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An Institutional Approach to Digitalization in Sustainability-Oriented Infrastructure Projects: The Limits of the Building Information Model

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Abstract: The transport sector accounts for a large share of global Co2 emissions. To mitigate the impact of climate change, several sustainability-oriented large-scale infrastructure projects such as electric road systems and expanding rail systems have recently been on the policy agenda. A parallel development that is expected to accelerate the transition of the transport sector is digitalization, which, although ongoing for many decades, has recently been augmented by concepts such as artificial intelligence (AI) and smart city technologies. The integration of these digitalization tools at the organizational level poses not only opportunities but also some challenges for the actors involved in infrastructure projects. An approach that is currently promoted in the infrastructure sector is the Building Information Model (BIM), which is a decision-making instrument that leverages various digitalization tools and applications. However, although the economic implications of BIM are widely discussed in the literature, the (inter-) organizational dynamics involving multiple actors in infrastructure projects are not fully grasped. Large infrastructure projects are sociotechnical endeavors embedded in complex institutional frames; hence the institutional norms, practices and logics in them are significant. Responding to this, this paper adopted an institutional analysis and put the BIM approach in the (inter-) organizational context in infrastructure delivery. Drawing on empirical data from three organizations in infrastructure delivery in Spain, this paper analyzed the tensions among actors during BIM adoption and implementation.

Keywords: digital transformation; sustainability; BIM; technology; institutional logics; case studies

1. Introduction

The transportation sector is one of the five key emitters of global Co2 emissions, with some estimates positioning it as the second most important contributor [1,2]. Several infrastructure projects, including electric road systems [3] and expanding existing railways [4] have been initiated. These sustainability-oriented projects are generally multi-actor and leverage the economies of digitalization in terms of decision-making [5,6]. The adoption of digitalization is shaped by the infrastructure sector context, by the (fragmented) interaction patterns among its constituents [7,8]. The infrastructure sector is a peculiar one since the relations among actors are characterized by short-term interactions, where the whole industry processes are considered loosely coupled [9]. In addition, since the lowest-price tender policy runs it, the actors are oriented on short-term gains [7,10]. Hence, the organization actors in infrastructure delivery focus less on the system process benefits and more on optimizing their own processes. Such characteristics may result in inertia to innovation and challenge the adoption and use of digital technology in general, thus impeding technological development [7,11].

One digitalization tool which has become pervasive in the infrastructure sector is the Building Information Model (BIM). BIM is reportedly the technology enabling the infrastructure sector transition to sustainability [12–14]. This implies that organizational actors in infrastructure delivery are integrating BIM technology into their transition route, thus adhering to the long-term Sustainability Development Goals (SDGs). Consequently, BIM contributes to sustainability from the economic, social and environmental perspectives, but also the organizational one. It adds value to the organization and fosters learning capabilities and contributes to resilience [15]. BIM has been described in different ways, including as a centralized repository for all data related to a project or asset [16], as facilitating cooperation among multiple disciplines across the different phases of a project [17] and as a digital platform associated with various applications [18].

BIM is currently promoted in public projects [19]. For instance, in the EU, the Directive 2014/24/UE mandates BIM adoption in infrastructure projects financed by EU public funds resulting in its application in several different countries [20,21]. Thus, organizations in infrastructure delivery are under pressure to find ways of incorporating the principles of BIM into their processes and into the design of their business models. To this end, BIM adoption is not an off-the-shelf solution because its deployment puts pressure on organizations to evolve toward more open and digital organizations [22–24]. This development has resulted in BIM technology redefining organizational boundaries, their processes and the governance of infrastructure projects which operate BIM through virtual design and construction (VDC) teams [25,26]. Furthermore, large infrastructure projects involve several organizations. The central transformation in the (inter-) organizational setting involving BIM technology is the boundaries that are substantially more permeable as multiple organizational actors engage with the BIM platform [21,24]. The challenges associated with the adoption of BIM cannot be explored in a view of simple binary states of adoption or non-adoption [8,27,28]. In this context, to fully grasp digitalization and innovation technologies, the diffusion of systemic innovation has recently been in focus [11,24,27,29]. Hence, we agreed with other scholars, e.g., [8,21,30,31], arguing that a relational and less focal view seems promissory to understand digitalization and innovation technologies in the multi-actor infrastructure sector.

BIM technology may be viewed as an institutional infrastructure that links different actors, which through new mandates, establishes legitimate logics and courses of action. In this regard, how these happen in infrastructure delivery remains a significant area for research and has been critically addressed in other industries, e.g., the aerospace industry [32] and more recently in healthcare [33]. These combined effects are a 'dramatical altering contextual force,' and it seems insufficient to engage in mere fine-tuning—instead, a broader change takes place in the organizational field and the organization arrangements [11,34]. Accordingly, the changes that are occurring in the nature of organizing and work practice require the balance of the flow of ideas from IT engineering and organization studies [35,36]. As noted by [35], technologies are synchronously "social and physical artifacts." However, given the new BIM mandate, the choice for technology adoption concerning the organizations in context is somehow limited. The consideration of agency needs to be taken into account—as organizations are ultimately 'inhabited institutions' [37], and there have been calls for taking a more critical view for the study of BIM technology [38,39].

An understanding of how organizations in the infrastructure sector are influenced by BIM—both technological and organizational—has important implications for the study of digital transformation in sustainability-oriented infrastructure projects. In particular, how the creators of the BIM mandate, similar to the adopters of digital infrastructure, seek to infuse the norms, values and institutional logics into the infrastructure [35,40]. As [40] argued, the well developed institutional perspective has concepts and theories that are highly relevant to the study of digital transformation, and for a similar argument see also [35]. Following [40], digital transformation may be defined as the "combined effects of several digital innovations bringing about novel actors (and actor constellations), structures, practices, values, and beliefs that change, threaten, replace or complement existing rules of the game within organizations, and fields."

