disputas políticas. A conclusão é que a díade política-tecnologia tem absorvido os impactos dos eventos críticos, o que acaba por resultar na remodelagem das instituições e organizações municipais ligadas à gestão e à difusão das TIC's que também precisam lidar com o jogo de interesses e as pressões externas.

**Palavras-chave:** TIC's; institucionalismo histórico; planejamento urbano; gestão urbana.


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## Coyuntura y eventos críticos en la trayectoria del modelado de información en Curitiba

Aunque sea una teoría prometedora para comprender procesos políticos complejos en curso, el institucionalismo histórico ha sido poco utilizado en temas de planificación y gestión urbana. Así, el objetivo de este estudio es (re)construir la trayectoria de gestión y difusión de las tecnologías de la información y la comunicación en el municipio de Curitiba para identificar coyunturas y eventos críticos. Metodológicamente, se utilizan los procedimientos de levantamiento documental y análisis del discurso. Los resultados muestran que Curitiba fue vanguardista en difusión tecnológica, pero hoy desarrolla acciones más responsivas que anticipatorias; con el tiempo, el papel de la difusión y gestión de la tecnología pasó de la estructura de gestión y planificación urbana a la estructura de administración municipal directa; las iniciativas tecnológicas siempre se han dado y se están dando de manera acentuada y descentralizada para la consolidación de un ecosistema; los ideales de formar una ciudad digital o una ciudad inteligente fueron motivadores de la coyuntura más reciente; la ideología que subyace al juego de los políticos y las afiliaciones partidarias parece haber sido dejada de lado en alineamientos de grupos locales para realizar ajustes tecnológicos; y que la gestión y difusión de las TIC sigue siendo controvertida en las disputas políticas. La conclusión es que la diada política-tecnología ha absorbido los impactos de los eventos críticos, lo que termina redundando en la remodelación de las instituciones y organismos municipales vinculados a la gestión y difusión de las TIC que también necesitan lidiar con el juego de intereses y las presiones externas.

**Palabras clave:** TIC; institucionalismo histórico; planificación urbana; gestión urbana.

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## 1. INTRODUCTION

Historical institutionalism is deeply established in political science (Thelen & Conran, 2016; Thelen & Steinmo, 1992) and therefore tends to have a central focus on political issues (Taylor, 2013). Generally, it tends to associate institutions with organizations and rules or conventions edited by formal organizations (Hall & Taylor, 2003). This approach has its centrality in explaining the actions and laws involved in political dynamics and in the understanding that a rule persists if there are no forces that induce change (Peters, Pierre, & King, 2005). Its central premise is particularly suited to studying political interactions in legal structures whose creation is essentially human and observing the sequentiality of life rather than sticking to an isolated time frame. This perspective fits well for studies that consider the incremental development of institutions in an original way rather than being subject to sudden or drastic changes (Sanders, 2006). Despite this, there are few investigations from this perspective to understand urban planning (Sorensen, 2017), mainly when it is associated with communication and information technologies applied instrumentally to solve cities' infrastructural problems (Pereira & Procopiuck, 2022).

The sequence of events creates a juncture, which determines institutions' establishment, maintenance, or modification. These events, in turn, are inserted into a social field that comprises several agents, creating an environment conducive to its development. The shaping of the trajectory

of a technological institution tends to occur through the diversity of visions that build it socially over time (Bijker, 2015), as a social process grounded in a dynamic of “increasing returns” is called path dependence (Pierson, 2000). Under this construction, the association of technological trajectories and public policies finds in historical institutionalism a robust basis for understanding the development of policies as a discontinuous process (Peters et al., 2005). Thus, in the context of an innovation ecosystem, the success of its continuity lies in creating a virtuous network of relationships that reward each other (Kon, 2016) and resist the oscillations of political visions of the decision-makers. For information modeling (IM), whether of buildings (BIM) or the city (CIM), it is no different.

IM can be considered an offshoot of applying information technologies (IT) and communication and information technologies (ICT) for computer simulations of the physical and the built environment. Both technologies can influence urban socioeconomic dynamics (Rezende & Procopiuck, 2018) and their planning and management. This (not so) new reality imposes new challenges on urban managers, especially the old paradigms of the human relationship with space-time (Firmino, 2007). BIM and CIM are two examples of tools that can bring contributions in this regard, the first at the micro and the second at the meso urban scale. The geographic information system (GIS) complements these technologies’ framework, considering the macro scale. BIM is, by broad definition, the process of modeling building information and its resulting virtual model, making it possible to manage its life cycle (Hamil, 2021) through links of this model with databases and data repositories (Gu & London, 2010). CIM, in turn, can be understood as an analogy to BIM on the urban scale (Gil, Almeida, & J. P. Duarte, 2011; Stojanovski, 2013, 2018). Both technologies allow the three-dimensional virtual simulation of their focus objects and let their agents perform simulations and obtain information to support decision-making. These two technologies act in support of urban and territorial policies.

It is also necessary to consider that the laws’ systems tend to be conservative and find ways to defend existing policy standards, as do the organizations that make and deliver them. Thus, establishing a standard makes it difficult to change an institutional design (Peters et al., 2005). Therefore, the challenge is understanding how stabilization processes of political conditions can represent a support base for the maturation of technologies or as a restriction for innovation.

In this article, we aim to (re)construct the trajectory of management and dissemination of communication and information technologies in Curitiba and its critical junctures and events. With this, we intend to place IM technologies in the historical trajectory of technological diffusion in the city and show how these technologies emerge from such a complex context. In theoretical terms, the study is justified because historical institutionalism offers a promising latent to analyze relationships between agents and structures and objects and concepts institutionalized in a given institutional environment (Hay & Wincott, 1998), with ideas assuming a central role even though they are distinct from preferences or conscious individual actions as they incorporate a priori normative issues (Sanders, 2006). Furthermore, implementing IM technologies causes organizational and institutional changes (Davies & Harty, 2013; Saka & Chan, 2020). Therefore, understanding the trajectory of institutions and organizations related to ICT and IT in Curitiba

can provide insights into the emergence of projects and initiatives that led to the implementation IM technologies in the city.

