

The path for the institutionalization of CIM in urban management and planning: a systematic literature review

ABSTRACT

Managing the urban space is a challenge with increasing complexity, among other reasons, because of the advances of information and communication technologies. The treatment of information technologies as human artifacts carrying social meanings is not new, and it has been occurring naturally in studies on Geographic Information System (GIS), Building Information Modeling (BIM). Between these two technologies, the concept of City Information Modeling (CIM) emerges from the adjustment of scale and semantics. The proficiency of institutional theory in understanding the political behavior of cities and evaluating from broad political processes to particular organizational processes of innovation is also not new. We aim to identify and examine publications on the adoption and implementation of BIM and GIS that use institutional theory to support their methods, discussions, and conclusions, intending to confront explanations of political and technological behavior in the implementation of these two tools that allow obtaining basic knowledge for implement CIM systems. Results show that external isomorphic pressures have received significant attention, overshadowing institutional theory's potential to look at issues from the perception of locally situated individuals. The conclusion is that institutional studies for implementing GIS and BIM can contribute to methodological and analytical frameworks for advances in CIM.

KEYWORDS: CIM. GIS. BIM. Institutional Theory. Institutionalization. SLR.

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1 INTRODUCTION

Digital city models gained centrality in discussions within urban studies and, among others, for processing and analytical purposes (Lemos, 2011). These artifacts can add value to the process of planning and managing the urban space (Pereira, Buzzo, Zimmermann, Huckembeck Neto, & Malgarezi, 2021). Other than that, these tools can enable new integrated decision support methodologies (Ergazakis, Ergazakis, Askounis, & Charalabidis, 2011), which represents new ways to face how we plan and manage the urban space. Also, while the data sciences evolve and diffuse among the urban society, we are experiencing the emergence of the urban sciences, which allows us to understand urban issues in ways that were not possible before (Duarte & DeSouza, 2020).

The perception of the value of treating information technologies (IT) as human artifacts that carry social meanings is not new (Sahay & Robey, 1996). Studies for Geographic Information System (GIS) and Building Information Modeling (BIM) have also applied this approach. City Information Modeling CIM studies, however, lack researches focusing on its implementation. CIM concept combines technologies to reproduce the urban environment for its planning and management (Gil, 2020). Among a diversity of combinations, one considers that CIM emerges from an adjustment of scale and semantics between BIM and GIS. GIS deals with georeferencing information from territorial cutouts spatialized on maps, which can be two-dimensional and three-dimensional (R. Chen, 2011; Stojanovski, 2018; Xu, Ding, Luo, & Ma, 2014). In turn, BIM is the construction information modeling process and the resulting model, making it possible to manage the life cycle of the construction process of a building (NBS, 2020) through links of this model with databases and repositories (Gu & London, 2010). This base can provide data for decision making throughout the project lifecycle (Arayici et al., 2011; Cao, Li, Wang, & Huang, 2017; Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013; Succar, 2009) and the life cycle of the building (Eadie et al., 2013; NBS, 2020; Travaglini, Radujković, & Mancini, 2014). The innovative changes brought about by BIM are organizational and institutional (Davies & Harty, 2013; Saka & Chan, 2020). CIM is, therefore, an analogy of BIM on the urban scale (Almeida & Andrade, 2018; Amorim, 2015; Gil, Almeida, & Duarte, 2011; Stojanovski, 2013, 2018; Xu et al., 2014).

Institutional theory has long been used to evaluate innovation processes, especially in organizational environments (DiMaggio & Powell, 1983; Zucker, 1987). It is a robust and multidisciplinary theory that has evolved in several fields of knowledge in recent years. In this sense, some authors have worked to bring a general overview and propose ways for a broader approach (Scott, 2014; Tolbert & Zucker, 1996). Our study is supported epistemologically under the scope of the organizational aspect of institutional theory. In its different aspects, the institutional theory is a relevant starting point for understanding organizations from the behavior of their agents and stakeholders, both endogenously and exogenously, or from the context in which they are involved. We observed, however, that, within the universe of publications regarding the three concepts (GIS, BIM, and CIM), a tiny sample of studies using the epistemological approach based on institutional theory.

We aim to identify and examine publications on the adoption and implementation of BIM and GIS that use institutional theory to support their

methods, discussions, and conclusions to confront explanations of political and technological behavior in implementing these two tools to obtain basic knowledge for the implementation of CIM systems. In the exploratory phase, the investigation promotes a systematic literature review (SLR), aiming to answer the following three research questions: (i) What are the objectives of the studies and how does the institutional theory contribute to its fulfillment?; (ii) How do these studies use institutional theory to assess questions about the adoption or implementation of BIM and GIS?; and (iii) What are the contributions of these studies to structure analytical models to support the adoption or implementation of the CIM?

In the confirmatory phase, two hypotheses are tested: (H1) institutional theory is underutilized in the universe of information modeling technologies; and (H2) GIS and BIM studies on its adoption and implementation bring relevant contributions to the design of methodological structures for the implementation and adoption of the CIM.

1.1 Institutions, theoretical approaches, and the institutionalization process

In a broad sense, institutions are restrictions created by human beings to orderly structure political, economic, and social dynamics. This broad variable explaining political behavior may have a nature that varies from informality to formality, evolving over time and connecting past, present, and future (North, 1991). Institutions emerge from shared cultural contexts and value systems, preserving dominant behaviors, rewards, and sanction schemes. The behavior is not necessarily motivated by norms but by classifications, routines, scripts, or schemes unconsciously introjected into individuals (Baptista, 2009). From the point of view of formal institutions, organizations will be viable when their fundamental premises are established: a regulatory framework generated from a political institution and that, e.g., has a supervisory agency that enforces it (North, 1991). These definitions and perceptions emerge from a broad debate that has unfolded over time and fostered by the study of institutions from different perspectives and areas of knowledge (see Hall and Taylor (2003), i.e.). As it encompasses the evolutionary process and the multidisciplinary character that permeates locally situated organizational and technological behavior, institutional theory can be a promising alternative to discourses to internalize technologies by imposing references to isomorphic practices and decontextualized best practices.