In this context, the overarching objective of this article was to analyze BIM in the context of sustainability-oriented infrastructure projects. More specifically, this paper sought to examine BIM deployment as a process creating disruptions and triggering actors' responses across organizations in infrastructure delivery. It adopted an institutional approach and analyzed how organizations in the infrastructure delivery set the wheels in motion, including how they work with current practices, introducing new organizational forms and changing logics. Studying digital transformation from an institutional perspective is about "how" the digitally enabled institutional arrangements in the context of the BIM technology unfolds in the (inter-) organizational setting. The institutional (logics) analysis, coupled with the processual character emphasis [41] for a sociotechnical understanding of BIM technology in the (inter-) organizational context, goes beyond the existing functional perspective and technological determinism correctly concluded also by other scholars [21,24,38]. Hence, it looks beyond the BIM functional discourse—the digital veil—and seriously considers the (inter-) organizational dimension and institutional actors' interpretive framing. In this regard, an institutional analysis of BIM adoption and implementation enabled a situational understanding of BIM innovation, since there was an opportunity to understand how BIM adoption drivers (in this context the institutional pressure or public client demands) influence its adoption and implementation. Empirically, the paper investigated both public and private infrastructure organizational actors (organizations A, B and C), which were heavily involved in sustainable infrastructure projects that required BIM use.

Methodologically, the paper was based on three case studies using data gathered over the course of four years from three organizations (involving client, consultant, and operator organizations). These three organizations were heavily involved in public projects, which required BIM use. After this introduction, the rest of the paper is structured as follows: Section 2 provides the theoretical framework, followed by the research design and method in Section 3. Section 4 discusses the findings, and finally, Section 5 concludes the paper by discussing some of the theoretical and practical implications, paper limitations and the suggestions for future research.

2. An Institutional Approach to BIM

The current institutional analysis within the information system research has focused on the macro-level examinations cross-organizational field [42]. The BIM may be viewed from an institutional logic, that is, the set of goals, values and prescriptions that are closely associated with a specific institution (e.g., the profession, corporate) and the organizing principles—the rationalities [32]. Following eminent scholars, [32] defined the institutional logic(s) as "a set of material practices and symbolic constructions—which constitutes its organizing principles, and which is available to organizations and individuals to elaborate."

Technology adoption and implementation such as the BIM involve multiple actors in the organization field, e.g., government, professional associations and organizational corporates, among others, each having their own set of regulatory, normative and cultural-cognitive framing [43]. At the organizational level, organizations in infrastructure delivery combine elements of sustainability and social welfare policies with market or corporate logics. The adaptation of BIM technology in this context is also a way of demonstrating organizational legitimacy, which is legislated by the coercive mechanism [43]. A useful concept in this context is that of 'logic multiplicity' [44]. Logic multiplicity refers to institutional 'pluralism,' where organizations are in a situation where there are multiple external constituents with different institutional frames and competing demands that affect the process of technology adoption and implementation [32,33,45]. Practically, this is important because organizations struggle with adopting and implementing BIM into their inter-organizational processes [18,28,46]. In this regard, an institutional analysis of BIM adoption and implementation provided a contextual understanding of BIM innovation, since there was an opportunity to understand how BIM adoption drivers influence its adoption and implementation in project-based organizations and networks.

In recent years, several studies have emphasized the "social construction of technology," redirecting the focus to the role of agency in technological change [47,48].

BIM interoperability and networking, both technological and organizational, raise issues of institutional interdependence whose understanding requires an appreciation of how prior assumptions, norms, values, choices and interactions create conditions for action and how subsequent action produces unintended and wide-reaching consequences. The recognition of the institutional implications of BIM technology and services would focus attention by blurring organizational boundaries, internetworking protocols, intellectual property, etc. In short, current research revolving around BIM deployment and its implementation would highly benefit from the consideration of recursive dynamics among the institutional forces at the macro level, as well as the organizations' responses and their institutional work, at the project inter-organizational level. Few articles discussed the former, albeit fleetingly [29,46,49], and almost none address the latter.

2.1. BIM Adoption and Implementation in the Infrastructure Sector

The history of BIM technology among engineering and project scholars has prominently promoted the achievements of BIM. In the early 2000s, the publications discussed first and foremost how BIM development and adoption in the civil engineering sector improved information management workflow, particularly design information, facilitating 'clash detection.' During the second half of that decade, BIM discussion involved references to the problem-solving tool and it served as a database for the value engineering data, hence useful for generating, simulating and managing value engineering ideas including material, resource, schedule and cost information. Since the early 2010s, the discussions involved the interoperability among BIM tools seeking to implement BIM standardization, and involving regulatory and industry perspectives [50–52].

More recently, the BIM discussion apart from optimizing engineering processes involved platform discussion and its role in the delivery of the lifecycle of projects and management processes, primarily in the coordination and communication interactions among the project actors and stakeholders, including digital information tracking and detailed process stimulation. [49,53,54]. In recent years, scholars have related BIM adoption with the management of supply chain partnerships, emphasizing transactions, inter-organizational aspects [55,56] and the role of the client in BIM implementation and innovation [11,24,31,57]. Owners are portrayed to have the capability to provide a fertile breeding ground for systemic innovation and establish an innovative environment among suppliers through their powerbase and choice of innovation policy. Hence, the limitations of the professional owner are seen as problematic; thus, negatively influencing the transformation of the architecture, engineering and construction (AEC) industry towards BIM-usage [57].

Most popular practitioners and industry reports however, suggest an increase in BIM adoption and implementation and its overall positive impact, regardless of the year in which they were published. For instance, according to the McGraw-Hill report from 2012 (https://www.construction.com/about-us/press/bim-adoption-expands-from-17-percent-in-2007-to-over-70-percent-in-2012.asp), BIM Adoption had almost quadrupled from 17% in 2007 to over 70% in 2012. On the other hand, a recent report from 2019 (https://www.thenbs.com/knowledge/national-bim-report-2019) showed that more than 60% of construction professionals recognized the benefits of BIM, stating that "it has brought them cost efficiencies and over half say it sped up delivery. Almost three quarters say it results in operation and maintenance savings." Although such reports included useful information, they had many shortcomings—including remedial or biased populations, and they did not differentiate between planned and actual BIM adoption; for further discussion, see [52]. The above reports, indeed, blended the social and organizational expectations with technical predictability, thus encouraging overly optimistic estimates of the benefits of BIM implementation and adoption. This optimal way—the normative approach—was included in the guidelines and standards and was used as the criterial for both the implementation and the evaluation of the processes.