## 2. HISTORICAL INSTITUTIONALISM AND TECHNOLOGICAL TRAJECTORIES

The institutional analysis allows for reading institutionalized relationships between political actors as objects and agents of history. According to historical institutionalism, these institutions can shape and direct political strategies but also result from deliberate conflictive political systems or political choices (Thelen & Steinmo, 1992). Actors are, therefore, strategic when they seek to fulfill complex, uncertain, and constantly changing goals in the long trajectories of organization and survival. As changes and adjustments occur silently over long periods, it is natural that incomplete perceptions and readings arise. Therefore, these insights may be hidden or inaccurate immediately after each event (Hay & Wincott, 1998). An example of this phenomenon is the role of the BIM manager, which appears in the context of the methodology's expansion to guarantee its implementation success (Rahman, Alsafouri, Tang, & Ayer, 2016). However, recent studies are questioning the long-term durability of this position, understanding that a project manager can replace it by incorporating BIM capabilities (Hosseini et al., 2018).

Strategies induced by a given institutional context can become fossilized and, over time, become worldviews propagated by official organizations and shape their image to the preferences of their stakeholders (Tolbert & Zucker, 1996). Historical institutionalism offers a solid basis for explaining institutions' formation, evolution, and transformation (Hay & Wincott, 1998), or its construction, maintenance, and adaptation (Sanders, 2006).

Thus, institutions are constraints humans design to shape their relationships, evolving and bridging the gap between past, present, and future (North, 1991). Path dependence marks the development of institutions over time, where a confluence of events or social pressures produces new ways of doing things (Sanders, 2006). Some theorists point out that a barrier that the historicist approach presents is that of masking political changes, therefore, being ineffective in explaining these changes without the aid of complementary structures or tools (Peters et al., 2005). Nonetheless, historical institutionalism has devoted special methodological attention to systematically understanding processes of institutional change and how these changes can occur. Thelen (2003) suggests two different approaches to institutional change: constant cause, which considers the same factors for the creation and modifications of an institution over time; and path dependence, which considers that the factors responsible for the design of an institution may be different from those responsible for its reproduction.

Path dependence is central to historical institutionalism because it considers the pressures and motivations that led to institutional changes over time (Sanders, 2006). These pressures motivate events that can form a critical juncture favorable to the occurrence of changes. The definition of a critical juncture occurs in a period of significant changes, which generally occur in different ways depending on the context, leaving very particular legacies (Thelen & Conran, 2016). Therefore, in the institutionalist approach, there should be no dissociation between the analyzed issues and their

context (Hay & Wincott, 1998). Critical junctures can also establish the starting point for processes dependent on their trajectory (Thelen & Conran, 2016).

The survival of institutions is strongly related to institutional transformations that make them capable of adapting to constantly changing social, political, and economic contexts (Thelen, 2003). Therefore, equal forces active in different realities tend to produce different results because they change under the influence of properties inherited from each local context (Tolbert & Zucker, 1996). The implementation of this trajectory of maintenance of institutions can occur due to conditions that allow institutional stability punctuated by exogenous changes (Thelen & Conran, 2016). Therefore, this historical approach to institutionalism enables us to understand how institutions stabilize over time and how the construction of this trajectory occurs through a balance resulting from their ability to adapt.

### 3. RESEARCH METHODS

The research bases are in analytical categories of historical institutionalism: the trajectory of dependence, critical junctures, and critical events. Empirically, the focus is on establishing, maintaining, and disseminating institutions related to ICTs in Curitiba. The techniques used for data collection were documental and bibliographic analysis, which formed the corpus of the analysis presented in Appendix. The analytical support is in discourse analysis techniques to build an explanatory narrative about the trajectory and critical events.

Box 1 shows the investigation's interpretive structures and ontological and epistemological bases. This box also shows the research strategy based on multi-methods, the observation units, the observational delimitation, the criteria for collecting data and information, and the analytical tools used.

**BOX 1** SUMMARY OF THE RESEARCH STRATEGY

		THEORETICAL JUSTIFICATION					
Theoretical	Assumptions	Ontological (“What exists to be known?”); An institutionalized trajectory of management and dissemination of ITs and ICTs in the city of Curitiba.					
	Knowledge apprehension	Epistemological (“How to know what exists?”); Systematic mapping of evidence of the institutionalization of a trajectory of critical events in the management and dissemination of ICTs.					
	Knowledge Nature	Phases/ Data collection base	Observational unit	Data collection criteria/ Application	Analytical categories and purposes	Analysis techniques and tools	Global empirical delimitation
		1 <sup>st</sup> Phase Chained selection of documents and empirical reports (Patton, 1990).	Trajectory of management and dissemination of ICTs in the city of Curitiba.	Intentional collection of documents for narrative reconstruction about the origins of the institutionalized trajectory.	City: contextualization. ICTs’ trajectory: organization models, technologies, urban management and planning functions, ecosystem specialization, agents’ intentions, political change. <b>Organizational typology:</b> direct public administration, indirect public administration, private organizations.	Narrative construction through to confrontation of information and facts.	Ontological constitution and epistemological explanations of a trajectory in a research universe encompassing urban planning, urban management, and ICTs in a local urban development ecosystem.
Empirical	Factual and observational	Objective trend					
RESEARCH STRATEGY							

Continue

THEORETICAL JUSTIFICATION						
Theoretical Knowledge apprehension	Assumptions	Ontological (“What exists to be known?”); An institutionalized trajectory of management and dissemination of ITs and ICTs in the city of Curitiba.				
	Knowledge apprehension	Epistemological (“How to know what exists?”): Systematic mapping of evidence of the institutionalization of a trajectory of critical events in the management and dissemination of ICTs.				
	Knowledge Nature	Phases/ Data collection base	Observational unit	Data collection criteria/ Application	Analytical categories and purposes	Analysis techniques and tools
		2 <sup>nd</sup> Phase: Survey on the Google platform.	Critical events on technological institutes in the process of institutionalizing ICTs in urban management in Curitiba.	Exploratory thematic research to explicit critical events of ICTs in Curitiba.	<b>Instrumental typology:</b> urban plans, technological artifacts, work methods, and techniques. <b>Relational patterns:</b> nature of organizational relationships, technological instrumentalization, technology adoption and diffusion, creation of laws, and formal rules. <b>Material bases:</b> technological products, institutional change.	Interpretive analysis focused on the characterization of artifactual and procedural technologies.
		3 <sup>rd</sup> Phase: Lawsuits and transparency portals.	Fundamental attributes set arbitrarily for the formation and stabilization of critical events.	Evidentiation of the “hard core” of decisions relevant to critical events and the trajectory of ICTs in Curitiba.	<b>Judicial content:</b> arbitration of intentions, imposition of obligations, penalization of behavior.	Interpretive discourse analysis by descriptive exhaustion of the information based on each critical event.