Sociological institutionalism considers a broader definition of institution, transcending the perception that they are just formal rules or norms and considering systems of symbols, moral models, and cognitive schemes that create meaning and guide the actions of individuals. Thus, even the most bureaucratic practices of an organization should also be explained in culturalist terms, considering them as a consequence of a transmission process that gives rise to cultural practices in general (Hall & Taylor, 2003). Culture is the adaptation of a particular group to the environment in which it finds itself. Thus, there is no defined plan to be followed to implement a given culture comprehensively throughout the world (Babič & Rebolj, 2016). This approach seems to be the most sensitive to local aspects. When it comes to the implementation of large systems, such as the CIM, the local technological and political ecosystem is probably as important as the resources of the technology itself, which will have to be

apprehended, accepted, and applied to generate products and make sense in support solutions for complex decision-making processes.

The institutional theory of organizations suggests that organizations are influenced by normative pressures from the external or internal environment, guided by legitimate elements, such as specific rules and laws. Incorporating this set of rules and restrictions can lead the organization to isomorphism with its institutional environment (DiMaggio & Powell, 1983; Zucker, 1987). Organizational institutionalism configures a relevant way of approaching institutionalization processes as it sheds light on the interconnection of individuals, organizations, and the supra-organizational context (Owen, Pansera, Macnaghten, & Randles, 2021). Therefore, the contemporary institutional theory fell under the focus of a wide range of social science researchers, who used it to analyze systems ranging from micro interpersonal issues to global macro structures (Scott, 2004). More recent and not fragmented, this understanding allows a more holistic approach, seeking to extract more significant gains from the theory. Some BIM studies, for example, have already used broader approaches to understand the motivations for initiating innovation implementation processes in organizations in the construction sector (see, i.e., Cao, Li, and Wang (2014); Cao et al. (2017); Cao, Li, Wang, and Zhang (2016)).

The macro approach, represented by sociological institutionalism, makes it possible to conceive an organizational field in which organizational institutionalism allows us to understand the behavior of the organizations involved in it. This approach allows the construction of the notion of institutionalized behavior in relation to practices, knowledge, and technologies, which can be recognized and identified through two factors: (i) a rule or quality of a social fact from a broadly standardized organized action, and (ii) an insertion into formal structures, such as formalities of organizations that are not linked to actors or situations in particular (Baptista, 2009; Zucker, 1987).

The starting point for establishing formal institutions is the establishment, e.g., of a legal or regulatory framework that guides the functioning of the dynamics to be exercised by the individuals who submit to them. From this, other formal organizations will act according to pre-established political, organizational, and technological structures. Two questions are fundamental for an institutional analysis: (i) how to build the relationship between institution, behavior, and technologies, considering the behavior and willingness to act of individuals?; and (ii) how to explain the process by which institutions arise or change (Hall & Taylor, 2003) enhancing or weakening technological processes?

Thus, an institution is a result or the final state of a reciprocal process of institutionalization by sedimentation of habitual actions automated by categories of actors interested in solving problems based on certain technologies or technological processes. These habitual actions deal with behaviors developed by an actor or a group of actors to solve recurring problems. In turn, reciprocal typification deals with the development of shared meanings linked to the usual behaviors (or actions) (Tolbert & Zucker, 1996). Nevertheless, as drivers and results of dynamic social processes, institutions are constantly subjected to innovations and changing processes. Institutional change is a relevant topic for innovation issues, as it deals with how institutions influence actors' behavior and how these actors can influence and even change the institutions themselves (Vargo, Wieland, & Akaka, 2015). So, institutionalization is built from this perception that

institutions are an end and result from a political, organizational, and technological process.

Institutionalization is, therefore, understood as a continuous dynamic process through which institutions maintain and modify, which can only be observed and perceived over time (Barley & Tolbert, 1997). When it comes to the technological aspect, the institutionalization of a particular technology is the continuous process of formalizing such technology within the organizational structures (Villodre & Criado, 2020) and fields. Mainly in the implementation of CIM processes, organizational fields are fundamental because, normally, there are dense relations of dependence on technological exchanges between locally located specialists.

These institutionalization processes are phenomena that can be broken down into stages for analytical purposes, as demonstrated by Barley and Tolbert (1997). Thus, establishing parameters that understand how much this particular technology connects to an organization's structures and operations is plausible if the appropriate variables are considered. Furthermore, the study of institutionalization requires an analytical framework that specifies the relationships between the principles of interaction and those of the institutional (Barley & Tolbert, 1997; Vargo et al., 2015). Thus, institutionalization is both a process and a variable property. Treating it as a qualitative state (something is or is not institutionalized) can lead to the loss of relevant issues of variations in levels of institutionalization and how these levels can affect the degree of similarity between sets of organizations (Tolbert & Zucker, 1996).

The innovation caused by technological changes, adjustments to the legislation, or reaction to market forces denotes the beginning of an institutionalization process (Ozdemir & Turker, 2019). Innovation does not occur automatically when actors or groups of actors introduce new ideas or products to the processes. Instead, innovation will broadly consolidate when new practices become effectively institutionalized (Vargo et al., 2015). In a continuum, these processes split into three broad sequential stages: (i) habituation, (ii) objectification, and (iii) sedimentation (Tolbert & Zucker, 1996). In the stricter context of the organizational environment, they are, in turn, supported by the three stages preliminarily proposed by Berger and Luckmann (1966-2014): externalization, objectification, and internalization. Once achieved, the sedimentation, facts, and routines are externalized and are more naturally transmitted through time and space, or continuously in one group and between different groups (Baptista, Newell, & Currie, 2010). Institutional theory, then, provides concepts that dismember this process and make it liable to be measured and evaluated internally to an organization and externally with the connection of the organization or its processes with other agents involved in the respective organizational field.

There are different ways to approach appropriation and inclusion of informational technologies in organizational configurations. Their shared understanding is that the institutionalization of technologies brings benefits to organizations (Baptista et al., 2010). An uncovered point of these theories is that, as technology becomes institutionalized, it becomes increasingly difficult for the actors to perceive its strategic value, becoming "forgotten". This phenomenon occurs mainly in stable work practices and environments, hiding the effects and impacts of technology (Baptista, 2009; Baptista et al., 2010). Once reached this point, information systems become trivial, commonplace, like furniture in the

organization's work environment, which is only perceived when it breaks or stops working (Baptista, 2009; L. Silva & Backhouse, 1997). On the other hand, the usual activity frees the foreground for discussion and innovation, as it unfolds with a minimum of decision-making over time, reserving energy for this (Berger & Luckmann, 1966-2014).