The research on BIM deployment is comprehensive. However, as [58] indicated, "the literature giving guidance on the use of BIM tools, methods and workflows largely concentrates on possible uses, not actual use." The lion's share of the existing literature is largely illustrative, e.g., [16] and the practice of BIM is rather scanty. Hence, the engineering and project literature for practitioners is strongly normative, process-oriented and optimistic about BIM deployment—"materialistic" in the sense of [35]. However, as presented in Table 1 below, some studies have focused on BIM adoption and implementation with differing methodologies that have enriched our understanding.

Table 1. Studies on BIM adoption and implementation.

Source	*Focus*	Research Method
[59]	*Analyzes the changing patterns of professional work practices due to Building Information Model (BIM) adoption*	Cross-case analysis and in-depth interviews
[25]	*Proposes thevirtual design and construction (VDC) framework that integrates an organization perspective with BIM, and other processes*	Conceptual framework
[60]	*Investigates the effects of BIM on construction project organizations using social network analysis (SNA)*	Comparative case study with a longitudinal SNA
[61]	*It aims to further understand the barriers to BIM implementation and how these barriers are related to BIM maturity*	In-depth multiple case studies
[62]	*Investigates how external factors promote the adoption of BIM technology*	Online survey using structural equation model and confirmatory factor analysis
[21]	*Anchoring inindustrial marketing and purchasing (IMP), this study examines the use of BIM in project networks and its effects across organization actors, resources and activities in business networks*	Qualitative case study involving interviews
[29]	*Explores the relation between BIM adoption motivations and BIM implementation*	Case studies and interviews with various actors per project
[28]	*Explores how BIM implementation process is pursued and its associated effects, i.e., the intra- and inter-organizational challenges*	Qualitative case study involving interviews
[63]	*Investigates reflective learning as a mechanism of change during BIM implementation*	Qualitative case study involving interviews
[24]	*Puts forth the BIM ecosystem concept and explores BIM-related products, processes and people in this ecosystem.*	Conceptual framework
[56]	*Examines how BIM affects inter-organizational partnerships across tiers and within firms' boundaries*	Comparative case study using semi-structured interviews
[11]	*Analyses the systemic innovation-related needs and decision patterns of architecture, engineering and construction (AEC) actors and the challenges associated with BIM diffusion*	Interviews with focus groups and professionals
[27]	*Explores BIM adoption in view of Maslow's motivational theory on the hierarchy of needs*	Interviews with focus groups and field observations
[64]	*Investigates UK's construction industry to understand BIM adoption*	Mix method combining qualitative interviews and survey questionnaire
[36]	*Analyses the readiness of the AEC industry concerning the product, processes and people for BIM adoption decisions*	Interviews with focus groups

Ref. [39] and [20] have recently noted that digital transformation involving BIM and its influence on work and social order has drawn little research attention to the organizational context. Fewer studies of engineering research on BIM deployment have tackled the organizational issues head-on. Linné, Gu and London, Singh and Holmström and Sackey et al. are notable exceptions in this context [11,21,24,27,36]. These papers typically adopted a more critical view. The research agenda was to explain why BIM deployment and its implementation experienced challenges and why managers were reluctant to endorse BIM wholeheartedly, see also [18,28,38,39]. Recently, [20] reported that software leaders (who are instrumental to BIM adoption) surprisingly did not support any standards for information technology because they did not want users to change their systems, etc. Nevertheless, we found the current debates of BIM conception and nature in the infrastructure sector as highly wishful and normative.

2.2. The Processual Character of Digital Transformation: BIM Innovation

Since C. Eastman and colleagues introduced the basics of BIM in the 1970s, it has come to be seen as an evolution of CAD design systems that provide a more 'intelligent' form of interoperable information. At the core of BIM technology is the promotion of data models involving information on buildings, infrastructure and thus as innovation, it plays a central part in the digital transformation of the infrastructure sector towards sustainable management practices [6,14]. BIM innovation therefore affects the project organizational behavior, but it is at the same time affected by the industry at large [11,27,28,46], thus introducing a processual character.

BIM innovation requires a multi-level consideration because the processual character can be better understood, shaping the organizational contexts and the network of various organizational actors. According to [29], "BIM is an innovation because it brings new workflows for innovative project delivery and deeply transforms the intra- and inter-organizational settings." While innovating with BIM is evoked in the institutional field, i.e., innovation carried along by influential norms, at the operations level, an (inter-) organizational process takes place [21,24,27]. At the organization level, copying with the BIM mandate implies breaking logic(s) and organizational practices which are institutionally enabled. Hence, the organizations' espousal with technology stretches over time and unfolds simultaneously with (new) organizational practices at multiple levels. The above implies the need to be attentive to the processual character of BIM innovation [8]. The four-stage process model by [41] of firms involved with an IT innovation served our analytical purpose. Although the model was not strictly speaking a stage model of innovation, it involved four processes: (1) comprehension, (2) adoption, (3) implementation and (4) assimilation, serving the emergence of heuristic knowledge [41]. In such a context, these innovating process stages provided the basis for showing the entire journey, i.e., how the institutional actors (i.e., the organizations and the individual professionals) interact throughout the (inter-) organizational innovation.

3. Research Design and Methods

The research design for this study was based on three qualitative case studies [65] of evolving digital transformation involving BIM technology. We conducted a multiple-case study in Spain following the replication logic [66]. Our empirical examination of BIM development in the (inter-) organizational context offered an opportunity to investigate the comprehension, adoption and partially the implementation processes in-depth. Furthermore, it enabled comparisons among cases along with multiple sources of evidence through, for example, direct observations, interviews and document analysis, which helped improve the overall quality of this study. We engaged in an iterative process that considered the empirical setting and theory concurrently [67]. Given the effect of the BIM mandate in the (inter-) organizational context, we focused on the links across units: government/industry initiative (the BIM mandate) and infrastructure organizational actors (organizations A, B and C), which were heavily involved in sustainable infrastructure projects, hence, requiring BIM use. Given that both relational and technical elements shape the digital transformation towards sustainable infrastructure sector, for this purpose, the comprehension and adoption processes concerned the (management) organizational level, while the implementation usually concerned both the (inter-) organizational and network level.