THEORETICAL JUSTIFICATION							
Assumptions	Ontological (“What exists to be known?”): An institutionalized trajectory of management and dissemination of ITs and ICTs in the city of Curitiba.						
Knowledge apprehension	Epistemological (“How to know what exists?”): Systematic mapping of evidence of the institutionalization of a trajectory of critical events in the management and dissemination of ICTs.						
Theoretical	Knowledge Nature	Phases/ Data collection base	Observational unit	Data collection criteria/ Application	Analytical categories and purposes	Analysis techniques and tools	Global empirical delimitation
	Intersubjective and perceptive	4 <sup>th</sup> Phase: Experiences and previous knowledge of researchers.	Experience in the context of formation, experimentation, and transformation of ICTs and organizational arrangements in the studied ecosystem.	Consensus judgments among the authors based on training and practical work in the areas of urbanism, administration, and ICTs on the configuration and relevance of critical events empirically evidenced and with different patterns of force to form critical events and the trajectory.	Structuring the trajectory: logical chaining, internal consistency of the flow of critical events, and external influences on the investigated technological ecosystem.	Discursive and recursive constitution of symbolic meanings.	
	Subjective trend				Technological processes and artifacts: creation, application, obsolescence, and innovation.		

Source: Elaborated by the authors based on Procopiuck, Sampaio, Freder, Garcia, and Rosa (2022).



As shown in Box 1, the development of the investigation took place sequentially according to the following phases: (1<sup>st</sup>) chained selection of documents and empirical reports (Patton, 1990), (2<sup>nd</sup>) survey on the Google platform, (3<sup>rd</sup>) lawsuits and transparency portals, and (4<sup>th</sup>) experiences and previous knowledge of researchers. The objective was to obtain historical documents for fundamental interpretive bases in a spectrum between the understanding of objective and subjective nature but always empirically based on the trajectory of technology diffusion in Curitiba.

The development of Phase 1 took place with the formation of a corpus of analysis consisting of documents and empirical reports raised in consultations with institutional and formal media of the organizations analyzed to form the first traces from critical events and evidence of possible institutionalization of the trajectory. The process of constitution of the analysis corpus advanced in Phase 2 with the use of the Google platform to obtain greater documentary consistency and complementary gray literature. Finally, Phase 3 led to the identification of discussions on judicialization processes, judicial databases, and transparency portals of public administration entities. Box 2 below points out the central agencies and channels that were the source of data collection. The synthesis of temporal milestones materialized in a timeline produced with the online tool Lucidchart (Lucid, 2021).

## BOX 2 SOURCE CLASSIFICATION AND DATA TYPES OF THE SAMPLING

Source	Order	Organization Typology	Data Type
Curitiba City Hall (PMC)	Primary	Direct Public Administration	Official institutional communication, Laws, and Decrees
Institute of Research and Urban Planning of Curitiba (IPPUC)	Primary	Indirect Public Administration	Official institutional communication, Technical Reports, Laws, and Decrees
Curitiba Development Agency S.A.	Primary	Indirect Public Administration	Official institutional communication
Urbanism of Curitiba S.A. (URBS)	Primary	Indirect Public Administration	Official institutional communication
Pinhão Valley Project	Primary	Municipal Public Administration Project	Official institutional communication
Smart Cities Institute (ICI)	Primary	Municipal Social Organization	Official institutional communication
LaBIM/PMC and LaBIM/SEIL	Secondary	Organizational Arrangement	Official institutional communication, Technical Reports
iCities	Secondary	Private Company	Official institutional communication
Gazeta do Povo	Secondary	Communication Vehicle	News and journalistic articles
Brasil de Fato	Secondary	Communication Vehicle	News and journalistic articles
JusBrasil	Secondary	Communication Vehicle	Files of legal proceedings

**Source:** Elaborated by the authors.

The interpretative analyses of discourses followed the institutionalist epistemology, seeking to (re) construct the trajectory of technology diffusion in Curitiba. At the same time, these analyzes outlined macro-scale scenarios to identify and characterize each critical juncture with emergence and outcome in critical events. More specifically, the institutionalization processes approach served to identify innovations tending to trigger gradual and continuous changes in organizational structures, with absorption with greater or lesser reluctance by the agents that make up such structures (Tolbert & Zucker, 1996). This mapping was fundamental because it tended to produce technological institutes, which are materialize by laws, corporate standards, or social norms (Gerasymchuk & Averkyna, 2012; Pereira & Procopiuck, 2022b). These institutes, in turn, were relevant because they are components of the institutions' trajectories and their critical junctures, with roots in the collective construction of formal or informal interactions manifested by diffuse means (Menshikova & Pruel, 2019). Therefore, the conduction of the analyses occurred to identify evidence of the process of institutionalization of technologies in Curitiba's urban management and the possible existence of technological institutes, with information recorded on documental bases, the gray literature, and empirical reports.

The analyses, therefore, ended up materializing in two distinct approaches. The first was focused on the local context and on the internal dynamics of Curitiba's municipal management to expose political actions and movements of alternation of power on the trajectory of the diffusion of technologies in the city; and the second was more contextual to put local efforts in a global perspective, elucidating some notoriously striking moments for technological diffusion in Curitiba.

More specifically, the approach of institutionalization processes served to identify innovations tending to trigger gradual and continuous changes in organizational structures, whose absorption occurred with greater or lesser reluctance by the agents that make up such structures. Temporality is crucial for understanding when events or critical junctures happen and their order and sequence.

## 4. RESULTS

The analysis is based on the trajectory of technology diffusion in Curitiba, highlighting three critical moments. Discussions about conjunctures are locally, nationally, and globally contextualized. The following sections present and discuss these results.