Therefore, we found that there are several ways to approach the processes of institutionalization of technologies, from the rational decomposition of the process to different epistemological approaches that shed light on the multiplicity of agents and variables that affect decisions of organizations or cities involved in certain processes technological. The barriers and benefits that these processes cause for local society present a paradox from which the constant monitoring of institutions and technologies seems to emerge. In this sense, having the means for efficient monitoring that does not burden the organization's processes and that does not limit the city to incorporate alternative technologies is a relevant challenge. Mainly because the focus on compliance with regulations generally shifts the focus of the performance of activities developed by the organization (Zucker, 1987) from the collective and long-term results sought by cities. In this sense, institutional theory and its methodological and epistemological diversity can contribute to the implementation of information modeling and georeferencing technologies at territorial-urban scales.

1.2 On GIS, BIM, and CIM

Since their rise in the scientific universe, ITs are seen as potential enhancers of human social and organizational issues precisely because they are human creations that incorporate social purposes (Sahay & Robey, 1996). Currently, BIM is considered a key factor for digital transformation in order to offer opportunities to insert the construction sector in the context of new paradigms that are taking root in the contemporary built environment, such as the internet of things (IoT) and the big data, for example (Ahmed & Kassem, 2018). The construction industry, which is admittedly a difficult environment for adopting new technologies (Cao et al., 2014), took BIM as an innovation that should bring significant gains (Babič & Rebolj, 2016; Bui, 2020; Cao et al., 2017), with a new way to create, share and use the project cycle (Eastman, Teicholz, Sacks, & Liston, 2011). Over the past two decades, BIM has received increasing attention from researchers and professionals (Cao et al., 2014; Cao et al., 2016). However, only recently, studies considering a sociotechnical approach to implementing such technology began to immerse (Bosch-Sijtsema & Gluch, 2019).

Therefore, BIM represents a significant turning point in technologies at the micro level to support the design and construction process. For this reason, sociotechnical approaches have been gaining ground, especially if we consider that when structures of shared technological interpretations and meanings do not emerge from the process, even the most radical of innovations can be implemented without significant consequences (Sahay & Robey, 1996). The very dispersion around the understanding of what BIM is and its purpose makes the expectations generated by each interest group different (Linderoth, 2017).

In a context of meso-level scale, to consider the scope of urban and regional planning and management, the incorporation of GIS has already made significant

contributions and continues to bring, in support of decision-making (Abarca-Alvarez, Campos-Sanchez, & Reinoso-Bellido, 2017). Concerning specialties, GIS is broad and multidisciplinary, attending all kinds of information linked to a given geographic data. In general, the most valuable contribution made by GIS to the CIM concept, which can even cover macro scales, is the georeferencing of modeled entities. This insertion of the object of analysis in a broader context, of a city, country, continent, or planet, is relevant because it denotes the location of territories. These territories, in turn, belong to a more extensive system with which it establishes relationships, which in turn can be represented and reproduced in a CIM model.

Thus, CIM is a means of trying to understand the urban phenomenon, from the simulation and reproduction of its physical aspects and the dynamics that happen in this environment, resulting from the interaction of a series of human and non-human agents. This simulation offers data-rich subsidies that are easy to view and allow for more informed decision-making. In addition, with the ability to reproduce urban complexity, simulation of scenarios further enriches the definition process within urban management— constructing the urban environment, its materiality, or its environment of relationships resulting from the various existing agents and elements.

1.3 On urban management and planning

Urban management operates within a polycentric logic in the sense of distributing power, that is, without having a well-defined center linked to the performance of local, regional, and international actors (M.-V. G. Silva & Procopiuck, 2019). Due to this complexity, there are many organizations involved in the process. All of them are plausible candidates to avail themselves of the benefits of a CIM model, and all of them are relevant and active agents in the utopian case of a virtual construction of the city operated, built, and fed collaboratively by everyone involved in the city the process. Thus, within the CIM paradigm's predictions, a city ideally will have a single model centralizing its information. In the face of the above mentioned, one can assume that it is more plausible that this process starts in a fragmented way. The institutional theory makes contributions precisely in need of interconnection between these potential technological fragments, decisions about adopting technology, and strategies for instrumentalizing different professions.

Contemporary urban development in its different dimensions must therefore consider the interrelationships between infrastructure, society, and institutions (Fernandez-Anez, Fernández-Güell, & Giffinger, 2018). Urbanism revolves around detecting and interpreting information, interactions, communications, and urban actions. These divide into scientific and political spheres, which, in turn, contemplate information and theory, action and regulation, respectively (Stojanovski, 2013).

Urban management techniques must adapt to different interpretations of cities (M.-V. G. Silva & Procopiuck, 2019). These methods and approaches, in turn, must follow integrated urban and technological development strategies (Firmino & Frey, 2014) and consider that they are dependent on the abundance of data, which can only be generated, managed, and transmitted with the help of digital

technologies themselves (Duarte & Álvarez, 2019). Finally, this diversity of data is managed in a multidisciplinary context, where there is no clear defined center of power but the performance of local, regional, and international actors (M.-V. G. Silva & Procopiuck, 2019).

In the Brazilian reality, acting as innovators in the democratic process falls to local governments (Flores & Rezende, 2018; Pereira et al., 2021), a consequence of the Brazilian federative design, which is excessively decentralized (Arretche, 2010). In the sense of inserting new ITs in cities to solve economic and social problems, the work of the public authorities has reoriented the development of communication infrastructures. Also, it has changed the ways of society acting in the urban context, having direct interference, also in the cycle of public policies (Rezende & Procopiuck, 2018). Strategically, then, it is relevant to value the local aspect when formulating public policies to implement and manage technology development in cities (Firmino & Frey, 2014).

For this virtual sociotechnical construction to materialize, it must have adequate communication infrastructures. The availability of public goods and collective equipment, in addition to the acquisition of goods and services dependent on access to information networks, is the scope of this process, these links directly to the effectiveness of the implementation of these technologies in the urban sphere (Rezende & Procopiuck, 2018).

2 METHODOLOGY

To better understand the panorama of institutionalism as an epistemological current in studies dealing with three-dimensional modeling related to urban space, the study developed a systematic literature review (SLR). These techniques are a mode of theory mining review that is nothing more than a literature review that extracts and synthesizes one or more elements among the four elements of the theory: constructs, relationships, explanations, and borderline conditions (Okoli, 2015). The methodology consists of establishing criteria and guidelines for the selection, organization, and analysis of studies relevant to the central theme of the research (Faisal Shehzad et al., 2020). The clear and transparent definition of criteria aims to eliminate possibilities of partiality or damage that may result from an unexposed or unclear criterion in the study selection process (Ruhlandt, 2018).