3.1. Research Setting

On 9 March 2018, the Ministry of Development in Spain introduced the BIM mandate for infrastructure projects to "incorporate, quickly and efficiently, innovation" into the transport and Infrastructure sectors [19] (p. 9). The goal was to facilitate the integration of information and communication technologies (ICTs) into the management of infrastructures and transport, prompting users and public actors to use open data providing relevant information [19]. With the promise to 'fix the industry's ills,' the focus interest for BIM in Spain has been reinforced by its central positioning within the Ministry of Development's Innovation Plan for Transport and Infrastructures 2018–2020 [19], indicating that: "It is also important, from the point of view of sustainability and the environment, that BIM technologies will supplement and correct an insufficient use of passive measures in the conception and design or the renovation of buildings and infrastructure." From this context, we selected three organizations:

1. Organization A, the project owner, and the rail infrastructure manager, that was established in 2003 and are engaged in large-scale project implementation, which requires state-of-the-art technology to support system coordination and integration.
2. Organization B was created in 1991 as a state company that manages and operates Spanish airports and heliports of public interest.
3. Organization C was created in 1968 to provide technical support in the development of investment programs in the field of transport and was specialized in carrying out studies and projects related to the transport and telecommunications sectors.

These three organizations were selected following several criteria: (1) the core business and operations involved infrastructure and technology management, (2) the organizations had central positions and were heavily involved in the digital transformation—the Spanish Ministry of Development plan [19] and (3) during the data collection, the organizations were continuously collaborating in BIM technology adoption and implementation.

3.2. Data Collection

The data collected for this research paper were part of a large corpus of qualitative data primarily collected by interviewing the management, project staff and engineers of the three organizations. In total, we conducted 11 interviews with respondents from the three organizations. Moreover, observations and participation in the meeting were conducted for a consistent period of 3 months. Nonetheless, between the formal interviews, informal contact was maintained with the management via e-mail and telephone. We summarize the data sources for each organization in Table 2.

Table 2. Data sources.

Organization	Respondents	Data Collection Method		
		Interviews	Note-Taking	Document Analysis
A	BIM engineers; architect; IT coordinator; program coordinator	*7*	√.	*More than 30 documents and reports.*
B	IT coordinator; program coordinator	*3*	√.	*More than 10 documents and reports.*
C	Program Coordinator	*1*	√.	*Organization-wide guidelines and frameworks for technology adoption and program management.*

3.3. Data Analysis

The approach for the data analysis followed the guidelines for qualitative inquiry [68] and was an iterative process in which the data were organized in first- and second-order analyses. During the first-order analysis, we wrote the case descriptions, which created a thick interpretation following the case study protocol [65]. As our analytical framework, we employed the technological adoption processes identified by [41]. We then analyzed our interviewees' descriptions and the secondary data (i.e., the BIM mandate, the industry regulations and the document reports) to understand how the organizations coped with the new technology and how such activities occurred. We focused on events that were considered essential and could be traced back to several years. In the first order of the analysis, the process was more iterative than linear in character. The main baseline was to move sequentially, but there were often other possible moves, involving constantly revisiting and progressively refining the data [69].

Because the cases were approached as organizations in the infrastructure delivery context, influenced by the BIM mandate, a systemic approach to analyzing the three cases was used. The management team and engineering representatives from each case were interviewed several times and independently to understand their comprehension of BIM technology. We collected data, involving interviews, observations and meeting participation from various actors residing in different levels to ensure data validity [66]. This was crucial to understanding the actors' divergent perceptions and understandings regarding BIM adoption and implementation (within the same organization).

In the second order of analysis we aimed at understanding the institutional logics that were in our organization—case contexts. To this end, we applied a "pattern-matching approach" [70]. We followed their approach in analyzing our qualitative data to capture the logics in context and their influence in the BIM innovation process. During the second-order analysis process, and while comparing the empirical findings with existing literature, we identified the three prevalent logics, namely the bureaucratic state, corporate and professional logics. In Table 3, we present the notable institutional logics and their characteristics in the setting. Following [33] we used labels from the cases studied (e.g., managerial, engineering and project) and hence used the broad terms for continuity with past work. We discuss the results of this analysis in Section 4.2.

Table 3. Notable institutional logics and their characteristics in the setting.

	State Logic (Bureaucratic)	**Corporate Logic (Managerial Rationalism)**	**Professional Logic (Engineering and Project Management Professionalism)**
Goal	To deliver sustainable infrastructure: pushing BIM innovation across the industry	To improve inter-organizational collaboration: effective BIM adoption and implementation	To deliver BIM project results: efficient work process and effective design and information models
Accountability	Public, end-users	Government, clients, and end-users	Professional community, management, collaborators
Basis of compliance	Expedience (i.e., regulative pillar of institutions) (Scott, 2014)	Expedience and professional obligation (i.e., regulative and normative pillar of institutions)	Professional obligation and shared understandings (i.e., normative and cultural-cognitive pillar of institutions) (Scott, 2014)
Logic understanding	Accountability and control	Accountability and control, and at times appropriateness	Instrumentality and at times; orthodoxy
Accountability mechanisms	Policy polls, a referendum	Independent audit	Professional and administrative oversight
Input	Regulations and standards related to BIM implementation	Business case and benefits management	Project management best practice, engineering IT norms, raw data
Performance metrics	BIM deployment (5–10-year time horizons)	Benefits report	BIM engineering best-practice, project outcomes
Tensions within logic	Intricate institutional work involving multiple experts	Tensions due to external and internal powers	Tensions due to several engineering and project backgrounds

4. Results

In this section, we present the findings from the three organizations' cases and case comparisons to illustrate the main themes that emerged from the data analysis.

4.1. BIM Innovation from Macro to Micro-Level

The organizations were situated in the infrastructure sector context in which they sought to deliver, as per the requirements set by the state agreement. The BIM mandate was the product of a broader initiative; it was preceded by the esBIM Spanish Committee, which is chaired by the Ministry of Development and was gathered for the first time in July 2015. The BIM Committee was made up of five different task groups that focused on distinct themes: strategy, people, processes, technology and international liaison [19]. The BIM Committees' goal was to set a roadmap for the implementation of BIM in Spain. To fulfill this goal, the Committee established specific actions to help the institutional actors and the clients adopt and implement BIM:

- Support the adoption of BIM, following the European standards CEN TC422.
- Support the introduction of BIM in public tenders.
- Set recommendations that support and expedite BIM adoption and implementation.
- Set a template for the BIM execution in projects, to facilitate the BIM scope in projects.