### 4.1 General context of the investigation

The place of application of the research, the city of Curitiba, has a recognized trajectory in the diffusion and application of technologies in its planning and management process (F. Duarte, Figueiredo, Leite, & Rezende, 2014). In this sense, the city has been the scene of various studies on the issue, which brings essential contributions to this research. Box 3 below presents three broad junctures, nationally and internationally, that contribute to the discussion by providing a background to the junctures identified by the study.

**BOX 3 BROAD JUNCTURES THAT CREATE A BACKGROUND TO THE STUDY**

Broad Juncture	Justification	Authors
Post-war and acceleration of the diffusion of ICTs and ITs	This is a period known to be marked by the rapid advance of information and communication technologies. These advances will also be felt in territorial management technologies, such as GIS.	Goodchild (2018); Santos (2000, 2008)
Redemocratization and Participatory Ideals	This juncture is originated by the promulgation of the Constitution of 1988 and materializes, for the Brazilian urban policy, in the promulgation of the City Statute in 2001, although the participative initiatives were already present in a certain way in the Brazilian urban management. Added to this is the strength of the discourse that ICTs and ITs are powerful tools to enable social inclusion and community participation.	Bailey and Ngwenyama (2011); F. Duarte and Espinola (2007); F. Duarte et al. (2014); Rezende and Procopiuck (2018); Ultramari and Firkowski (2012)
Market Opening and State Reform	Market opening has provided better access for local governments to technologies. The State Reform established new frameworks for organizations, among them the figure of Social Organizations, which resulted in a great impact on the local context of Curitiba through the creation of the ICI.	F. Duarte et al. (2014); Leite and Rezende (2010); Procopiuck (2007)

Source: Elaborated by the authors.

**4.2 Trajectory of ICTs in Curitiba from critical junctures and events**

Curitiba has a relatively long history of adopting urban management and planning technologies. In the 1950s, the municipal public administration began to use electrical equipment to mechanize the tasks performed by municipal officials. Data processing was the responsibility of Information Supervision until the early 1970s, which also dealt with, for example, library organization services (Decreto Municipal nº 205, de 1972). In 1972, the territorial tribute (IPTU) began to be processed digitally with the help of the state ICT company (CELEPAR) (F. Duarte et al., 2014). The local urbanization company URBS created the municipality’s first Data Processing Center (DPC) in 1974 (Leite & Rezende, 2010).

**4.2.1 First critical juncture: the emergence of the ecosystem based on the diffusion and adoption of technologies**

The Institute of Research and Urban Planning of Curitiba (IPPUC) created a DPC in 1976 (F. Duarte et al., 2014), advancing, in 1989, to the creation of the Supervision of the Data Processing Center (Instituto de Pesquisa e Planejamento Urbano de Curitiba [IPPUC], 2021c). The institutionalization of this specialized organizational structure brought autonomy to data processing, opening a path for the internalization and maintenance of information technologies on a more consistent basis to support the city’s urban planning activities. Political-institutional support for the material and resource management base of ICTs advanced in 1989, with the critical event represented by the

Municipal Master Plan for Micro informatics. This plan aimed more vigorous activities for creating local networks and distributed processing (Leite & Rezende, 2010).

In the 1980s, URBS took over the management of the transport system as the concessionaire of the lines. In a parallel trajectory of ICTs application internalized in an organizational structure of urban planning (IPPUC, 2021a), the IPPUC data processing center started work in 1983 to build the integrated traffic control system in partnership with URBS (F. Duarte et al., 2014). This critical juncture was the first in which the internalization of technology in a public urban planning organization began to be applied to solve public transport problems in the Bus Rapid Transit system (BRT). In this case, the technology was internalized and developed by a public agency dedicated to urban planning and started to be disseminated and applied as an external solution for another public agency responsible for public transport.

The creation of the Municipal Technical Registry System took place in 1984. The purposes of this registry were to record measures to form the city's cartographic base and create parameters for the socioeconomic assessment of the population, identify the need for legislative regulation of regional and local management issues in municipal territory, and seek greater rationality for land occupation and use. This systematization of cadastral information paved the way for creating the cartographic system of technical information and urban analysis (SCITAN), which emerged from a pioneering movement towards geoprocessing technologies (IPPUC, 1984c; Leite & Rezende, 2010). The expansion of this system to the city of Joinville, Santa Catarina, was a critical event that marked the beginning of the generation of solutions for problems external to the IPPUC and the municipality of Curitiba. With the replication of this solution, the DPC advanced by signing cooperation agreements with 15 other Brazilian cities (IPPUC, 1984b). With the same previous logic regarding the internalization of technology, the land registry system opened spaces for applying ICTs in other cities.

Locally, the IPPUC DPC offered 74 systems for municipal management in the mid-1980s. These technological solutions included, e.g., systems for the Municipal Treasury, the registration of buildings, registration and processing of complaints and suggestions (channel 156), public transport statistics, data on education, and personnel management (IPPUC, 1984b). The publication of the report "Curitiba in Data" with information, indicators, statistics, and history of the municipality to society in general in 1988 was an advance beyond solutions to organizational problems (IPPUC, 1988). The dissemination of this information gained significant momentum in 1990, with this information being made public on CD-ROM (IPPUC, 1990). Now the dissemination of information has also turned to citizens-users of geographic information.

In the 1990s, ICTs expanded significantly in the city, permeating various spheres and processes of municipal management and society; there have also been important advances in free training for the population with the offer of computer courses in schools (F. Duarte et al., 2014). A new critical event occurred in 1995, with the transfer of management of the DPC from the IPPUC to the Municipal Public Administration Department (MPAD) (Leite & Rezende, 2010). In 1998, IPPUC developed and implemented the Curitiba Urban Equipment System (SEUC), a georeferenced cadastral base with data on urban equipment in the municipality (Wons et al., 2010). In the process of evolution, advances start to create primary conditions to form citizens-creators of ICT solutions

and, consequently, the insertion of the base of competencies and technological infrastructure into the municipal government.

In this first moment of insertion and maturation of ICTs in Curitiba, there was the creation of consistent bases to insert technologies in municipal organizations from the performance of an organization specialized in urban planning. The next moment was the simple dissemination of information, with progress towards training citizens to apply such technologies. This historical process shows essential evidence of the formation of an ecosystem to support the development of technologies and communication and information in the city, which focused on the internalization and application of technology.