Therefore, SLR is the primary research method to examine publications and identify constructs and relationships between research findings concerning the CIM's main research domain and analytical structures. The methodological path for achieving these objectives appear in Table 1, which presents the research strategy.

Table 1 – Research Strategy

Phase	Procedures	Instructions
1	Select the database	Examine the available bases and make the selection according to relevance
2	Choosing keywords and their applications	Define the search keywords and in which part of the document the words should appear
3	Specify search filters	Define which filters to apply to the search results of the databases
4	Unify database and remove duplicates	Gather research on BIM and GIS and remove duplicate files that have appeared in more than one search
5	Verification of the keywords in the body of the documents	Check if the keywords occur at least once in the body of the article
6	Refinement of research with a complete reading of documents	Read the summary, introduction, and conclusion of all articles to exclude false positives. Subsequently, further reading of the remaining articles.
7	Inclusion of articles from the “backward/forward” process.	Include relevant articles left out of the first data collection

Adapted from Ruhlandt (2018).

The database consulted was Scopus / Elsevier, one of the leading scientific dissemination platforms in the world. The terms used were five, as shown in Table 2. Only articles published in peer-reviewed journals were selected for sampling. Once set, we filtered the primary database according to the inclusion and exclusion criteria listed in Table 3. The complementation of data was done through the backward/forward methodology, as suggested by Webster e Watson (2002).

Table 2 – Research formulas

#	Research formulas
1	(TITLE-ABS-KEY (bim) AND ALL ("institutional theory") AND ALL ("building information model*")) AND (LIMIT-TO (DOCTYPE , "ar"))
2	(TITLE-ABS-KEY (bim) AND ALL ("institutionalism") AND ALL ("building information model*")) AND (LIMIT-TO (DOCTYPE , "ar"))
3	(TITLE-ABS-KEY (gis) AND ALL ("institutional theory") AND ALL ("geographic information system")) AND (LIMIT-TO (DOCTYPE , "ar"))
4	(TITLE-ABS-KEY (gis) AND ALL ("institutionalism") AND ALL ("geographic information system")) AND (LIMIT-TO (DOCTYPE , "ar"))
5	(TITLE-ABS-KEY (cim) AND ALL ("institutional theory") AND ALL ("city information model*"))
6	(TITLE-ABS-KEY (cim) AND ALL ("institutionalism") AND ALL ("city information model*"))

Table 3 – Criteria for inclusion and exclusion of articles

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> - English written articles; - Peer-reviewed journal articles; - Studies that have the institutional theory as epistemological support, either directly or indirectly; - Studies that deal, directly or indirectly, with the adoption or implementation of GIS or BIM. 	<ul style="list-style-type: none"> - Publications other than journal articles and without peer review; - Publications in a language other than English; - Publications where the terms referring to institutional theory appear without a clear definition or without bringing practical contributions to the discussion; - Articles that use or apply GIS or BIM to fulfill their objective and do not build a discussion around the adoption or implementation of the tools.

Three research questions guided the protocol for article reading. The first research question is to understand the objectives of the analyzed studies to elucidate the directions pointed out by GIS and BIM research that use institutional

theory as an epistemological basis. As seen, institutional theory can present itself with different approaches in academic research. Thus, the second question focuses on understanding how studies apply institutional theory, which is crucial to analyze. Finally, this research also aims to point out relevant contributions in studies of the adoption and implementation of GIS and BIM for the construction of analytical structures of CIM as a tool to support urban planning and management. Thus, the third and last research question directs to the fulfillment of this issue. Table 4 below lists three questions.

Table 4 – Research Questions

#	Research Questions
Q1	What are the objectives of the studies , and how does the institutional theory contribute to its fulfillment?
Q2	How do studies use institutional theory to assess issues related to the adoption or implementation of BIM and GIS?
Q3	What are the study's contributions to the structuring of analytical models to support the adoption or implementation of the CIM ?

3 RESULTS PRESENTATION

Despite being a theory already used to understand the phenomenon of innovation adoption in the scope of information systems (Bui, 2020), the institutional theory does not seem to have the same weight in the debates about GIS, BIM, and CIM as it has in other issues of technological changes. A tiny sample of studies uses the epistemological approach of institutional theories in the universe of publications regarding the three concepts. Combined, the peer-reviewed articles on GIS, BIM, and CIM sum up to almost 80.000. In opposition, the study identified only 27 of these as adopting the institutional theory in a relevant way, demonstrating the knowledge gap in which the study develops, identifying the opportunity that opens up in the absence of studies supported by institutional theory.

First, institutional theories are relevant instruments for understanding organizations from the behavior of their actors and stakeholders, both endogenously and exogenously, or from the context in which they belong. Second, the scarcity of studies in BIM, GIS, and CIM that use this potential inherent in applying institutional theories to understand the insertion of these concepts into organizational environments. Therefore, the above scenario confirms hypothesis 1. Continuing, Table 5 presents the synthesis list of the articles analyzed after the entire execution of the methodological path.