The Ministry of Infrastructure complemented the above actions by establishing the Innovation Plan for Transport and Infrastructures 2018–2020, which helped us analyze the use of BIM in rail infrastructure, airports, harbors and other linear infrastructures [19]. Each of the organizations under study was represented in the BIM committee and actively participated in the series of the meeting—every six months. The organizational representatives—these leaders—considered the BIM initiative would ultimately be worth it, so they pushed its implementation in their respective organizations. Starting in 2019, by this point, the mandate required full implementation, with organizations setting up teams to accomplish the complete system in sequence. For that purpose, each of the organizations launched pilot projects involving BIM, referred to as an 'exemplar' model, because earlier sites in the course would assist as exemplars for the following projects (internal document; cooperation agreement within organization A and B, 2019). As mentioned earlier, the action plans were established by the organization representatives. However, the longer-term goals and each representative's and organizations' visions for the BIM implementation varied. An interesting feature of the initiative was that despite the influence of organizations' processes and their benefits plans, the organizations would distribute the funding for BIM technology according to their vision. This fact allowed organizations to create their own (various) concepts for the long-term goals to pursue.

The management team of organization A adopted BIM because the institutional pressure drove them to, that is, the BIM mandate. As the client–organization A decided to make BIM mandatory by contract, their decision had effects on other actors in the network. Other actors, involving other organizations included in this study, were starting to work with BIM due to the above influence. Being a client, some amongst the management team stated that "we want to use BIM so that we can see the design errors earlier, eliminate extra cost, and simply because the 3D model tells us better what we get." Similarly, in the organization B, BIM was considered due to the government mandate. The interviewees stated that they "were adopting the new technology (BIM) because the government required it in all public projects." However, within organization C, the actors held different positions regarding BIM adoption. The organization C approach to BIM was the most gradually developed, involving years and competences with other technologies over two decades.

4.2. Institutional Actors and Their Responses

As indicated earlier, [41] discussed how the technological innovation process went through the stages of comprehension, adoption, implementation and assimilation. Although the three studied organizations were subject to institutional influence, the BIM development in each organization unfolded in various ways. Following [41], we drew a more definite distinction among the comprehension, adoption and implementation process phases, than BIM literature currently does. For the most part, all of the three terms in the existing BIM literature, in our view, were used interchangeably to cover the digital transformation and BIM innovation process in its entirety.

Within each organization, the BIM technology was characterized by uncertainties and a common theme among the hurdles we witnessed was the existence of practices that seemed to oppose apparent economic rationality. For example, we observed consultancies being rewarded for the implementation of BIM technology, which we qualified to be correct at first sight only. We found IT managers who probed BIM methodologies, which they were not convinced of (organizations A and B). Moreover, we observed disagreements over how BIM technology was comprehended and how it should be adopted and implemented. We observed agents carrying the discussion regarding BIM technology one way for organizational purposes only to do so very differently for government audiences. We also noted behaviors and comments that symbolized that the BIM innovation process was far from fitting or straightforward (see example quotes in Table 4).

Table 4. Example quotes.

"Our work processes are quite decentralized, each and everyone follows the practices (. . .). Hence before BIM implementation, we intended to structure our work. Hence, we have created seven specialized groups following the normative (we were not close to the necessary condition)" (Organization A)
"How this mandate affects the organizations and processes internally, the responsible people and later the inter-organizational project phases is not yet clear. This part is going to be the most complicated, [in my personal opinion" (Organization A)
"For the purpose of BIM implementation, we at the moment are relying on external technical assistance (consultants)" (Organization A)
"We need to interpret the BIM normative and translate it to our work processes. For instance, we need to identify the same components in each of our airport operations and define processes that are linked to BIM implementation." (Organization B)
"Set-up of BIM gradually in three periods, each of them necessitating even-higher specialization. For instance, period one is about identifying the processes and elements that are linked to BIM implementation. Within the second period, through the help of the external consultor, we will identify and decide how we will model the current data in our work process" (Organization B)
"We have not identified any KPIs (i.e., key performance indicators) yet" (Organization B)
"We have launched pilot projects and are keeping track of the BIM methodology; for instance, we have a prototype that was focused on exploitation and maintenance. We have done a project and construction work involving BIM application focusing on maintenance but starting from a previous experience since in 2017 (. . .) we created a BIM prototype for testing and definition of standards applied in T3 de Barajas. That model will serve as a reference to define standards and modeling protocols because in the end it is difficult to define modeling standards without modeling (without a practical case) to define and differentiate the standards and then we will take that pilot airport and go one step further with it, and we will try to integrate(. . .)" (Organization B)
"(. . .) we do not have the capacity to store all the information, how a shared folder can be carried, in which manner. The first barrier we had was not having the tools not being able to do things as we want. We can still ask it from outsiders [consultants and technical support], and it was one of the options that they propose, but it ends being mismanaged and less learning for us" (Organization B)
"(. . .) I don't know how to refer to the colleagues in charge, perhaps the 'integrators' (referring to the BIM Coordinators)" (Organization C)
"We have started, since early 2015, to model using BIM technology in our projects. This contrary to the actual request by the project managers. For instance, we started creating modules, using BIM technology in complement to GIS, (i.e., Geographical Information System) well beyond the design application . . . That is before the BIM mandate" (Organization C)
"Although we have no automatic processes, our work trials, and experience have helped to define our call for proposal in a project revolving around the BIM use. This helps to select the partners in projects and the overall bidding process." (Organization C)

In the institutional context of our case(s) analysis, we found three logics to be salient: professional (engineering and project management), corporate (management) and government (state) logics, displayed in Table 3. This signifies that the practices and reasoning were legitimate and more meaningful in the setting if they followed with these three logics. Given that these logics have been identified in prior work involving information technologies [32,33,44], the institutional complexity as a result of these logics has not been studied in the BIM adoption and implementation context to our knowledge. The corporate logic was emphasized in the meetings and internal documents under terminologies such as "strategic direction," "technology department" and "strategy and business development." The professional logic could be seen in the discussion of the "procurement of all necessary resources for the execution of the Plan," "Technical and quality control," etc. The government logic was visible and manifested in the discussion to "identify synergies and correlation among the initiatives and other public administration bodies," "to specify the makeup of the different initiative teams," "to review the periodic monitoring reports" and "to monitor the initiative and ensure the metrics are observed." The above behaviors directed us to utilize academic literature for explanations.