#### **4.2.2 Second critical juncture: sedimentation of the technological ecosystem on organizational bases**

The institutionalization of technologies developed by the city of Curitiba, combined with the intensification of uses by its citizens and public bodies in other Brazilian cities, generated a more punctual critical juncture. This institutionalization produced conditions for the emergence of the critical event represented by the creation of the Instituto de Informática de Curitiba (ICI) in 1998.

This organization was qualified as a non-profit social organization and intended to develop activities related to scientific and technological development, teaching, and research in informatics and telematics, assuming responsibility for managing and disseminating communication and information technologies on a municipal scale (Instituto das Cidades Intelientes [ICI], 2021). Now it is the infrastructure itself and the basis of technological competencies that emerge in the internal context of the municipal administration to gain organizational and institutional autonomy.

In the field of organizational relationships embedded in the technology ecosystem, an important milestone was the consolidation of the implementation of the single and automated ticketing card in the public transport system of Curitiba, consolidated in 2002 (IPPUC, 2021b). Today, all buses in the URBS-regulated fleet, which also covers those operating in metropolitan municipalities, are connected to this system, and about 59% of the system's users use the card (Urbanização de Curitiba [URBS], 2017). ICT popularization programs continued in the 2000s in the field of relations with citizens, but for the training and access of the general public to the internet. An example of these initiatives was the "Typing the Future" program, which implemented internet access points in many public equipments (F. Duarte & Espínola, 2007; F. Duarte et al., 2014; Leite & Rezende, 2010).

The municipal internet connection network expanded in 2005 (F. Duarte et al., 2014). Under the logic of forming an organizational arrangement based on communication and information technologies, the MPAD incorporated the Technical Information Office in 2006, which left the City Hall structure (Leite & Rezende, 2010). In the same year, ICI inaugurated a Situation Room fed with data by MPAD to serve as a basis linked directly to the mayor's decision-making process (Vaz, 2015).

The Integrated Strategic Information Center was inaugurated in 2007 to support public administration's decision-making process, providing support for hardware, software, people, and procedures (F. Duarte et al., 2014). An essential new organizational arrangement emerged in 2007

with the creation of Curitiba's Agency of Development and Innovation (Agência Curitiba). This agency aimed to promote the municipality's economy by developing infrastructure on business bases linked to technology and innovation but emphasizing public-private partnerships (Agência Curitiba, 2017a). Organizationally, public-private partnerships operationalize the connection between technological infrastructures originating from municipal management and the local market.

An expansion of the ICT infrastructure took place with the installation of public Wi-Fi internet points in parks and urban facilities in 2008 (ICI, 2021). In addition to direct actions for dissemination, Curitiba also adopted measures on territorial planning to consolidate an environment favorable to the emergence of an ecosystem of technological innovation centered on communication technologies and information technologies. In the 2000s, e.g., the Tecnoparque logistics ring was implemented. This urban space encompassed important institutions to encourage research and technological development and aimed to facilitate the expansion of the technology sector, taking advantage of the established infrastructure (F. Duarte et al., 2014; IPPUC, 2021b). The program's launch in 2018 incentivized the innovation ecosystem, with the municipality granting financing and tax incentives (Prefeitura Municipal de Curitiba [PMC], 2020).

Advances continued in the 2010s to improve urban mobility, e.g., implementing the integrated mobility system (SIM) to monitor real-time public transport and the city's transit system (IPPUC). The Operational Control Center (CCO) was inaugurated at URBS in 2012, bringing together professionals to monitor traffic and public transport in the city (URBS, 2021). The inauguration of the CCO marked the beginning of the implementation of the SIM. These two projects had the participation of ICI (ICI, 2012). SIM already had 1,000 cameras monitoring urban mobility and security in Curitiba in 2014 (URBS, 2014). The technological ecosystem has advanced to integrate large urban systems based on the performance of autonomous specialized sectoral organizations of public transport, transit, and ICTs in the city. Until this stage of development, the limitation of the discussions was usually in functional adjustments within the municipal government regarding its form of organization, functioning, and solutions. Therefore, the clashes over alternatives tended to be more centered in the city's technical management than in the political field.

#### ***4.2.3 Third critical juncture: the emergence of diffuse organizational solutions towards the idea of the digital city***

IPPUC created the Metrogeo project to start an interactive GIS system around the end of the decade 2000 and beginning of the decade 2010, developed in partnership with the Coordination of the Metropolitan Region of Curitiba (COMEC). The scope of this system covered geographic, cartographic, tabular data, and images of the Metropolitan Region of Curitiba (IPPUC, 2017). The third stage seems to move towards organizational arrangements to cover the 29 municipalities in the Metropolitan Region of Curitiba. This expansion has been taking place with the internalization of technologies in the city's planning and management structures and the dissemination of information to citizens supported by a specialized organizational base to develop technological solutions for the city.

In the innovation dimension, Agência Curitiba created the Vale do Pinhão project in 2017, an Innovation Ecosystem based on the model of other ecosystems, such as Silicon Valley, in the United States. The project aims to promote innovation, growth, and internationalization (Agência Curitiba, 2017b). In 2017, the agency started promoting events to share and disseminate knowledge between companies and organizations, which seeks to associate local cultural elements with the perspective of developing communication and information technologies through the Paiol Digital initiative (Agência Curitiba, 2021). The city of Curitiba seems to continue betting on creating an ecosystem supported by business activity that seeks to connect with the international context based on technology and innovation. With this, the historical trajectory continues to form a material and functional basis to seek legitimacy and sustainability by offering internal and external solutions.

The emergence of controversies about the legal nature of ICI and its focus on a technical strategy to develop technological solutions marks the trajectory of the technological ecosystem that consolidates and expands to find more support in local political and corporate relations. The consequence of the organizational strengthening and strategic self-determination of this Institute was the emergence of criticism from academics and technicians regarding the difficulties of communication and adherence to the municipal technological governance system (Vaz, 2015). Now the municipal strategy has tended towards an effort to (re)internalize technical skills and infrastructure. To this end, in 2013, the Information and Technology Secretariat (SIT) was created by the municipal government to build new bases for the relationship between PMC and ICI (Varela, 2017). In a game of forces between public and private political interests, the relationship between these two organizations became marked by conflicts over, for example, transparency in contracts signed by former managements with ICI, data ownership, and management of dependent municipal services of communication and information technologies (Varela, 2017). At this stage, the tensions within the institutional arrangement in the technological ecosystem gained a new level by placing it within the scope of private interests in a Social Organization, which assumes a business nature in the face of public interests carried by the municipal government.