Table 5 – Final study sampling

#	Author (Year)	Objective	Cit.
1	(Hayes & Rajão, 2011)	To support the hypothesis that for the millennium development goals to be achieved, it is necessary to understand the different institutional logics surrounding the past and present uses of GIS in the Amazon region.	33
2	(Sahay & Robey, 1996)	Describe the social meaning structures belonging to GIS using inductive methods.	69
3	(Ahmed & Kassem, 2018)	Develop and validate a taxonomy for the adoption of unified BIM; Identify the constructs that are part of this taxonomy and how they affect the first three stages of BIM adoption - awareness, interest, and decision making.	30
4	(Akintola, Venkatachalam, & Root, 2017)	Examine the circumstances that created the need for new roles and positions related to BIM in the context of South Africa, putting in place the sustainability of its legitimacy.	18
5	(Babič & Rebolj, 2016)	To explore the stability and persistence of two-dimensional approaches based on drawing techniques on paper in the light of institutional theory.	13
6	(Bosch-Sijtsema & Gluch, 2019)	Create an understanding of the role and actions of BIM actors	2
7	(Bui, 2020)	Explore the challenges and opportunities of implementing BIM in the context of civil construction in a developing country. Understand how the project team adopted BIM in the first pilot infrastructure project in Vietnam and analyze institutional pressures	1
8	(Cao et al., 2014)	Examine how three types of isomorphic pressures impact BIM adoption in civil construction projects.	91
9	(Cao et al., 2016)	To investigate how the implementation in project design organizations in construction project execution processes is associated with their motivations for implementation and factors external to the project.	18
10	(Cao et al., 2017)	Identify the motivations of designers and contractors to implement BIM in civil construction projects; and Investigate how different motivations impact organizations' BIM capabilities and other contextual factors.	70
11	(Faisal Shehzad et al., 2020)	Explore and categorize the effect of the main factors in the adoption of BIM and offer more in-depth aspects regarding different stages of adoption processes. Structure four clusters of 74 identified factors that affect the four stages of the BIM adoption process	0
12	(Gustavsson, 2018)	Explore new positions in the construction industry and how they challenge old power bases and professional expertise.	12
13	(Hetemi, Ordieres-Meré, & Nuur, 2020)	Analyze BIM in infrastructure projects with an approach focused on sustainability. Examine the implementation of BIM as a process that creates disruptions and elicits responses from actors in organizations to implement infrastructure.	2
14	(Ho & Rajabifard, 2016)	Examine the institutional foundations of the strategies used to support BIM adoption in Singapore.	16
15	(Honic, Kovacic, Sibenik, & Rechberger, 2019)	Generate a material passport based on BIM that allows assessing the recycling potential and the environmental impacts of civil construction materials.	7
16	(Hosseini et al., 2018)	Test the viability of the position of BIM manager to endure as a prominent role in the process.	10
17	(Linderoth, 2017)	Develop a conceptual framework for how the development of meaning-making processes shapes the adoption and use of ICT's, with a specific complementary discussion about BIM.	8
18	(X. Ma, Xiong, Olawumi, Dong, & Chan, 2018)	Integrate BIM into the life cycle of a civil construction project; Develop a roadmap for BIM to be implemented systematically in construction projects.	32
19	(Succar & Kassem, 2015)	Delimit terminologies, review applicable dissemination models and clarify research methodologies for the adoption of BIM	119
20	(Bosch-Sijtsema, Isaksson, Lennartsson, & Linderoth, 2017)	Explore the use, restrictions, and driving forces perceived in BIM implementation in medium-sized companies.	33
21	(G. Ma, Jia, Ding, Shang, & Jiang, 2019)	Discover the dynamic mechanism of BIM adoption by clarifying the interaction between institutional and technological factors.	7
22	(Pozzebon, Tello Rozas, & Delgado, 2015)	Identify which context explains the emergence of a PGIS in the Sierra Nevada region; Identify the significant social and environmental consequences of a PGIS implemented in local communities.	5
23	(Saka, Chan, & Siu, 2020)	Investigate the primary factors driving the sustainable adoption of BIM in small and medium-sized companies and the dynamics of these factors in developing countries.	3

24	(Saka & Chan, 2020)	Assess and investigate the dynamics of barriers to BIM adoption from the perspective of small and medium-sized companies in developing countries.	6
25	(Shahrudin, Zairul, & Haron, 2020)	Redefine the skills in BIM that architects have to demonstrate when working in the institutional architectural environment.	1
26	(Wang, Lu, Hu, Gao, & Pishdad-Bozorgi, 2020)	Explain the behavioral logic and boundary conditions for the adoption of ICTs in small and medium-sized construction companies.	0
27	(Hochscheid & Halin, 2020)	Clarify questions about the adoption of BIM and factors that can influence the success or failure of this process, particularly in the implementation stage.	0

Table 6 – Contribution criteria

Theme	Active Contribution	Passive Contribution
GIS	The discussion takes place around the GIS and its implementation or adoption;	Issues related to adoption or implementation appear secondarily in the debate, being a consequence or the background for the primary debate;
BIM	The discussion takes place around the BIM and its implementation or adoption;	Issues related to adoption or implementation appear secondarily in the debate, being a consequence or the background for the primary debate;
Institutional Theory	The institutional theory or its consequences are mentioned clearly and directly as having been an epistemological current adopted in the study;	Discussions about institutions build a backdrop or support analysis without much theoretical deepening.

Table 7 –Classification of studies' contribution

Article	Article																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
GIS / BIM	A	A	A	P	A	P	A	A	A	A	A	P	A	A	P	P	A	P	A	A	A	A	A	A	A	P	A	A
Institucional Theory	A	A	A	A	A	P	A	A	A	A	P	P	A	A	P	A	A	P	A	A	A	P	A	A	A	A	A	P

Note: A=Active, P=Passive.

We organized information according to established criteria and to answer the research questions. The first, and perhaps the main one, was to assess whether the study's contribution to the themes is active or passive. Table 6 below details the criteria used to determine these differences.

Table 7, on the other hand, classifies the studies according to these criteria. It is possible to notice that most of the articles made an active contribution both in the aspect of the technologies themselves and institutional theory. Both in the theme "GIS/BIM" and "Institutional Theory," there are, respectively, 20 (74%) active contributions and 7 (26%) passive contributions. Simultaneous active contributions in both themes were identified in 17 (63%) articles, while simultaneous passive contributions totaled four (15%).

The studies that have passive contributions divide into two groups: the first deals with developments related to the adoption of BIM or GIS, the second is related to studies focused on technical issues applied to the tool, which in turn needs to be implemented in some context. For this second group, only one study addressed creating a tool to process and analyze data from BIM models to assess the recycling potential and the environmental impacts of civil construction materials (Honic et al., 2019). The first group, on the other hand, has a larger sample, having called attention to the focus that these studies have on the integration of the new logics resulting from a technological innovation process

Figure 2 - Adherence of institutionalist approaches with the definitions brought by the studies