As outlined by the institutional responses [45], following [33] we adopted the three phases [41] of the digital transformation. In the process of comprehension, as outlined in Table 5, the project team members in organizations A and B adopted a relatively mindless stance towards the new technology, while complying with the new BIM mandate advanced by the government policymakers—the state logic. Regarding the corporate logic promoted by the funders of the social enterprises and administrative workers at the governmental level, the project team members, in both organizations A and B, mainly followed it as taken-for-granted. Lacking in-house competencies with BIM technology, the leaders in both organizations A and B, promoted professional logic (engineering and project management), described backward tactics of escape and disguised nonconformity. For example, in organization A, they spent less time wondering about the new technology, knowing that external consultants specialized in tech come to the rescue—as usual—in their context. While in organization B, they appointed new leadership to cope with the BIM deployment—obeying corporate logic—and influenced towards their logic. In short, during the comprehension process, relatively alike in organizations A and B, they started to rely on the external consultants (business model), thus detaching from the professional logic. On the other hand, in organization C, while the management team complied with the new regulation, they had a more in-depth consideration of the new project's collaborative practices that the BIM technology implied (closely related to mindful innovation in the sense of [41]). The management team in organization C, leveraging their in-house competencies, adopted multiple interest approaches, both external and internal. They focused towards immediate stakeholders—seriously considering the government mandate and endorsing individual members to participate in external managerial debates—while concurrently and proactively engaging in internal technical dialogues pursuing professionalization, shaping the values and criteria.

Table 5. Institutional responses observed in the case analysis.

Digital Transformation Phase per [41]	1. Comprehension	2. Adoption	3. Implementation
Case A	- BIM platform emergence as a new form of collaboration in their project-based organizational contexts. - Organizing information sessions to interested audiences. - Proactively informing stakeholders, and regulators on the progress of the digital transformation. - Mostly concerned with external legitimacy, while addressing both organizational and technical competencies related to BIM in a superficial manner	- Signing a formal assistance contract with external consultant firms for the implementation of BIM. Utilizing external expertise—complete reliance on external consultants - External consultant firm develops and performs the necessary actions for the implementation of the plan execution BIM (PEB), including the design for the BIM processes to be implemented. - External consultant firm provides qualified training to people who will participate in BIM implementation process	- Creating a task group comprising forty (40+) members with competences in Building Information Modelling - Coordinating the management team, the task group and the Consultant - External consultant: implements the corporate PEB, defines the support infrastructure for the BIM implementation and develops the information exchanges necessary between systems and departments
Case B	- Formalizing contracts - the plan of actions to follow the BIM guidelines. - Promoting new organizational leadership to work with BIM technology. - Building embedded relationships with institutions in the environment; organizing stakeholder engagement sessions.	- Recruitment of experts who are credible to significant constituents. - Building partnerships with technology suppliers and consultants—major Spanish firms. - Signing a formal assistance contract with external consultant organizations for the implementation of BIM.	- Coordinating the management team and the consultant firm - The following specialties: BIM implementation, management of projects or works, and production of BIM models are the complete responsibility of the consultant
Case C	- A more in-depth consideration of the new project collaborative practices, the move from analog to more digital collaboration. Addressing both organizational and technical needs. - Multiple interest approach both external and internal focused towards immediate audiences/stakeholders—seriously considering the government mandate. Endorse individual members to participate in external managerial discourses—pursuing legitimation. Concurrently, engage in internal technical dialogues—pursuing professionalization.	- Utilizing operational experience in the technology design processes, relying upon in-house capabilities. - Building embedded relationships with institutions in the environment. Formalizing and professionalizing operations and organizational structures to follow the BIM mandate. - Selecting, identifying responsibilities and assessing their status in terms of resources, know-how, risks, etc. so that the processes selected for implementation and monitoring are specified.	- Ensure alignment between internal stakeholder groups, particularly between corporate management, the project and the engineering team; increase communication flow—to ensure participants have sufficient information to organize their project processes accurately. - Coordinate BIM deployment with different project phases, e.g., planning, design, construction, maintenance and operation. Indicating the level of information and the detail necessary among the various work teams (internal stakeholders), in the life cycle of assets that fall within the scope of the project

Table 5. *Cont.*

<table>
<tr><th>Digital Transformation Phase per [41]</th><th>1. Comprehension</th><th>2. Adoption</th><th>3. Implementation</th></tr>
<tr><td colspan="4">Institutional tactic—in response to logic(s) in brackets [45]</td></tr>
<tr><td>Case A</td><td>Acceptance towards state logic
- Comply (S)
Acceptance towards corporate logic
- Habit (C)
Reluctance towards professional logic
- Escape (P)</td><td>Acceptance towards state logic
- Habit (S)
Contradicted towards corporate logic
- Comply, conceal, buffer (C)
Controlling towards professional logic
- Co-opt (P)</td><td>Contradicted towards corporate logic
- Bargain, challenge, buffer (C)
Escape of professional logic
- Co-opt, avoid (P)</td></tr>
<tr><td>Case B</td><td>Acceptance towards state logic
- Comply, pacify (S)
Acceptance towards corporate logic
- Habit (C)
Reluctance towards professional logic
- Escape (P)</td><td>Acceptance towards state logic
- Habit (S)
Contradicted towards corporate logic
- Habit, bargain, conceal (C)
Controlling towards professional logic
- Co-opt (P)</td><td>Contradicted towards corporate logic
- Comply, conceal (C)
Escape of professional logic
- Co-opt, avoid (P)</td></tr>
<tr><td>Case C</td><td>Acceptance towards state logic
- Comply, balance (S)
Compromise towards corporate logic
- Pacify (C)
Compromise towards professional logic
- Balance, influence (P)</td><td>Acceptance towards state logic
- Habit (S)
Compromise towards corporate logic
- Buffer (C)
Contradicted towards professional logic
- Bargain, challenge, buffer (P)</td><td>Escape of corporate logic
- Buffer (C),
Influence of professional logic
- Balance, control (P)</td></tr>
<tr><td colspan="4">Logic multiplicity and dominance—bootstrapping outcome [33,44]</td></tr>
<tr><td>Case A</td><td>Aligned |S > C > P|
Multiple logics central to BIM technology are in tune and favorable towards state logic.</td><td>The dominance of corporate logic and escape from professional logic |C + S > P|
Aligned</td><td>Contested
|C vs. P|
Multiple logics central to BIM technology give rise to contradictory prescriptions.</td></tr>
<tr><td>Case B</td><td>Aligned |S > C > P|
Multiple logics central to BIM technology are in tune and favorable towards state logic.</td><td>The dominance of corporate logic and escape from professional logic |C + S > P|
Aligned</td><td>The dominance of Corporate logic and escape from professional logic |C > P|
Multiple logics central to BIM technologies give rise to contradictory prescriptions.</td></tr>
<tr><td>Case C</td><td>Aligned |S > P > C|
Multiple logics central to BIM technology are in tune and favorable towards state logic and followed by professional logic.</td><td>Contested |P vs. S + C|
Multiple logics central to BIM technology give rise to contradictory prescriptions.</td><td>Aligned |P > C|
Multiple logics central to BIM technology are in tune and favorable towards professional logic.</td></tr>
</table>