From the emergence of this game of forces between private and public interests, the adjustments of organizational arrangements began to depend on agreements formalized by short-term management contracts between ICI and the City Hall of Curitiba. An example of these agreements was signing a contract in 2018 between these two institutions, valid for 36 months. The purpose of this adjustment was to bring greater transparency to the relations between these two organizations and, simultaneously, ensure greater technological autonomy for the municipality (PMC, 2018b, 2018c). Internally of the game of forces, the management change in the municipality resulting from democratic electoral processes (2013/2016 and 2017/2020), SIT had its functions emptied by the lack of existing contracts and dismantling of its technological and administrative structures (PMC, 2017). The outcome was the extinction of SIT in 2019 by law nº 15,461 (Lei nº 15.461, de 10 de julho de 2019), which transferred its attributions to MPAD (Lei nº 15.461, de 10 de julho de 2019). The Information Technology Superintendence within the MPAD structure incorporated this knowledge base and technological infrastructure into the municipal government structure (Decreto Municipal

nº 801, de 2019). During these adjustments and in conjunction with PMC, in 2019, ICI launched the channel 156 mobile app (ICI, 2019). At this critical moment, amid political and organizational adjustments, the search for social legitimacy seems to occur by offering a technological solution aimed at the citizen.

As part of the local technology ecosystem, the city of Curitiba has been hosting the international smart city event Smart City Expo since 2018 (D'Ornelas, 2017), which approaches from a market perspective creative and innovative solutions to urban problems (iCities, 2021). The event has a partnership with Pinion Valley and ICI (iCities, 2017, 2018). This event seems to show some level of institutionalization of the technological ecosystem since its organization and realization took place from the market initiative represented by iCities, with the municipal government assuming the role of simple host of the event.

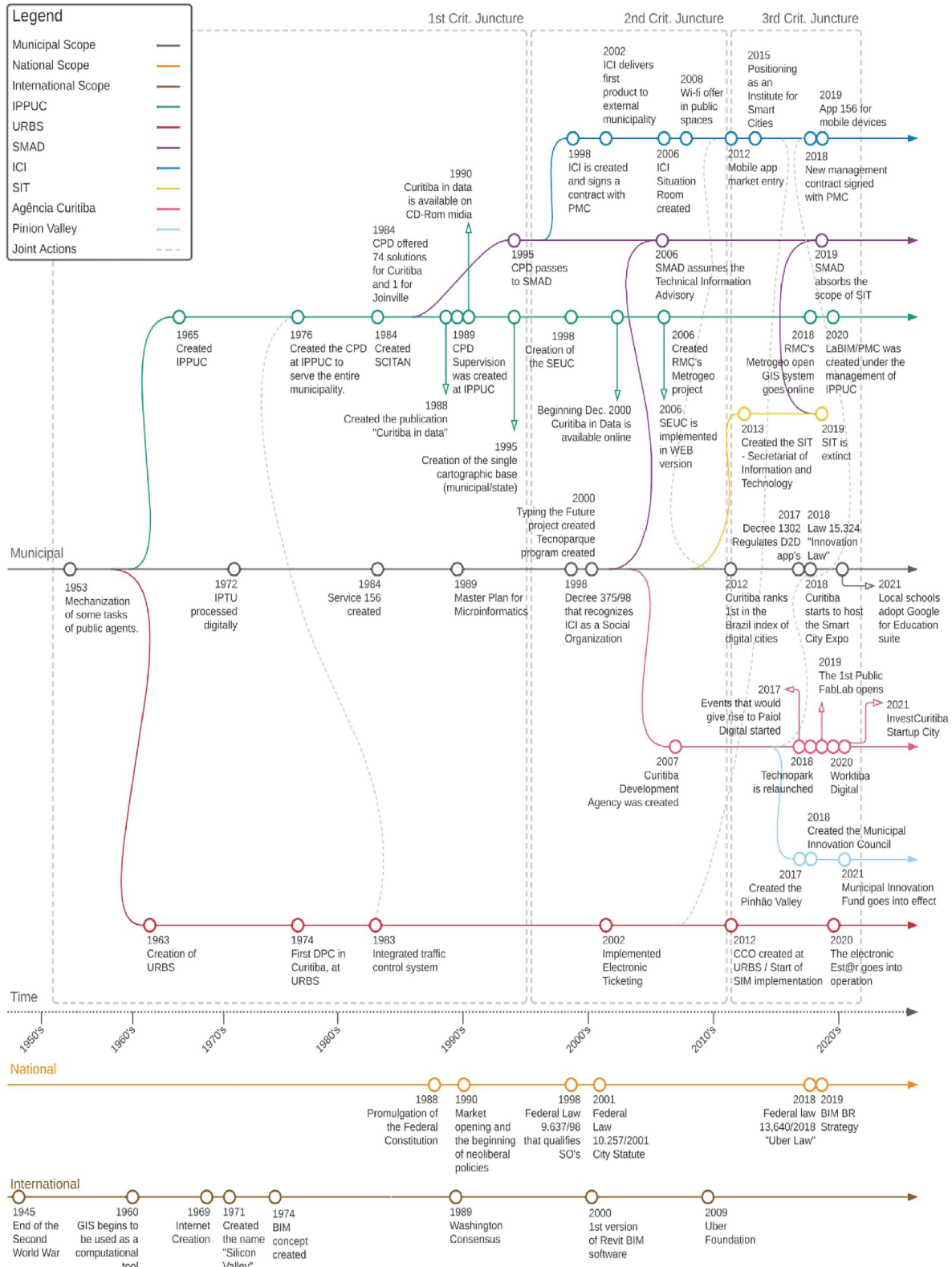
In the political dimension, the institutionalization of the ecosystem advanced to, in addition to the market and municipal executive power, seek support in decisions of the municipal legislative power. An indication of this critical event was the enactment, in 2019, of the "Innovation Law." This law creates rules on incentives for scientific and technological research in the production environment, formalizing an entrepreneurship and innovation ecosystem. The organizational support of this ecosystem was in charge of the Municipal Innovation Council (PMC, 2018a), which has the Pinion Valley Municipal Innovation Fund with R\$10 million in the initial contribution made by PMC (PMC, 2021).