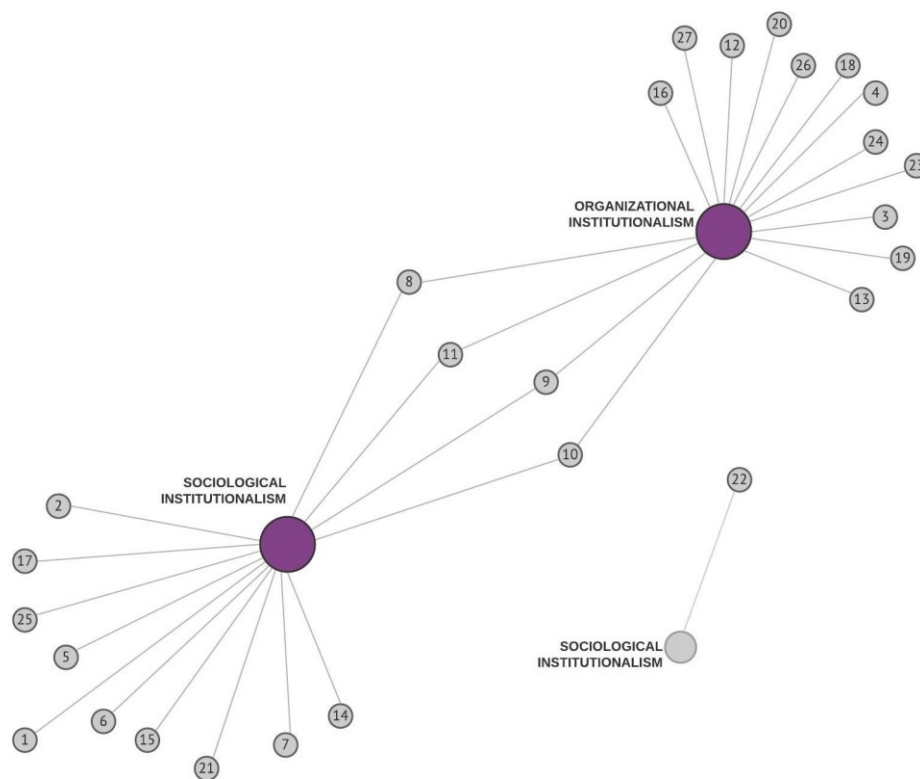


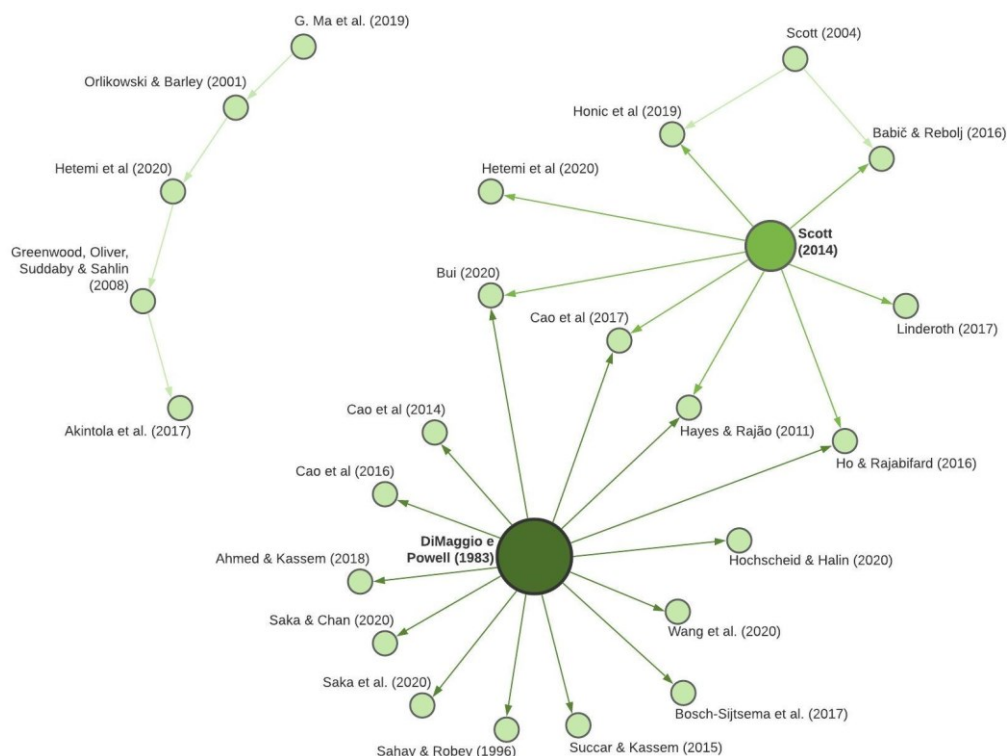
Figure 1 presents a map of articles concerning the theories used in addition to the institutional theory, with a highlight for studies that use the Innovation Diffusion Theory, being present in nine of the studies. Another theory that appears with some prominence is the Technology Acceptance Model followed by the Technology, Organization, and Environment Structure, with four and three records, respectively. Two other theories that call attention are the Sociology of Knowledge and the Social Construction of Reality, with three mentions each.

Figure 2 indicates the approaches to institutional theory more aligned with the way studies present it, as proposed by Hall and Taylor (2003). In this sense, it is relevant to note that the figure points to the most significant conceptual adherence with the definition and application of theory in studies, which does not mean that the approach has been watertight. As already pointed out in the initial sections of the study, institutional theory offers interpretive flexibility within the various forms it presents itself. This classification, therefore, has the objective of understanding the general panorama of the focus given to institutionalism. The organizational and sociological approaches are prevalent, even overlapping these approaches in some studies. Only one of the studies presented a historicist approach.

4 DISCUSSION

Among the studies, we identified the significant presence of two references dealing with organizational institutionalism. The first one, by DiMaggio and Powell (1983) and Scott's (2014). The prevalence of these leads to a deepening of their views, approaches, and applications. We also discuss the findings of studies in the light of the institutional theory and what we presented in the first sections.

Figure 3 – Studies on institutional theory with more occurrences in the sampling



4.1 The institutional isomorphism of DiMaggio and Powell

DiMaggio and Powell's (1983) article has received over 16,000 citations since its publication and has been a reference for studies in the most diverse areas of knowledge, especially economics and business, social sciences, sociology, government, and public administration issues. Their debate contrasts with Max Weber's (Weber, 1968-2009) argument that bureaucratization results from competition between market companies, competition between states, increasing the need for lawmakers to control their subordinates and citizens, and the bourgeois demand for equality before the law. Among the three, the first would be the most important. Instead, they propose that bureaucratization and rationalization are no longer caused by competition and the need for efficiency. They also point out that organizational change results from processes that make them more similar but not necessarily more efficient. For this support, the authors rely on the theory of structuring organizational fields by Giddens (1979). They argue, then, that highly structured organizational fields provide a context where

individual efforts to deal with uncertainty and rules usually lead to structural, cultural, and resulting homogeneity (DiMaggio & Powell, 1983, p. 147).