During the adoption process stage, the first tensions amongst and within the logics came to the surface. In organizations A and B, the management team coped with administrative issues by focusing on technical benefits and promises, by crafting new contracts and actually delaying the adoption of BIM technology, solving the problems momentarily—temporary 'fix' effects [71]. Thus, professional engineers and project managers in both organizations A and B selectively chose not to resist, achieving an alignment between the logics. Subsequently, project managers and engineers followed the management's vision, particularly the latter [33,44]. However, they slowly advanced. In organization C, however, during the adoption stage process, the management team struggled to 'build the case,' for the BIM infrastructure set-up, unlike in the comprehension process phase where the logics were aligned. This was possible because the management team and the engineers would envision BIM infrastructure and their position from their framing, maintaining their dialogue using the same concepts. Nonetheless, the reasoning and meaning differed for each of them. During the adoption process phase in organization C, that dialogue materialized, surfacing their actual meaning. At this point, multiple logics central to BIM technology gave rise to different prescriptions. Although possibly described as a situation turmoil—where logics confronted—where they struggled over meanings [37]. Considering the orientation and the background of organization C however, the technology and engineering knowledge in their system predominated. Hence, the engineers and project managers were capable of inducing their view while referring to the combination and coordination metrics making sense for the management team, e.g., through (de)centralization and network indicators. In organization C, therefore, in contrast to organizations A and B, some effective tactics were exercised first internally within the professional logic, but mostly towards the corporate logic. For example, by bargaining—negotiating with the management team—and at times challenging the requirements in the face of efficient processes.

As outlined in Table 5, BIM technology and work processes were not yet deployed given that the BIM mandate was initiated in March 2018. At the time of this study, the BIM implementation process was mainly demonstrated in some pilot, mostly large-scale projects (particularly in organizations A and B). Although preliminary, some differences among the cases could be argued. For instance, within organization C the professional logic dominated, and the corporate logic was defied. In organization A, the corporate and professional logic started to confront, and in organization B, the dominance of the corporate logic persisted. The alignment in organization C was primarily because the professional logic, i.e., the engineers, particularly the software oriented and project engineers, were convincing in their argument and achieved support both in external managerial discourses and in internal technical dialogues.

5. Discussion

The findings from the empirical analysis told us that the management teams' practices were strongly influenced by the government or industrial norms and corporate logic. The flow of influence remained notoriously lopsided. In other words, during the comprehension process phase, the institutional structures had more impact on the actor organizations in the field than the reverse. Indeed, the most critical distinguishing logic during the technology adoption process phase was professionalism. Because the material aspect of the technology required the active engagement of professionals, the mindful technology comprehension processes were triggered [41]. The professional logic can be crucial, especially when it becomes "direct," and aligned within their rationale (the case of organization C). Moreover, corresponding internal or external institutional work by professionals for BIM comprehension and adoption across organizations results in more successful BIM implementation in projects.

Our data revealed three main logics competing throughout BIM adoption across organizations: the state, corporate and the professional logic. The BIM mandate, as an institutional pressure, implied long-term motivation that influenced the organizations' motives for BIM adoption in view of competitive advantage (involving all three organizations in our study). Secondly, corporate-based requirements were rather short-term but predominant and usually related to client demand for BIM adoption (particularly in organizations A and B). The presence of the three logics made the frame institutionally complex [72] and underlined technology adoption and the change of organizational practices as responsible. In addition, we found that the complexity was intensified with conflicts within each logic as well, e.g., contested corporate values among administrators in external bodies and managers in the organizational level, or professional rationales that differed between project managers and engineers.

The presence of institutional complexity—competing logics —triggered multiple institutional responses as the actors coped with the BIM technology adoption and implementation in our three cases. We used [45] institutional response categories to match the actor's responses we captured, which have proven helpful elsewhere [33,73]. In this context, the organization C at first engaged with the external legitimation work (e.g., gaining support from the government and other actors who promoted BIM technology) as well as internal legitimation by launching the BIM task group and maintaining close cooperation with the top management for the digital strategy—introducing employees to the new logic. In contrast to the revolutionary attempt where the change affected all parts of the organizations at the same instant, the above underlines a gradual approach to the new technology adoption, deemed appropriate in the literature [40]. Indeed, as [24] proposed, it makes sense to discuss BIM coevolution in terms of its ecosystem, i.e., across products, processes and people. Among the three cases we studied, organization C could be considered more responsive and professionally active compared to organizations A and B. This was mainly due to technological experience and in-house competence and the fact that organization C did not have rigid BIM-based partner selection criteria in their pilot projects [29,74]. Within organization A, although the BIM adoption processes were consistent with institutional demands, the management relied upon rigid criteria and did not open up for the professional responsiveness. In organization B, the again compliant BIM adoption and implementation were not sustained by any collaboration structure, nor collaboratively communicated by the engineering and project professionals (see Table 5). Indeed, organization C displayed a more collaborative and engaging institutional work attitude toward BIM implementation.

An analysis of the case indicated that the focus on sustainability has become more important for project success, and the BIM innovation in the long term will be closely related to its capability to add value to the infrastructure business model [25]. Therefore, it will depend on the sustainability of the model, including the extension in the owner organization [14], but also of the sustainability throughout the actors' network and its inter-connectedness [21]. This will require a strategic endeavor for the organization in fostering its adoption and animating good practices and other initiatives for creating visibility and empowerment [24]. Unfortunately, such a perspective was not found in any of the studied organizations.