A new movement from the municipality's internal organizations occurred in 2020, with IPPUC creating LaBIM/PMC, a BIM (building information modeling) laboratory. This laboratory aims to become a training center for the entire technical staff of the municipality (IPPUC, 2020). The BIMBR strategy placed the federal government as a promoter of BIM as a Brazilian public policy from 2018 and supported the creation of LaBIM/PMC (Decreto nº 9.377, de 17 de maio de 2018; Decreto nº 9.983, de 22 de agosto de 2019). This public policy made the use of technology mandatory in the direct or indirect execution of engineering and architectural works and services performed by public administration bodies and entities (Decreto nº 10.306, de 2 de abril de 2020). The laboratory is in the implementation phase and has the support of LaBIM/SEIL. This is a BIM laboratory of the Secretariat of Infrastructure and Logistics of the State of Paraná (SEIL) formed by a technical cooperation agreement between the institutions (IPPUC and SEIL).

Figure 1 summarizes the trajectory of the evolution of information and communication technologies in Curitiba.



**FIGURE 1 CURITIBA'S TRAJECTORY IN THE SCOPE OF ICTS AND DATA PROCESSING**



Source: Elaborated by the authors.

### 4.3 Broad critical junctures and events that framed Curitiba's trajectory

Critical junctures are periods marked by macroscale events that reflect significant local changes (Thelen & Conran, 2016). Therefore, the issues analyzed from a historical institutionalist perspective cannot be dissociated from such a context (Hay & Wincott, 1998) because even the structures and actions of entities as broad as the State are conditioned by their historical trajectory (Skocpol, 1996). Thus, the following analyses consider the local, national and international contexts for creating conjunctures that contribute to explaining part of the relevant events for the trajectory of Curitiba in the diffusion and management of ICTs, establishing more connections with broad contextual influences and less close relationships causal.

#### 4.3.1 *The post-war as the initial juncture of the diffusion of ITs and ICTs*

The formation of the first remarkable conjuncture began at the end of the 2<sup>nd</sup> World War when the global acceleration of technological development began (Santos, 2000) and the expansion of applied scientific knowledge. Considering expertise and technologies internalized locally, the beginning of this period in the trajectory of development of technologies applied to management in Curitiba occurred with the first attempts at mechanization in the municipal government. This mechanization was followed by creating organizations specialized in planning and technical management of the city, such as URBS and IPPUC. Although generalists, these events show the first moves towards institutionalizing the use of technological artifacts, developing technical competencies, and incorporating strategic intentions into local political discourses. These events are critical milestones in shaping the dependencies of local trajectories and are naturally connected with global political and technological trajectories.

In the technology field, advances in GIS application as a computational tool began in the 1960s (Goodchild, 2018). The internalization of infrastructure and the development of competencies by IPPUC in these two decades led it, for example, to create a pioneering georeferencing system in 1984. The institutionalization of the continued application of this spatial planning tool associated with the development of the CPD internally to an organization specialized in urban planning and management seems to have been the embryo for creating tools and resources for georeferencing. An example of these resources was the publication of the "Curitiba em Dados" report. These events, even if punctual, are essential for maintaining a trajectory of construction and updating technological infrastructures that allow the teaching and learning of technicians and professionals who support political discourses with products and services seeking innovation.

The rise of ITs also brought implications for territorial management, specifically with the emergence of information modeling technology for buildings, BIM, a concept created in the 1970s, and solid advancements in the 2000s. In Curitiba, the technology was only the object of action for its implementation in the early 2020s. Its primary motivation was the emergence of a federal law that made its adoption mandatory. Still, if taking the local or regional context, there were previous movements, such as the creation of LaBIM/SEIL, in 2015 (Laboratório BIM do Paraná [LaBIM], 2015). Or even initiatives such as the movements made by Vale do Pinhão to encourage the digitization of the civil construction industry, such as creating a hub focused on promoting entrepreneurship, innovation in smart cities, sustainable construction, and renewable energy (Vale do Pinhão, 2019).

### **4.3.2 Re-democratization in Brazil and participatory and inclusive ideals**

In the political field, within the re-democratization movement of Latin American countries, the Brazilian Federal Constitution of 1988 reconnected, with less ideological dependence, the country with the political and technological dynamics that were developing globally. In management and policy, this new institutional base was vital to driving the development of more inclusive and participatory public policies (Lei nº 9.637, de 15 de maio de 1998), which would demand increasing technological instrumentation by the municipalities. In the organizational dimension, this critical event was fundamental for decentralizing the allocation of resources and power to Brazilian municipalities, reinforcing autonomy for local development (Souza, 1998). In the procedural dimension, which is fundamental for the parameterization and standardization of information, the City Statute brought challenges to reconciling participatory processes, information bases, and communication mechanisms for urban planning in municipalities with more than 20 thousand inhabitants (Lei nº 10.257, de 10 de julho de 2001).

In this line, Curitiba, the basic guidelines of the Action Plan of the Municipal Government 1983-1986 anticipated by declaring that “this administration has the urgent commitment to achieve the following objectives: a) to develop more favorable conditions for the increase and a better social distribution of income; b) democratize the use of the city and its equipment; c) promote the participation of all segments of the population in the management of the city” (IPPUC, 1984a, p. viii). The materialization of these premises occurred, for example, in actions to encourage community participation in urban planning policy (IPPUC, 1984a) and with DPC developing technological solutions for the digital processing of the IPTU and control of the road and railroad timetables (IPPUC, 1984b). Although defending the existence of participatory practices in urban management in Curitiba is currently quite controversial (Metzner, 2015), the technological and institutional bases have already been established to operationalize and expand more democratic processes. This juncture of adjustments in the guidelines for the elaboration of public policies and interaction between public entities and the population provided a favorable environment to (re)value existing institutions to assume a leading role in the planning of the municipality of Curitiba.