The authors aimed to analyze organizational and social changes, using a robust and diversified theoretical framework for this purpose. As a result, three mechanisms of isomorphic institutional change emerge - coercive isomorphism, mimicry processes, and normative pressures. In the universe of GIS and BIM publications, this article appears first cited by Rajao and Hayes (2009) and Cao et al.(2014), respectively. From that point on, the study became a theoretical source of institutional theory within BIM publications, which, in turn, becomes related to isomorphic pressures. Even in other studies in the scope of civil construction, such as Jepson, Kirytopoulos, and Chileshe (2020), the institutional approach ends up having a focus on isomorphism. Some authors even come to present an opposite view to that of institutional theory, based on this interpretation that it accounts for the external context, with other theories that, according to them, have a greater scope, as Y. Chen, Yin, Browne Glenn, and Li (2019) do.

The context mentioned above may indicate that there may be a tendency towards a limited view regarding institutional theory among the studies analyzed here, which reduces it to an approach that looks at the external context and takes into account isomorphic pressures. This reading is entirely accurate and pertinent, but it is incomplete, as the initial sections of this study have already demonstrated. In the following sections, we also deepen this affirmation.

4.2 Scott's three pillars of institutions

In the same field of organizational institutionalism, Scott (2014) points to a broader scope of applications of institutional theory, considering in his discussions the pre-existing institutionalist approaches in economics, politics, and sociology. As the author himself points out, knowledge of what happened previously is vital information (Scott, 2014, p. 55). This multidisciplinary consideration and the historicist approach lead to a more comprehensive epistemological structure, resulting in its proposal for the three pillars of the institutions, which are: (i) the regulative pillar; (ii) the normative pillar; and (iii) the cultural-cognitive pillar.

As previously noted, three articles from the sample directly mention the social construction theory of reality by Berger and Luckmann (1966-2014), which structures the debate on the sociology of knowledge, also cited in three other articles (not necessarily the same). Scott's study (2014) also bases a wide range of other epistemological bases on this theory. The author derives the concept that institutions can be represented by verbal designations and need human action to become a fact.

Therefore, human action precisely directs the construction of what is considered to be reality and assigns meanings to objects, procedures, processes, technologies, or routines. These variables, in turn, are closely linked to the context to which they belong and, following the theory of Berger and Luckmann (1966-2014, p.22), there is no human thought that is immune to the ideologizing influences of its social context. The context here is related to the concept of the organizational field, which understands that the actors are subject to variable vector forces (or influences), which in turn depend on their location in the field and their relationship with other actors, as in an electromagnetic field (Scott, 2014).

Thus, the organizational field comprises organizations that constitute an environment of institutional life, such as suppliers, producers and consumers, regulatory agencies, and others that produce similar products (DiMaggio & Powell, 1983). These fields operate within a specific institutional logic shared by various actors who establish relationships with each other through relational systems within the limits of the field itself in space-time (Scott, 2014).

Thus, in a scenario of adopting or implementing technology, managers need to understand the benefits of technology for their organization, fleeing the commonplace and generalizations. Each context is unique, and its particularities directly affect the construction of meanings, interpretations, implementation, and results (Sahay & Robey, 1996). Still, when identifying the relevant social groups, it is possible to identify institutional logics that permeate the social dynamics of this group (Hayes & Rajão, 2011).

4.3 Matters relating to adoption and implementation

Some authors present discussions about the importance of considering and knowing everyday practice. When applied the sociological approach, cultural and cognitive aspects are equally relevant for research, so it is plausible to say that institutions are built in daily life, in the daily overlap of routine (Linderoth, 2017). Other studies, such as Babic and Rebolj (2016), demonstrate that more than pointing to the process of institutionalization of technologies, the challenge lies in institutional change. That is, breaking with institutionalized practices to implement new practices linked to new technologies.

Regarding this insertion of new practices, Linderoth (2017) argues that an implementation and adoption process will tend to be more successful as the new activities manage to be gradually absorbed in the pre-existing daily routines, promoting a gradual change. Thus, practices aligned with institutional logic and existing work tasks will be better accepted. This approach aligns with what Zucker (1986) and Baptista (2009) pointed out as the constitutive expectations, which speak of the gradual insertion of innovation into a daily routine as a way for its institutionalization. In addition, this approach also points to a possible response to the cultural perspective, proposed by Hall and Taylor (2003), that although there is a diffusion of new practices, people tend to resort to already existing frequently and established protocols.

In addition, making the change gradual can make individuals' perceptions of innovation more positive, further increasing the chances of success (Bosch-Sijtsema et al., 2017). At the same time, encouraging the dissemination of disruptive habits and supporting initiatives that create new standards around new forms of behavior is also a possible path to the success of implementation and adoption processes (Ho & Rajabifard, 2016). This approach, in turn, acts on what Zucker (1986) and Baptista (2009) point to as the background expectations, or where a collective perception that innovation is something familiar and part of everyday life is widespread. Braking this familiarity can happen if the technology presented is way too abstract to actors, then it can be perceived as a potential threat (Linderoth, 2017).

These findings point to the importance of daily habits and the role of interpretation of individuals in breaking with the existing reality and in the

institutionalization of new practices. Just as Baptista (2009) pointed out when mentioning that institutionalized practices are so deeply rooted in the structures of an organization that they go so far as to become furniture or something that is taken for granted and commonplace. One way to accelerate innovation processes where there is a firmly established culture may be to understand the existing standards in that culture that can receive new components (Babič & Rebolj, 2016).

Still, in the case of institutional changes, it is relevant to consider that digital transformations, which involve rapid and disruptive changes, need to be considered as being inserted within sociocultural expectations or existing institutions (Hetemi et al., 2020). The adoption process can vary depending on governmental pressures, cultural differences, technical practices, and demographic issues (Faisal Shehzad et al., 2020).