6. Conclusions

There is no doubt that information technology, manifested in the BIM, is an essential tool in the route of infrastructure projects to sustainable development [12,15]. This implies that it is an innovation that results in efficiency and productivity [11]. It is in this context that the new Directive 2018/24/UE mandates BIM adoption, in infrastructure projects financed by EU public funds, to accelerate the implementation of BIM. However, this mandate also implied that it is a new institutional infrastructure demanding an institutional change [32,44].

Given that digital transformation in general and for BIM in particular, involving rapid and disruptive changes [11], it must be viewed as embedded in the socio-cultural expectation or existing institutions [40]. In this context, BIM technology may be viewed as a systematic innovation that requires institutional shifts in terms of sustainable infrastructure delivery [6]. In this paper, we analyzed BIM from an institutional perspective. This was relevant as to the best of our knowledge, yet there were limited empirical studies that employed the institutional lens for understanding the adoption and implementation of BIM. We conducted an in-depth multiple case study of three organizations involved in a sustainable infrastructure delivery project.

At the broader level, internally, an organization is a dynamic environment which could be argued to be an ecosystem [24]. Although the new BIM mandate in EU projects did not instantaneously cause the shift in the logics governing actors' behaviors, it may be argued that the new mandate strengthens the corporate logic, and in some instances it has weakened the professional logic. Our interviews with the three organizations' representatives revealed barriers in the BIM adoption and implementation.

Although the current debates in the BIM literature correctly argued that BIM technology has made coordination and inter-organizational collaboration open and almost free-flowing [25], the actual practice of this requires an institutional logic. The current debate in BIM literature, however, is for the major part normatively oriented and does not address the institutional demands and the actual (inter-) organizational processes—the complexities involved in the adoption and implementation of BIM technology. We therefore suggest that the current normative view be complemented with an evolutionary ecosystem approach in line with Singh and colleagues [11,24,27], and through the industrial marketing and purchasing (IMP) approach that views technology as context-dependent, as well as through organizational relationships of various actors, being individual professionals or organizations [21,30]. In conclusion, there is a need for a theoretically grounded focus and empirically informed study to help provide a situational view of BIM technology in practice. In this context, we suggest an institutional framing of BIM technology as digital transformation in the infrastructure sector. Such a view could simultaneously unearth the integration and standardization in addition to how these relates to the local (inter-) organizational configuration context, including its practice, in time and space.

6.1. Implications for Theory and Practice

Giving the new BIM mandate, by linking our findings to the relevant theoretical lens, this paper illustrated the structuration process that occurs among the macro structures, the project and the network actors during BIM adoption and implementation in sustainability-oriented infrastructure projects. The paper added to the literature concerning technology and institutions by revealing the dual dynamics among the institutional structures and organizational actors. The article set a step in the right direction to unpacking the institutional complexity (actor's rationalities) and their strategic efforts that created the challenges during the BIM technology adoption and implementation. Hence, this paper differed from many others in how it reported the BIM mandate, the process of BIM technology adoption and implementation, as well as the ambiguity around its means and ends. Thus, although the different actors in our case had generic instructions in the BIM mandate, they translated it and coped with it differently, producing various ends of the digital transformation. BIM technology does not merely emerge following the linear adoption protocol. It unfolds unexpectedly and actors' agency or institutionally conscious managerial decisions and actions are crucial [11,24].

We recommend the following steps that can be considered to productively advance the discussion revolving around BIM adoption and implementation in sustainability-oriented infrastructure projects. The first step is for actors and organizations implicated in BIM adoption and implementation to understand that they are caught in an institutional bind [33]. The organization leaders, who are representing the organizations and promoting BIM, suggesting (how) to adopt and implement it, are all caught up in interrelated institutional pressures and logics that are at times contradictory. Independently, all the actors apart from the senior staff, will be affected by the institutional forces. If the actors realize this, they can be more mindful of the pressures and the choice they have. Secondly, when implementing BIM and sharing the platform with third parties in sustainability-oriented infrastructure projects, organizations need to 1) realize that the platform set-up is a complex process and the screening of inter-dependencies among collaborators, peoples' activities and within processes is crucial [21,75]; 2) identify how BIM is essential to their plan and asset maintenance and realize that it coevolves with the project development. From this perspective, following VDC guidelines among collaborators should be agreed upon and key terminologies updated [25]; 3) recognize that it has to serve all the actors involved in the project [24]. Lastly, training opportunities on BIM implementation should be made available at the operational and strategic levels. Importantly, inter-organizational project actors cannot justify investments in VDC tools as BIM, based on their project value proposition, but the value proposition should sustain the actor's organization's support across a program of projects [25].

Finally, the above implications are essential considering the fact that BIM implementation requires a theoretical approach that also focuses on the non-technical organizational aspects of BIM. The adoption and implementation of BIM should among other things also consider relationships, coordination mechanisms and the learning involved as discussed by [21,24]. Hitherto, such an approach could draw on organizational theories, neo-institutional theory, social networks and environmental strategy.

6.2. Limitations and Future Research Directions

One limitation of our study was that it covered only the initial implementation phase of the BIM mandate. We argued that the new BIM mandate could create regulatory pressures considering that institutional settings differed across contexts. For instance, the adoption of BIM might have differing effects for actors at the local levels, i.e., to the organizations in the infrastructure delivery. From this context, future research with a focus on the macro-level needs to shed light on this type of mandate or similar policies if they are a way to stimulate or inhibit BIM development across the organizational field. In addition, it would be interesting if future research could explore whether BIM technology promoted the deskilling or reskilling of professionals, whether it altered communication patterns of (inter-) organizational structures, whether it promoted centralization or decentralization and finally whether it enhanced organizational performances contingent on organizational context and position in the delivery model. All these aspects are strongly related to the sustainability of the BIM initiative inside organizations. At a more systemic level, there is a need to explore the patterns of BIM diffusion as this is critical to understand the issue of infrastructure sustainability at the network level.

Author Contributions: The study design was carried out by E.H. and J.O.-M., based on an idea proposed by E.H. Both J.O.-M. and E.H. collected the data. E.H. analyzed the data, while J.O.-M. and C.N. helped to make sense of the data by taking an outsider perspective, criticizing and scrutinizing the interpretations. The paper was mainly written by E.H. and C.N., with E.H. as the main contributor. All authors have read and agreed to the published version of the manuscript.

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