### **4.3.3 The opening of the market in Brazil and the Reform of the State**

As for the contribution of technologies, Figure 1 shows successive events that may suggest causal relationships. An example of this can be the Washington Consensus prescribing the implementation of neoliberal policies in Latin America (Williamson, 1990). Brazil followed these prescriptions when it promoted the opening of the internal market (F. Duarte et al., 2014) to new technological alternatives (Leite & Rezende, 2010). This contextual influence may have been reflected in the increase in innovations in the management and development of technological tools by the municipal government of Curitiba, as shown in Figure 1. In the Brazilian political-administrative dimension, the State Reform of the mid-1990s created the legal figure of Social Organizations and the National Publicization Program (Medida provisória nº 1.591, de 9 de outubro de 1997; Decreto nº 375, de 23 de junho de 1998). One of the local reflections of this guideline was that the municipal government of Curitiba created ICI in 1998 as a Social Organization (Decreto nº 375, de 23 de junho de 1998),

which started to maintain a service provision contract and assume responsibility for the technological legacy of the municipality (Leite & Rezende, 2010).

Unlike the technological convergence generated by these critical events, the political sphere began to present tendencies to intensify disputes between public and private interests. In the case of ICI, the legacy of a technological heritage when taking over the management of the municipality's data shows a point of fragility or exposure to the public interest. This possible weakening of the defense of the public interest generated extreme tensions in the second half of the 2010s, with the judicialization of the confrontation of public and private interests managed by that institute. The central object of this controversy was the source codes of the systems developed by the Institute for the municipality, which, finally, had the ownership transferred from the municipality to the ICI. The consequence was that the city started to pay monthly to access the products developed by this organization (Resende, 2016), which are crucial to bringing public services from the municipality to the population. In 2016, the institute was the target of operations that investigated the subcontracting of companies to perform services that are part of the scope contracted with the municipal government, which came to be called "quarterization" of services (outsourcing by an outsourced) (Ribeiro & Marés, 2016). In 2017, conflicts continued in new lawsuits filed by both parties on these same issues (JusBrasil, 2017, 2018). This turbulence culminated with the signing of the management contract in 2018, intending to provide more transparency to the relationship and autonomy of the municipality (PMC, 2018b, 2018c).

The trajectory of the formation of institutional arrangements led to the public-private composition of organizations in the municipality of Curitiba, calling attention not only to the political and ideological confrontations generated but also to the quasi-business nature of the delivery of technologies for the urban development of the city. URBS is also an example of this in the operation of the transport system in Curitiba and the definition of technical fares for bus tickets, which generate frequent controversies among the companies operating the system (Banda B, 2017; Brasil de Fato, 2018). The central issue is that this movement brought the structure of municipal public management closer to the private dynamics, which seemed to be an essential factor for innovation and entrepreneurship in the technological ecosystem of Curitiba. At the same time, this produces controversies since objectives and interests of action may differ between organizations, especially of different natures.

## 5. CONCLUSION

Curitiba presented an avant-garde character at the national level concerning the ideals that fostered technological development and the implementation of these technologies in management and urban planning, which resulted in establishing a technological ecosystem. However, with the exponential increase in the speed of technological advances and the detachment of municipal planning from ITs and ICTs, the city began to take more responsive than anticipatory actions, especially regarding IM applied to urban management and planning. Among other reasons for this finding, we can point to the energy spent on controversial issues or the opening and closing of secretariats linked to technologies in the last ten years. Added to this is that actions occur in a dispersed way around common themes and, sometimes, within the same organization. It is possible to see that the motivations for responsive actions have been external pressures, whether of a regulatory nature, such as laws from higher levels of the federation or in the form of market or society pressures. If considered in the international context,

it is evident that Brazil, as a developing country, has a responsive role compared to the global context. This time lag is both an indication and a reinforcement of global inequalities.

Although documental analysis and institutionalist epistemology are insufficient to attest to the effectiveness of the action of some initiatives mentioned in the study, it is clear that formal institutional figures exist. In this sense, there is a relevant role of mixed economy organizations in the municipality in promoting innovation at the local level.

As seen, the ICI was the primary source of infrastructure, equipment, and trained technicians, which served the PMC concerning the application of ICTs to conduct local public policies until the mid-2010s (Procopiuck, 2007). Today, the institute still has a relevant and protagonist role. Still, little by little other organizations are gaining space as the municipal public power creates institutions that allow this decentralization and greater flexibility of action on different fronts. ICI is also a partner in many of these initiatives, but as private organizations increasingly participate in other activities in the municipality, it is plausible that other agents play a relevant role in this scenario. Concerning information modeling, IPPUC and Agência Curitiba play a leading role. In other words, information modeling in support of territorial management in Curitiba is a legacy of the technological ecosystem as a whole, and, increasingly, this ecosystem has had actions spread among organizations and agents. The perceived movement is one of decentralization, which may be a response to the political-technological structure regarding the absorption of controversies and the results of critical events.

The regulatory and normative mechanisms for establishing institutions linked to the dissemination, planning, and management of technology and innovation policies are the majority in the action of public authorities in Curitiba. The primary way for the public authorities to promote technological public policies was through the formation of a legislative basis (laws and decrees), the dynamization of the internal bureaucratic structure (constituting councils), and the creation of specialized organizational structures (secretariats and superintendencies). This action logic is not surprising, given that these actions are of a local public-private entrepreneurial nature. However, it is also clear that these actions carry mimetic intentions toward a large number of external experiences. For example, recently, the city took Silicon Valley in California as inspiration and, quite explicitly, a term coined in the 1970s (Malone, 2002). Another example is the name of the BIM laboratory of the city (LaBIM/PMC), inspired by the state BIM laboratory (LaBIM/SEIL), founded in 2015.

With the increase in the complexity of technological systems resulting from their rapid rise in contemporary society, there was also an increase in the number of formal institutions established to act with this scope. Consequently, it also increases the complexity of the design of the organization chart of the municipality. This movement is the materialization of Milton Santos' (2000), that each technical system represents an epoch in history and that the techniques of our contemporaneity allow a convergence of times, ensuring simultaneity in actions and accelerating the historical process. Looking at Figure 1, this is what we see.

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## APPENDIX – DOCUMENTAL BASIS

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