Regarding these variations and emphasizing the technical issue, innovation and change processes in organizations, especially those that imply institutional disruptions, can generate transitional positions or roles. The new and existing roles are jobs in continuous fluidity (Gustavsson, 2018). The positions directly based on BIM, for example, supplement the lack of expertise on the method in the positions of project manager. These capacities, however, are increasingly being absorbed by the project managers themselves, making the specific demand for BIM-related jobs tend to disappear (Hosseini et al., 2018).

This notion of transience in institutionalizing a technology touches the three-stage structure proposed by Tolbert and Zucker (1996) and by Berger and Luckmann (1966-2014). The sedimentation or internalization phase is directly related to this moment when the struts cease to exist, and the positions are once again exercised without technological adjectives as before. Once the individuals performing the functions that previously required specialized consultancy internalized the technology, the demand for specific positions ceases to exist, and the technology is effectively incorporated into the process. The innovation and the change of the methodological structure in the approach to projects and construction create the demand for professionals who facilitate the traditional positions to understand and adapt their functions to the new reality (Akintola et al., 2017).

Also, today, the transformation of adoption and implementation processes, which previously were top-down, are now influenced from the bottom up. This phenomenon manifests itself in informal institutions that begin to shape formal institutions, resulting in the improvement of technological factors (G. Ma et al., 2019). The improvement could be related to the release of organizations from isomorphic pressures, especially mimetic ones. However, even though the participants have strong economic motivations to improve the project's performance as their BIM capacity matures, this growth in the economic issue does not necessarily require a parallel decrease in desire to improve their social image (Cao et al., 2017). In other words, the need for individuals and organizations to feel socially accepted within their context tends not to cease to exist even if their technological capacity grows.

This observation has a strong adherence with the institutional model proposed by Tolbert and Zucker (1996), who consider that 'supersocialized' individuals will compact and follow social norms without accurate reflections or resistances based on their interests. Still, this parallel strengthens how pertinent it

is to use isomorphic pressure reading to analyze processes of adoption and implementation of technologies, at the same time that it opens a new window of debate about the individual and his behavior.

4.4 Relevant insights for the institutionalization of CIM

The analyses and discussions we promoted earlier point out that institutional theory, as it has already done for other informational technological innovations, can contribute to its institutionalization process. From addressing aspects of the external context and the pressures, they establish on organizations and their behavior to read individuals' behavior as the discussions showed potential.

CIM is yet to be introduced in a context where there are already institutionalized practices, and, therefore, its approach must consider the institutional change. In this sense, it is worth pointing out that a broad structure and considers the existing practices and routines of organizations and stakeholders to be involved in the process is necessary. In addition, because it is an adjustment of scale and combination between two distinct universes - BIM and GIS, the civil construction market, and urban planning and management organizations - this structure should be multi and interdisciplinary. Also, it should consider in its structures those pre-existing for both universes, that is, when it comes to the conception of a CIM maturity matrix, i.e., it should take into account the constructs and categories proposed by BIM and GIS maturity matrices.

Finally, even though BIM and GIS have a considerable difference in "age," their level of academic debate and practical application leads us to believe that both have the aforementioned institutionalized practices. In addition, these technologies operate in two very fragmented realities, be it the civil construction market (Babič & Rebolj, 2016) or the scenario of urban planning and management (M.-V. G. Silva & Procopiuck, 2019). Thus, there is a demand for scope and semantic diversity, both in the practical and programming sense, in which these structures need to be considered.

5 CONCLUSION

The results confirmed the two hypotheses, demonstrating to H1 that an approach - that of external isomorphic pressures - has received a great deal of attention and, as a result, overshadows latent potentials of the institutional theory of looking at issues of individuals. As for H2, we demonstrated that both studies for GIS and BIM bring the potential to contribute, theoretically and with practical bases, to the construction of methodological and analytical structures for CIM.

There is a widespread notion in the universe of GIS and BIM debates that institutional theory has more adherence to organizational issues, more specifically from the external context. This notion appeared in the tendency to support studies in the publications of DiMaggio and Powell (1983) by Scott (2014). However, from the sampling authors' conclusions, it was possible to extract observations and findings that adhere to epistemological classes proposed by other authors, such as Zucker (1986), Hall and Taylor (2003), and Tolbert and Zucker (1996). As Scott (2014) puts it, the institutional theory is among the most vibrant and fastest-growing social science theories in several areas of knowledge. Furthermore,

precisely for that reason, finding the broadest forms of its application in the scope of the adoption and implementation of GIS, BIM, and CIM seem to be among the most relevant findings of this study.

The varied institutionalist approaches to understanding the complex dynamics of change, innovation, and consolidation of institutions had their origins in different areas of knowledge such as economics, political science, and sociology. Concerning planning and urban management issues, all of them can be absorbed and used due to their multi and interdisciplinary character. However, in the specific focus given by the study, it is noted that the use of the contributions that these epistemological approaches can offer can be even greater.

The institutional theory offers relevant possibilities for contributing to studies of the implementation and adoption of technologies. Mainly because it offers strategies and methods so that organizational change processes can be gauged and monitored. In other disciplines, this support is in a more advanced stage than in information modeling technologies and territorial georeferencing to support urban and regional planning and management.

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O caminho para a institucionalização do CIM na gestão e planejamento urbano: uma revisão sistemática da literatura

RESUMO

A gestão do espaço urbano é um desafio de complexidade crescente, entre outros motivos, devido ao avanço das tecnologias de informação e comunicação. Não é recente a percepção do valor em se tratar tecnologias da informação como artefatos humanos que carregam significados sociais. Essa abordagem tem sido aplicada também em estudos para o Geographic Information System (GIS) e para o Building Information Modeling (BIM). Do ajuste de escala e semântico entre essas duas tecnologias emerge o conceito do City Information Modeling (CIM). A teoria institucional se apresenta com grande potencial para avaliar processos de inovação, especialmente em ambientes organizacionais. O objetivo do estudo é examinar um recorte de publicações sobre BIM e GIS que façam uso da teoria institucional para dar suporte a seus métodos, discussões e/ou conclusões. Os resultados demonstram que a abordagem das pressões isomórficas externas tem recebido grande foco de atenção e, por consequência acaba por ofuscar potenciais latentes da teoria olhar para questões dos indivíduos. A conclusão é que estudos para o GIS e o BIM com abordagem institucionalista trazem potencial para contribuir para a construção de estruturas metodológicas e analíticas para o CIM.

PALAVRAS-CHAVE: CIM. GIS. BIM. Teoria Institucional. Institucionalização. SLR.

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